

1—BASIC MECHANICAL SKILLS

ABOUT THIS CHAPTER

This chapter has several sections. It should be read carefully to prepare for using all the other chapters.

The first section is **GENERAL TERMINOLOGY OF BICYCLE PARTS**. This section covers only the most basic and universal terms. The other chapters will each start with a terminology section with terms that are more specific.

The second section is **THREADS**. Understanding thread descriptions and thread types is perhaps the most important basic mechanical skill.

The third section is **PRESS FITS**. Press fits are a means of holding pieces together other than by threading them. It is a system with its own unique set of techniques and rules.

The fourth section is **LUBRICANTS**. Understanding the proper use of greases and oils is critical to being a good mechanic.

The fourth section is **CLEANSERS AND POLISHES**. This section covers what types of cleansers, solvents and polishes might be used, and how to use them properly.

The last section is **TOOLS**. This section covers use of common mechanic's tools. The other chapters describe how to use bicycle mechanic specific tools. A list of recommended tools is in the appendix.

GENERAL TERMINOLOGY OF BICYCLE PARTS

Chapters on individual component areas of the bicycle have more specific terminology and definitions. For the purpose of this manual, the following terms apply to the frame and basic components.

Frame: The structural piece, usually a number of tubes joined together, to which all of the components are attached.

Fork: The structural piece that attaches the frame to the front wheel. The fork turns to allow the rider to control the bicycle.

Frame set: The frame and fork combination.

Head tube: The near-vertical tube that is the forward most part of the frame.

Top tube: The upper tube of the frame that extends back from the head tube to the seat tube.

Down tube: The lower tube of the frame that extends from the bottom of the head tube to the bottom of the frame (the bottom-bracket shell).

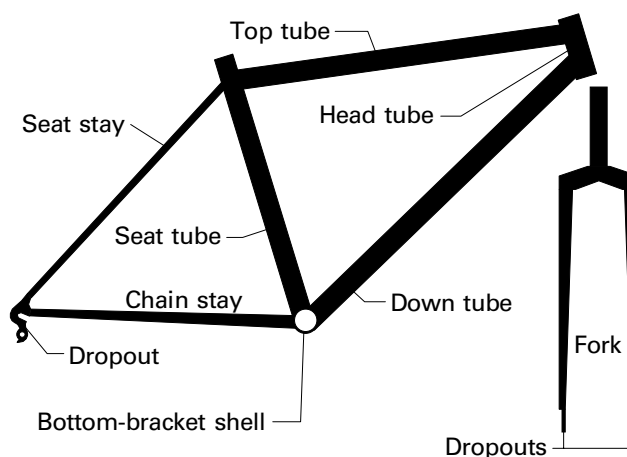
Seat tube: The near-vertical tube that is at the middle of the frame, which the seat post slides into.

Bottom-bracket shell: The portion of the frame that contains the crankset bearing parts, which are called the bottom bracket.

Seat stay: The two tubes of the frame that start from below the seat and meet the chain stays at the center of the rear wheel.

Chain stay: The two tubes of the frame that go from the lower end of the seat tube and meet the seat stays at the center of the rear wheel.

Dropout: The fittings at the end of the fork, and at the juncture of the seat stays and the chain stays, to which the wheels are attached.



1.1 Parts of the frameset.

Deraillleur: There are two such mechanisms: a front deraillleur and a rear deraillleur. The front deraillleur moves the chain between the selection of gears on the crankset; the rear deraillleur moves the chain between the selection of gears on the rear wheel.

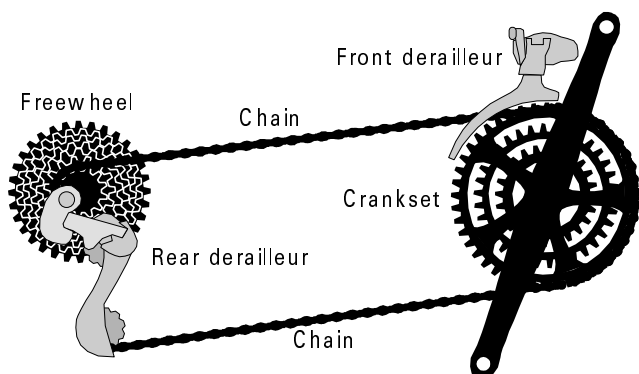
Chain: The loop of links that connects the front gears to the rear gears.

Freewheel: The set of rear gears. Freewheels and freehubs have a confusing overlap of terminology. *For clarification, see the terminology section of the chapter regarding these items.* In a general sense, the freewheel is the set of gears that the chain turns in order to apply drive forces to the rear wheel.

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Crankset: The mechanism that is turned by the rider's feet. It consists of two lever arms called crank-arms, one to three gears called chainrings, and a bearing assembly that the crank arms rotate around called the bottom bracket.

Bottom bracket: The bearing assembly that allows the crankset to rotate in the bottom-bracket shell.



1.2 Parts of the drivetrain.

Wheel: The assembly consisting of the hub, spokes, rim, tire and tube.

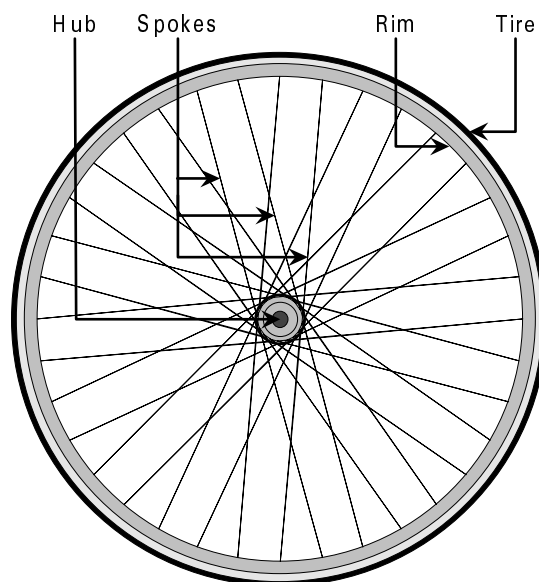
Hub: The assembly at the center of the wheel that houses the axle bearings, and to which spokes attach.

Freehub: A hub and freewheel that have been combined into a single integrated assembly.

Spokes: The tensioned wires that join the hub and rim together.

Rim: The hoop at the outer edge of the wheel to which the tire is mounted.

Tire: The rubber hoop at the outer edge of the wheel assembly.



1.3 Parts of the wheel.

Headset: The bearing assembly that connects the fork to the frame and allows the fork to rotate inside the head tube.

Pedal: A mechanism that supports the rider's foot. It contains a bearing assembly and is mounted to the crank arm.

Seat post: The pillar (usually a tube of metal) that attaches the seat to the frame.

Saddle: The soft structure that supports the rider's posterior.

Stem: The piece that connects the handlebars to the fork.

Handlebar: The piece that supports the rider's hands and is turned to control the bike.

Brake lever: The levers that are operated by the rider's hands to control the braking function.

Shift lever: The levers operated by the rider's hands that control the derailleurs.

Brake caliper: The mechanisms that squeeze against the rims to control the bike's speed.

THREADS

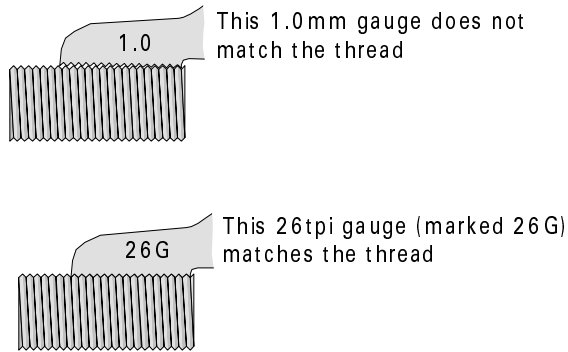
THREAD IDENTIFICATION

One of the key challenges to the mechanic is to be able to replace or upgrade parts with compatible parts. One of the most significant obstacles to be overcome is the number of different thread standards used on bicycles. For example rear axles alone come in seven different varieties. Threads are described by a two part number, such as $3/8" \times 26\text{tpi}$ or $10\text{mm} \times 1\text{mm}$. The first number refers to the diameter of the male version of the thread and the second number refers to the pitch. When identifying a thread, start with pitch.

The first step to identifying a thread is to measure the pitch with a pitch gauge. Pitch is a measurement of the frequency of threads, or the distance from one thread to the next. In an inch system (BSC and Whitworth), pitch is measured by the number of threads that occur in one inch of thread length, and in a metric system pitch is the distance from one thread to the next.

Pitch is measured with a pitch gauge by mating the gauge to the thread. If the gauge can be held down in the thread at both ends simultaneously, the thread is identified (see figure 1.4). The best pitch gauges available come with both metric and Whitworth gauges. Although Whitworth is quite rare, Whitworth pitch gauges are compatible with the BSC (British Standard Cycle) threads found on many bicycle parts. Although gauges are not normally marked with the appropriate units, the thread is metric whenever the number in-

cludes a decimal point, and the pitch is in inches whenever the number on the gauge is followed by the letter “G” or the letters “TPI” (for Threads Per Inch).



1.4 When the teeth of the thread pitch gauge will all go into the threads simultaneously, then the gauge matches the thread.

The next step to thread identification is to measure the diameter. Diameter is a measurement of the male thread’s outside diameter (O.D.). It is usually a nominal measurement. A measurement is a nominal measurement when an actual measurement is rounded up to an even number. For example, a thread with a 6mm diameter is only *nominally* 6mm. The actual diameter is more like 5.9mm.

Metric bicycle threads are available in .5 millimeter increments, so always round the actual measurement up to the nearest .5mm to arrive at the nominal measurement. Inch bicycle threads are available in minimum 1/16 inch increments, so always round up to the nearest 1/16 inch or its decimal equivalent to arrive at the nominal measurement.

Examples:

If the thread measures 5.9mm— it is 6.0mm.

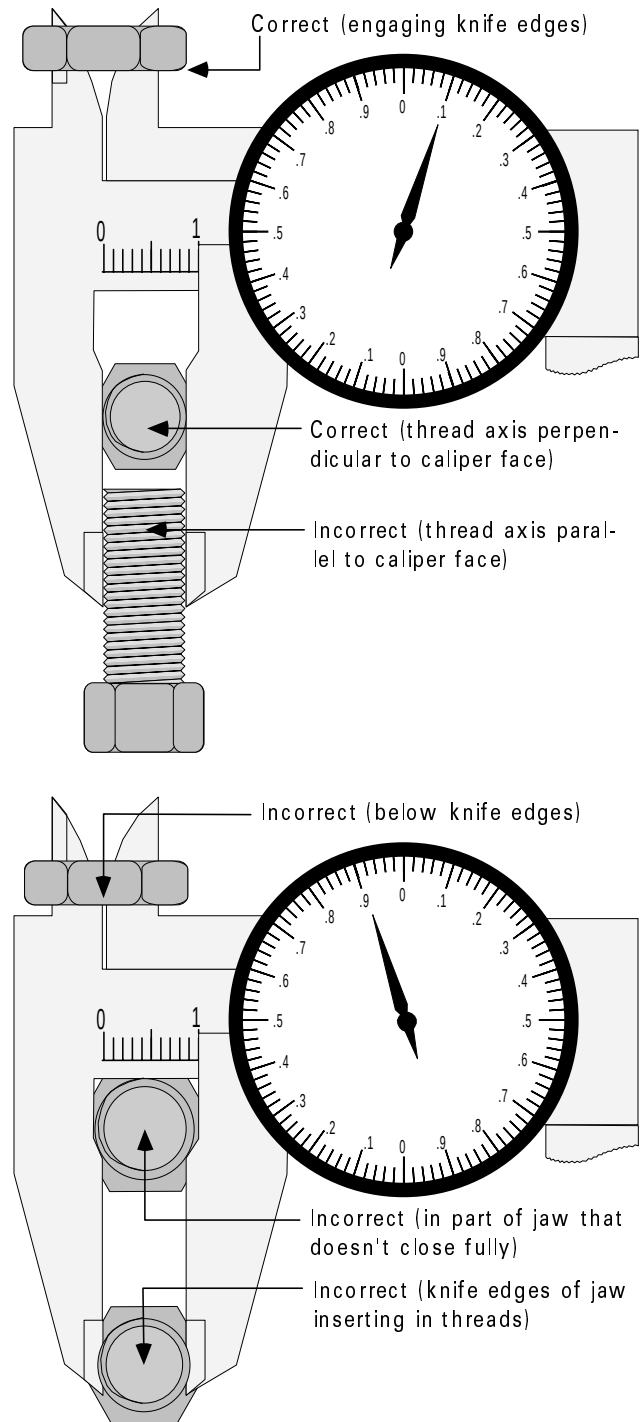
If the thread measures .370"— it is .375".

If the thread measures 23/64"— it is 3/8".

Diameter may be measured in inches or millimeters. The best way to determine which units to use is by measuring the pitch first, because the diameter is almost always in the same units (a 1.0mm pitch threaded item is sure to have a metric diameter). The exceptions are on Italian-manufactured frames, which have metric diameter and inch pitch on the fork and in the bottom-bracket shell, and on Italian-made hubs, which may have metric diameter axles with inch pitch. Italian bikes will also have this combination of metric diameter and inch pitch on the freewheel mounting threads, but in this case it is not an issue because the Italian thread happens to be compatible with the com-

mon BSC freewheel threads. Also, Jou Yu (Joy Tech) hub axles have metric diameter combined with inch pitch in some inconsistent cases.

When measuring diameter use a caliper. Measure the thread with the axis of the thread perpendicular to the face of the caliper, the axle centered in the caliper jaws and not on any slot in the threads.



1.5 Correct and incorrect ways to measure thread diameter.

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Female thread diameters are rarely provided. When the pitch is 24tpi, 26tpi, or 1mm the inside diameter will be approximately .7–.9mm less than the male.

Following is a chart of useful equivalents of thread diameter. Start by taking a measurement in inches or millimeters and then look in the right-most column for the nominal thread diameter.

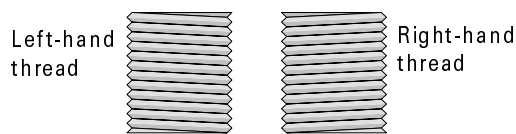
THREAD DIAMETER EQUIVALENTS (table 1-1)

Approximate measurement in millimeters	Approximate measurement in inches	Nominal fractional inch thread diameter
7.7mm	.303"	5/16"
9.4mm	.366"	3/8"
12.5mm	.492"	1/2"
14.1mm	.555"	9/16"
25.2mm	.992"	1"
28.4mm	1.118"	1-1/8"
31.6mm	1.244"	1-1/4"
34.7mm	1.366"	1-3/8"

Approximate measurement in inches	Approximate measurement in millimeters	Nominal metric thread diameter
.149"	3.8mm	4.0mm
.189"	4.8mm	5.0mm
.228"	5.8mm	6.0mm
.307"	7.8mm	8.0mm
.351"	8.8mm	9.0mm
.346"	9.3mm	9.5mm
.389"	9.8mm	10.0mm
.976"	24.8mm	25.0mm
1.358"	34.5mm	34.7mm
1.370"	34.8mm	35.0mm
1.409"	35.8mm	36.0mm

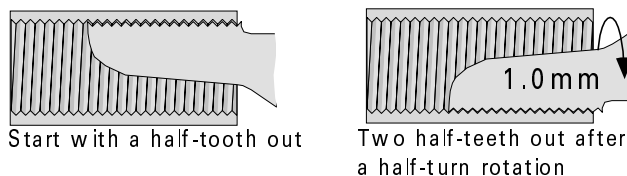
On all pedals and most bottom-bracket threads (as well as other rare occurrences), the final aspect of thread identification is the thread direction. Right-hand threads (most common) tighten or are installed with a clockwise rotation and loosen or are removed with a counterclockwise rotation. Left-hand threads (left pedals, some right-hand-side bottom-bracket parts, and certain freewheel cones and dust caps) tighten or are installed with a counterclockwise rotation and loosen or are removed with a clockwise rotation.

Thread direction of male threads may be identified by observation. Held vertically, the threads on a right-hand thread will slope up to the right, and the threads on a left-hand thread will slope up to the left (see figure 1.6).



1.6 Whether the thread slopes up to the left or up to the right shows the thread direction.

Female threads may be identified as left or right by the following test. Install a matching thread pitch gauge into the thread in question with exactly one tooth of the gauge left outside the thread. Rotate the gauge in the threads at least one-half turn clockwise. Observe the amount of gauge teeth outside the thread at this point. If they have increased, it is a left-hand thread. If they have decreased, it is a right-hand thread. If the gauge is rotated counterclockwise instead of clockwise, the results will be opposite.



1.7 Rotate a thread pitch gauge in a female thread to determine the thread direction.

THREAD TENDENCIES

It is helpful to know what threads are likely to be encountered in certain situations. The country of origin of a bicycle frame is likely to determine the thread used in the bottom bracket and the fork/headset. Different countries tend to use different thread standards. The standards are BSC (British Standard Cycle), Metric, Italian Whitworth, and ISO. ISO stands for the International Standards Organization. The ISO has adopted many existing thread descriptions to be the ISO standard. Some of these existing threads are metric, and some are BSC. ISO standard threads may have a metric or inch description.

Bicycle frames made in Taiwan, and Japan are certain to be BSC or ISO thread. Bicycle frames made in the U.S. are also virtually certain to be BSC or ISO thread, but sometimes small manufacturers of top end racing bikes use Italian threads. Bicycle frames made in Italy are virtually certain to be Italian thread. French bicycles are the greatest source of confusion because they used to be French thread, then switched to Swiss thread, and finally have switched to ISO threading. Bicycle frames from other countries are seen much more rarely, and it is best to rely strictly on measurements in these cases. See the bottom bracket and headset chapters for description of BSC, ISO, French, Swiss, and Italian threads.

The country of origin of a component is useful in determining the thread type of fittings within the component, but the threads that attach a component to another component or the frame may be unrelated to the country of origin. For example a bottom bracket made in Japan for an Italian bicycle would be Italian thread. Another example would be that an Italian made freewheel installed as original equipment on an older French bicycle would probably be a French thread. The threads used within any Japanese, Taiwanese, or French component are likely to be metric. The threads used within any Italian component are likely to be metric or Italian Whitworth (a bizarre combination of metric diameter and inch pitch). There is little consistency with U.S. component manufacturers to use metric or inch threads. Those U.S. component “manufacturers” that contract to have their products made in Asia are more likely to use metric threads. For example, Grip Shift uses metric threads on fittings, but fittings on Bullseye hubs use inch pitch threads.

PREPARATION AND ASSEMBLY OF THREADS

The primary form of thread preparation is lubrication. Preparation of threads with oil or grease permits ease of assembly and disassembly. Lubrication makes it easier to feel when the threaded component is becoming tight enough. Corrosion is also prevented by lubrication; however, lubrication is counter effective on threads with nylon inserts.

In most cases the lubrication choice is between oil and grease. Oil is generally used on threads of small diameter or fine pitch. Ease of application is the primary advantage compared to grease. Grease is used on threads of larger diameter and coarser threads. Its advantage over oil is durability under exposure to moisture and less of a tendency to evaporate.

In some cases it is preferable to use a compound called Loctite instead of lubrication. Loctite is a liquid that hardens and expands after application. It is not a glue, but works by expanding to fill a gap and exerting pressure between the parts. Loctite used on threads aids ease of assembly, prevents corrosion, prevents threaded components from coming loose and consequentially reduces the need to over-tighten parts, risking their damage. Loctites generally cure in a few hours. The hard cake that Loctite compounds cure into is not an adhesive. The hard cake deteriorates if the threaded item is turned after curing. Use of Loctite is redundant on threads with nylon inserts. (*Loctite is toxic— minimize contact.*)

There are several grades of Loctite. Some of the following grades are available from automotive stores or United Bicycle Tool Supply, but some must be purchased at industrial bearing supply companies.

Loctite 222 is the lightest grade available and is applicable on thread diameters up to 6mm. Typical uses of Loctite 222 include: accessory mounting bolts/nuts, brake mounting bolts/nuts, and derailleur limit screws.

If only one grade of Loctite were to be used, it should be Loctite 242. It is heavier than the 222, and is used on larger diameter threads. Typical uses of Loctite 242 include bottom-bracket fixed cups and headset locknuts, but it is also acceptable to use it on smaller thread diameters.

Loctite 290 is a special application thread locker that is more heavy-duty than 242, but can be applied to already assembled components to penetrate into the threads. Typical uses of Loctite 290 include already installed accessories (such as fenders) and already installed bottom-bracket fixed cups.

Loctite 272 or 277 are extremely heavy-duty compounds that would not allow removal without damage to the tool or part. They are used when threads are damaged and as an alternative to replacement when permanent installation will not be a problem.

Loctite RC680 serves as a substitute for 272/277 and can be used in other non-thread applications on the bike, such as enhancing the security of a pressed-in part like a headset cup.

Loctite 660 (Quick Metal) is not applicable to threads at all, but will fill gaps for press fits of up to .5mm.

When assembling threads pay close attention to how they feel. Threads that feel tight during assembly should be checked for:

- Thread compatibility

- Paint in threads (Clean with tap.)

- Damaged threads (Clean with tap, die, thread chaser or file.)

- Cross-threading (Restart thread with better alignment.)

That threads feel effortless to assemble is not by itself an indication of thread compatibility. When the female thread is a larger diameter than the male, no effort will be required for assembly, even when there is a pitch mismatch. If pitch match has not been verified but the difference between the O.D. and I.D. of the parts is acceptable, then it is acceptable to use test-mating of parts as a way to determine compatibility. This is a useful technique in cases where it is impractical to check the pitch because of small I.D., or short overall thread length.

A thread that gets tight and then feels easier to turn as it is secured is probably stripping.

REPAIR OF DAMAGED THREADS

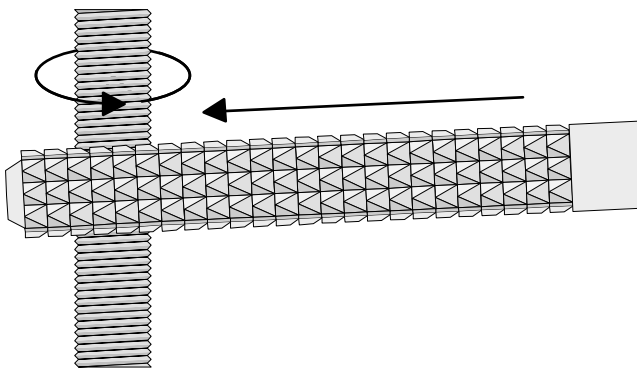
Ideally, when threads are damaged the part should be replaced. If tools are available and the damage is not too severe, it may be possible to repair the thread.

The best repair will be accomplished with a thread cutting tool such as a tap (for internal threads) or die (for external threads). When repairing threads with a tap or die, first make sure the damaged thread and tap or die have compatible thread description. Start the tap or die on the end of the threaded item that is in the best condition to ensure proper alignment.

If the die is a variety with a split in it so it can be compressed or expanded, it should be fit in a special die handle that has expansion and compression adjusters. Thread the die onto the good portion of the thread with it expanded to a loose fit. Then compress it until it is barely snug before starting to cut on the threads that need repair.

An alternative to using a tap or die is to use a thread chaser. A thread chaser does not actually cut threads. It does realign threads that have been mangled. It is most often used on solid axles or the dustcap threads in crank arms.

The least expensive way to repair a thread is with a thread file. The thread file is best when there is just a small ding in a thread. Thread files can be used on mangled male threads. Available from various bicycle tool and general tool suppliers, thread files come in both inch and metric pitches. After matching the pitch on the file to the pitch of the thread being repaired, the file is then stroked in the direction of the thread angle, while the item being repaired is slowly rotated.



1.8 To use a thread file, match the file pitch to the thread pitch, then stroke the file at the angle of the thread while rotating the threaded item.

Stripped threads can sometimes be repaired just by chasing them with the appropriate tap, die, or thread chaser. If the thread still does not hold after this repair, repair options include use of Loctite 277 or RC680, drilling the damaged thread out to a larger

diameter and re-tapping to use a new size, or replacing the damaged part. Using Loctite is a solution only when there is no further need to remove the part. Converting to a larger diameter thread may be limited by available material or parts. Replacing the damaged part has no disadvantage, except cost or limitations of availability.

To repair a stripped thread by going to the next larger diameter, first drill out the old threads to the appropriate size for the tap that will create the new thread. When drilling to tap, the use of a larger bit than recommended will lead to poor thread depth and will probably result in further thread failure. The use of a smaller bit than recommended will result in the tap jamming and breaking off in the hole. To determine the correct drill size a simple formula can be used. If it is a metric thread, subtract the pitch from the nominal diameter of the thread; for example, converting a stripped 4.5mm $\times$.8mm female thread to 5mm $\times$.8mm requires drilling the hole out to 4.2mm ($5.0 - .8 = 4.2$). Another example: the correct tap drill for tapping a 6mm $\times$ 1mm thread would be 5mm ($6 - 1 = 5$). For inch thread (which is unlikely to be needed due to the rare use on inch threads on bicycles), a special or unusual drill bit size is needed. Inch size threads require “tap drills” which are unique sizes that are numbered instead of described by dimension. After drilling out the hole use the appropriate tap for the new thread size.

REMOVAL OF DIFFICULT NUTS AND BOLTS

To remove a stubborn nut or bolt *first* use a penetrating oil and allow to soak for a few minutes. Then use the best-fitting tool possible. If it is a screwdriver, apply heavy, downward force while turning the screw. If a screw or bolt head is deformed in the attempt to remove it, try vise grips locked securely on the head. If vise grips fail, use a small saw (Dremel or rotary tool) to cut a slot in the head to fit a slotted screwdriver. Another alternative is to file flats on the side of the bolt or nut head to fit an open-end wrench. If all of the above fail, the next option is to drill a hole in the bolt or screw between one-half and three-quarters of the bolt diameter and then hammer in a screw extractor to turn out the bolt. The screw extractor is the first option if the screw or bolt head shears off. The last resort is to carefully drill the bolt out with the tap drill that is the appropriate size for the existing thread diameter. The method for determine the correct size for the drill bit is covered in the preceding section, **REPAIR OF DAMAGED THREADS**. Then chase the threads out with a tap.

To remove a stripped nut, screw, or bolt that rotates without removing first use penetrating oil. If possible, grab nut, screw, or bolt with vise grip to pull up while unthreading. Another alternative is to insert something like a screwdriver underneath the nut or screw or bolt head and apply leverage while unthreading. The last alternative is to use a saw to cut off the nut, screw, or bolt head.

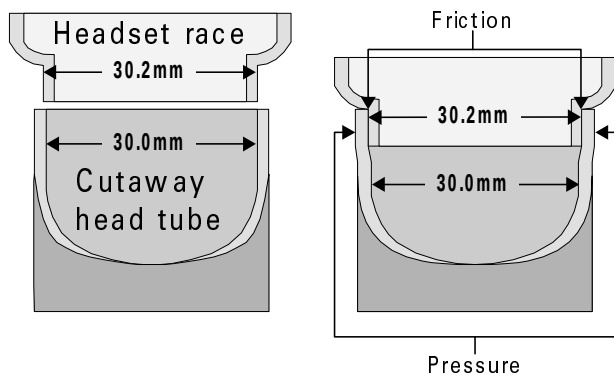
PRESS FITS

DEFINITION AND IDENTIFICATION OF PRESS-FIT TOLERANCES

A press fit occurs when one part is inserted into another with pressure and is held together by the friction between the mating surfaces.

A common press fit is the interference type. With an interference type, the fit is accomplished when a male cylindrical shape is pressed into a smaller hole. The tolerance between the two parts is generally in the range of .1–.3mm (.004–.012"). Examples of interference press fits include:

- Headset races pressed into the head tube
- Headset race pressed onto the fork
- Dustcaps pressed into hub shells and pedals
- Bottom-bracket bearing cartridges pressed into a bottom-bracket shell
- Bearing cups pressed into hub shells and pedals
- Cartridge bearings pressed into bottom brackets and hubs
- Cartridge bearings pressed into pedals



1.9 These cross-sections show a properly sized headset race before installation into a head tube, and again after the head tube has deformed to accommodate the press fit.

Another type of press fit is the tapered press fit. In this case the male component is tapered so that the farther it is pressed in, the tighter it becomes. Examples of this fit include:

- Cotter pins on cotter-type crank arms
- Cotterless crank arms that fit on a spindle with tapered flats

PREPARATION AND ASSEMBLY OF PRESS FITS

Preparation to install a press fit should include identifying that the male component is a suitable amount larger than the female; cleaning the mating surfaces so that they will be free of lubrication, corrosion, and dirt; and treatment with Loctite 222 if preventing corrosion is a concern.

To install press-fit components, a special pressing tool is often required (see the section of the book that applies to the particular component in question.) In the absence of a proper tool, sometimes a vise can be used, and if that is not suitable, a hammer may be used. In either case, pay particular attention to the alignment of the parts as they go in. With a hammer, use a block of wood or a plastic hammer to protect the components from damage. With a vise, similar types of protection may also be required.

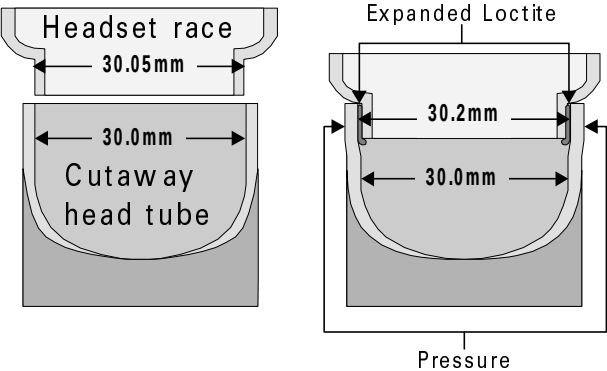
Proper installation of tapered-press fits simply involves pressing the part in hard enough so that it will hold. Preparation to install tapered-press fits includes an examination to determine that the length of engagement is acceptable and cleaning the mating surfaces, so that they will be free of lubricants, corrosion and dirt.

For more information and diagrams concerning tapered press fits see the section of this book regarding crank arms.

When press fits slip together with little or no effort, Loctite compounds may be used to improve the fit. If the fit requires only mild force to install, it will probably creak or slip under operating conditions, or moisture may penetrate and cause corrosion, then the use of Loctite RC680 would be appropriate in most cases. When installing sealed cartridge bearings (hubs, bottom brackets, and pedals) Loctite 242 is preferred, so that removal will not be too difficult. If a press-fit part slips right in with no effort, but does not jiggle about once installed, then Loctite RC680 is required in all cases except for sealed cartridge bearings. Sealed cartridge bearing installation requires Loctite 242, usually. If Loctite RC680 is used to improve a marginal press fit, the fit should be considered as good as new, except that removal and reinstallation would require re-application of Loctite. If the press-fit part is loose

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and jiggling after installation, it is best to find a better fitting part. If a better fitting part is not available, Loctite RC680 is recommended. Effectiveness may be limited by how loose the parts are initially, and the by fact that with press fitting there is no way to ensure proper alignment of the parts.



1.10 The headset race and headtube here do not have enough dimensional difference to create enough friction; when Loctite RC680 is added before installation, it expands and creates more pressure (and therefore more friction).

Loctite 660 (Quick Metal) is a thick paste that will provide security when the male part is up to 1mm smaller in diameter than the female part. No precision alignment of the parts is assured, but loose pieces that cannot be repaired in any other way may benefit from Quick Metal. A good example would be when the head tube on a Murray or Huffy juvenile bike becomes flared and the headset parts are loose and jiggling. Because these bikes use non-standard oversized headset dimensions, there are no practical alternatives for repair except the use of Loctite 660 (Quick Metal).

LUBRICANTS

GREASE

Not all greases are suitable for bicycle use. Bicycle bearings operate in a relatively low temperature range, so grease designed for automotive use often does not become effective at bicycle operating temperatures. Greases made specifically for bicycle use include Phil Wood, Bullshot, Var, Shimano, Finish Line, Pedros and Campagnolo. The best automotive grease is a light grade of Lubriplate.

Grease failure could come at any time. Factory original greases are often of the lowest quality, and also are applied in very limited or erratic quantities. Frames are often inadequately cleaned at the factory, so bottom-bracket and headset grease is often contaminated with abrasives even before the bike has been ridden. For these reasons it is difficult to project the normal time or miles between bearing overhauls. As a soft rule of thumb, 2000–3000 miles or two to three years of generally fair-weather riding should make a bike ready for an overhaul. The best method to determine whether grease is overdue for replacement is inspection. See table 1-2 below, for causes and evidence of grease failure.

The container and applicator of grease is as important as the quality. Open tubs invite contamination; application from open tubs is messy. Grease is best used in squeeze tubes or grease guns.

Whether greasing a thread, insertion, or bearing, an ample quantity of grease will reduce likelihood of drying and moisture contamination. Wipe excesses away when assembly is complete.

Grease should be treated like any other unnatural substance that can penetrate the skin. Minimize exposure or avoid it entirely by wearing disposable latex painter's gloves. Clean hands when exposure is over.

GREASE FAILURE (table 1-2)

Cause of grease failure	Evidence of grease failure
Age: This is one of the most likely reasons for grease to fail, particularly on bikes that see little use.	Lack of grease, grease absent from ball path, grease caked like half-dry mud.
Internal contamination: This other highly likely cause of grease failure is caused by particles worn from the bearing surfaces.	Light-colored greases turned dark, translucent greases turned darker and opaque.
Moisture contamination: This cause is only likely when the bike is ridden extensively in wet conditions.	Reddish rust color in grease, rust on bearing parts, water droplets in grease or bearing area. Colored greases turn a lighter shade.
Dirt contamination: This cause of grease failure is most likely if contaminated grease that has oozed out of the bearing is wiped off the wrong way.	Gritty feeling like sand in the grease, not the same as the rough feeling from a tight bearing.

OILS

Oil is used on threads, derailleur pivots, brake pivots, lever pivots, the chain, inside freewheels and inside internally-gearred multispeed hubs.

Not all oils are equally suitable for bicycle use. The oil needs to be resistant to accumulating grit, durable to exposure to the elements, and light enough to penetrate into tight areas. These characteristics outweigh the significance of any more technical considerations, such as the type of oil base or whether Teflon is part of the formula. Oils that are specifically suitable to bicycle use include:

- Phil Wood Tenacious Oil
- Triflow
- Bullshot
- Superlube
- Campagnolo
- Allsop
- Finish Line
- Pedros
- Lube Wax

The oils at the top of this list are generally more suited to use in wet conditions while oils that appear lower down on the list are more suitable for use in dry, dusty conditions.

Popular oils that are specifically unsuitable for most bicycle applications include:

- WD40
- Sewing machine or gun oil
- 3-in-1 oil
- Motor oil

Method of application is very important with oils. Aerosols are environmentally unfriendly and usually lead to excessive application. The only exception to the problem of excessive application is with spray lubricants that are designed to “dry” in a matter of minutes after application (such as Finish Line and Allsop oils), but these may be the worst offenders environmentally. In general, oils used in external applications should be used sparingly to avoid dripping and dirt accumulation, and excesses should always be wiped off immediately. Overall, the best form of application is from drip applicators. They are economical to use as well, because waste is limited.

In addition to their value as lubrication, oils are also used to facilitate disassembling frozen threaded components. Special penetrating oils perform this function best. Triflow, Allsop, and some other bicycle oils are somewhat effective for penetration.

Manufacturers of internally-gearred hubs recommend special oils that are generally unsuitable for use elsewhere on the bike. Sturmey Archer Cycle Oil is one of these, but a suitable replacement would be 10-weight motor oil.

CLEANSERS AND POLISHES

One of the cleansers needed for proper bicycle cleaning is an ammonia and water solution for cleaning dirt and removing greasy fingerprints. If using a household cleanser such as 409, Fantastik, or Top Job, they will leave a soapy film that will need rinsing. Window-cleaning compounds clean as well and do not leave a film behind.

For cleaning bearings, drive train components and any other heavily greased or oily components, choose between either mineral spirits or non-toxic biodegradable solvents (such as citrus-based solvents.) These are the environmentally correct alternative to gasoline and kerosene. If using mineral spirits, avoid excess contact with skin, eyes, and fumes by wearing rubber gloves, safety goggles, and by working in a well ventilated area. Mineral spirits and citrus-based solvents leave an oily film and are not suitable as a last preparation before assembling a press fit. Drying time (of mineral spirits or biodegradable solvents) in confined areas such as inside chains, freewheels, derailleur and brake pivots, is quite slow and generally is aided by blowing with compressed air. If using a biodegradable solvent, remember that once it is contaminated with oil or grease it is no longer environmentally friendly.

For certain uses, a more heavy duty solvent (such as acetone) is needed. Use acetone or rubbing alcohol when an oil-free surface is required (press fits, braking surfaces). Use acetone on extremely stubborn dry grease. Both acetone and alcohol are highly flammable and volatile, so do not use them around flames or high heat sources (no smoking). Avoid skin and eye exposure, and keep fumes to a minimum by disposing of soaked rags promptly in a fire-safe self-closing metal bucket. Alcohol is far more environmentally friendly than acetone. There are no biodegradable-type solvents that perform the same function as these two compounds.

Wax or polish is used to improve the appearance of paint jobs and to protect them. Most automotive waxes are suitable for bicycles. Wax should be applied to clean surfaces with light rubbing. After it dries it should be wiped off with a soft cloth. Check the label of any automotive product before using it on the painted surface of a bicycle. Test products of uncertain suitability on the bottom of the bottom-bracket shell.

TOOLS

This section covers the proper use of common tools that are not unique to bicycle mechanics. This section also covers the use of the bicycle repair stand. There is a comprehensive list of common tools and bicycle specific tools in the appendix. The types of tools and concepts covered in this section are as follows:

- Box- and open-end wrenches
- Ratchet drives and sockets
- Torque and torque wrenches
- Adjustable wrenches
- Pliers and vise grips
- Screwdrivers
- Utilizing mechanical advantage
- Hammers
- Hacksaws
- Files
- Grinder
- Drilling
- Taps
- Using repair stands

BOX-AND OPEN-END WRENCHES

Always use the smallest wrench that will fit. A 16mm cone wrench seems to fit on a hub cone with 15mm flats, but a 15mm wrench is the smallest that will fit. It may be possible to turn a 15mm cone with a 16mm wrench, but it is likely to damage the nut and the wrench.

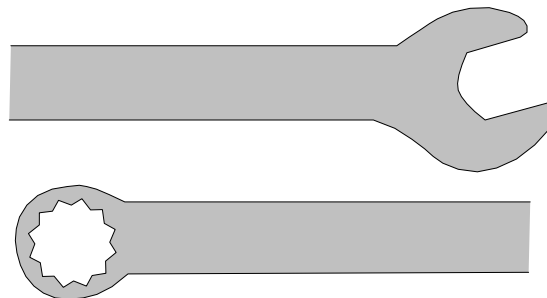
Box- and open-end wrenches are non-adjustable wrenches that are made in specific sizes that are supposed to closely match the fittings they will be used on. They come in inch and metric sizes. Metric sizes are most common for bicycles. Certain inch and metric sizes are interchangeable in one direction only (because the substitute is only slightly over-sized). These are:

- 13mm wrench on 1/2" fitting
- 14mm wrench on 9/16" fitting
- 16mm wrench on 5/8" fitting

Open-end wrenches contact the fitting at only two points, making them inclined to round off nuts, especially if they are held in poor alignment to the fitting. Their advantage is access from the side of the fitting when access from the end is difficult. They also generally allow a more flush fit against surfaces adjacent to the fitting, so are well suited to low-profile nuts and bolt heads.

Box-end wrenches enclose the fitting and contact it at six points, reducing the likelihood of rounding the fitting under heavy load or poor alignment and

fit. Their limitation is with low-profile fittings, or fittings with no access from the end. Box-end wrenches come in six-point and twelve-point configurations. The six-point configuration is more durable and has better purchase (surface engagement), but twelve-point wrenches are quicker to get positioned on the fitting.

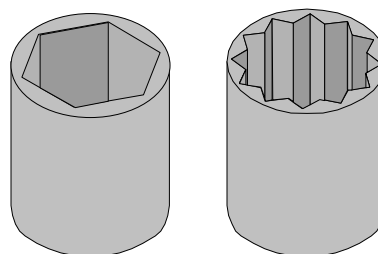


1.11 Open-end wrench on top, box-end wrench below.

RATCHET DRIVES AND SOCKETS

Ratchet drives enable working faster because they do not require removal of the wrench on the return stroke. Good applications of a socket and ratchet drive include crank-arm bolts, brake-mounting nuts, axle nuts, and seat-post binder nuts.

Socket wrenches (which can be fitted to a ratchet drive, torque wrench, or socket driver, or may come prefixed on certain spanners) are similar in their advantages to box-end wrenches, but even more useful when there is limited or no side access to the fitting, such as with crank-arm-mounting bolts.



1.12 Six-point socket (left) and twelve-point socket (right).

TORQUE AND TORQUE WRENCHES

Torque is a measurement of a force's tendency to produce torsion and rotation about an axis, used most often in bicycle mechanics to describe the tightness of

a threaded fitting. It is measured most often in ft-lbs (foot pounds), in-lbs (inch pounds), and kgf-cm (kilograms of force per centimeter).

A torque of 1ft-lb is a pound of force on a lever one foot long. If the lever were six inches long, it would require two pounds of pressure to apply 1 ft-lb of torque. A torque of 1in-lb is one pound of force on a one inch long lever. If the lever was six inches long it would require two pounds of force to apply 12in-lbs of torque ($12\text{in-lbs} \div 6" = 2\text{lbs}$).

All the torques in this book are in in-lbs. For some of the larger values a torque wrench calibrated in ft-lbs will be needed. It will be necessary to convert. At other times, it will be necessary to convert manufacturers' recommended torques in ft-lbs to in-lbs to use an in-lb wrench. Use the following formulas.

$$\text{in-lbs} \div 12 = \text{ft-lbs}$$

$$\text{ft-lbs} \times 12 = \text{in-lbs}$$

Sometimes manufacturers provide recommended torques in kgf-cm, which are found on very few torque wrenches. In this case, convert kgf-cm to in-lbs or ft-lbs. Use the following formulas.

$$\text{kgf-cm} \div 1.2 = \text{in-lbs}$$

$$\text{kgf-cm} \div 13.8 = \text{ft-lbs}$$

These two formulas contain generously rounded conversion factors for ease of calculation. They should be accurate enough for the precision required in bicycle mechanics.

Torque wrenches are tools used to measure torque while tightening a fitting. They come in two varieties. The torque beam variety has a bar that swings across a scale as force is applied. Its advantage is that it is easy to know when calibration is needed and they are easy to calibrate. If the needle fails to return to "0", bend the bar until it points to "0". The preset type has a cylinder that is twisted until the desired torque is set. The head will swivel when that setting is achieved. The preset torque wrench is difficult to calibrate, but has an advantage in that it may be available with a ratcheting drive. It is difficult to know when the preset type is out of calibration (other than experiencing mechanical failures), and it must be sent back to the supplier/manufacturer for calibration.

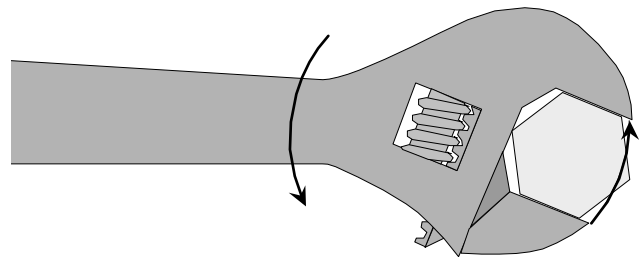
Using torque wrenches is strongly recommended. All mechanics have trouble torquing things correctly by feel. Unfortunately, we learn torque from the negative feedback of numerous failures. All mechanics can benefit from the use of a torque wrench. When a mechanic's feel is off either the part fails (stripped threads or bolt head) as it is tightened or it comes apart while riding the bike.

In many cases the design of a fitting does not allow the use of a socket that fits on a torque wrench. For this reason I have invented a new unit of measure that will be used in this book. After many in-lb notations there will be another notation in parenthesis (the new unit that describe torque). This second notation is the amount of load to place on the end of a common tool to achieve the correct torque. For example, the torque for a hub locknut might be shown as 180in-lbs (45lbs@4"). The notation (45lbs@4") means apply 45 pounds of force at a leverage length of 4 inches. The leverage length will be based on the common tool length used for the job. If there is a wide range of tool lengths commonly used for doing a job, then the leverage length will be based on one of the shorter tools available. If the tool is longer, either recalculate the load or "choke up" on the lever to the stated length.

Even while use torque wrenches, it will be necessary to rely on feel for certain items. The best way to develop the correct feel for those items that a torque wrench cannot be used for, is to feel the torqued item with a regular wrench after *every* time a torque wrench has been used. Since the recommended torques in this book are never the absolute maximum that a fitting can withstand, it is easy to check for the correct feel by advancing the regular wrench no more than a few degrees past the point reached by the torque wrench.

ADJUSTABLE WRENCHES

Adjustable wrenches should be used only when no pre-fit wrench is suitable or available. Always make sure that the adjustable wrench is well snugged before applying force. Position the wrench so that when the wrench rotates, the tip of the adjustable jaw follows the tip of the fixed jaw through the rotation. Rotating the adjustable wrench in this direction is critical because experience shows that the adjustable jaw is less likely to break.



1.13 Direction to apply force with an adjustable wrench.

1 – BASIC MECHANICAL SKILLS

PLIERS AND VISE GRIPS

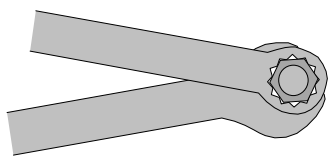
Pliers are used for grasping and holding, not for turning nuts and bolts unless the flats are already distorted so that a pre-fit or adjustable wrench cannot be used. Vise grips are locking pliers that have a much stronger grasp than regular pliers. They are used to hold things firmly, such as when using the grinder on small pieces, and may be used on nuts and bolts when the wrench flats are already destroyed.

SCREWDRIVERS

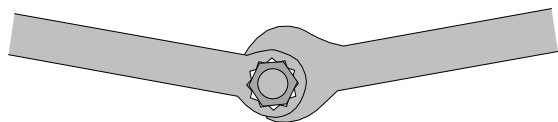
Always use the largest screwdriver that will insert fully into the slot of the screw. This applies equally to slotted screwdrivers and Phillips screwdrivers. Maintain the axis of the screwdriver in line with the axis of the screw.

MECHANICAL ADVANTAGE

With two opposing levers, the shortest lever determines the limit of force that can be applied. Increased mechanical advantage can be achieved by lengthening leverage (by using a longer tool or adding a cheater bar to a tool). Increased mechanical advantage can also be achieved by changing the angle between opposing levers. The worst mechanical advantage is with levers 180° apart, and the best is when the levers are close to 0° apart (allowing clearance for hands and tools).



1.14 Two wrenches arranged for good mechanical advantage.



1.15 Two wrenches arranged for poor mechanical advantage.

Increased mechanical advantage on a screwdriver can be achieved by wrapping the handle with a rag to increase the diameter. Apply increased force into the screw to prevent the slot from stripping. The tendency, when a screw head is about to strip out, is for the screwdriver to rise up out of the screw head. By pressing firmly down on the screwdriver, it will be kept fully engaged with the screw head. This reduces the chance of the stripping occurring because more material engages the tip of the screwdriver.

HAMMERS

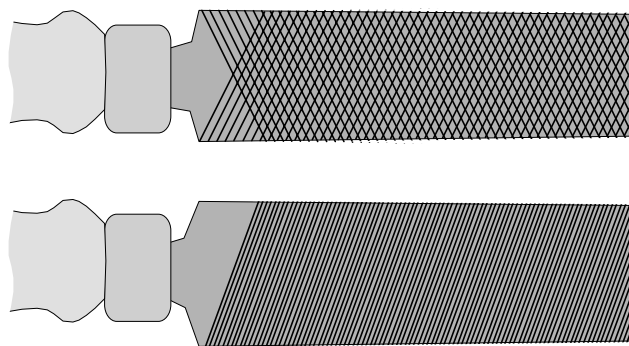
Hammers are used to apply force when removing press-fit items, and to install pressed items when there is no specialized tool. Before using a metal hammer, always try a soft hammer first. Soft hammers are usually made of plastic or rubber. When using a metal hammer, it should be a 12 ounce ball peen, not a claw hammer. Claw hammers have the wrong weight, balance and head shape. Wear eye protection when using a metal hammer to hit anything metal.

HACKSAWS

Hacksaws are generally used for cutting fork columns (steerer tubes) to length, removing locks and chains with lost combinations and keys, and shortening bolts and axles that are too long. For most uses, a blade of 32 teeth per inch is sufficient. Install toothed blades with the teeth pointing away from the handle and apply force on the pushing stroke. Cutting with a hacksaw generates a lot of heat, so be careful when touching items that have just been cut. Metal fragments created by hacksawing can easily get in your eye, so always wear eye protection. Hacksaw blades wear out easily. Replace them regularly.

FILES

Files are used for smoothing a metal surface, particularly after using a hacksaw or grinder, and they are used to alter the fit of parts that are too large. Flat files should be 10–12" long and come in two different cuts: bastard and mill-bastard. Bastard files are coarse files with a crisscross cut that are used for removing large amounts of metal quickly. They often leave a rough finish. Mill-bastard files have a finer cut with no crisscross and are used when little material is to be removed. They leave a smoother finish than the bastard file.



1.16 Bastard file (top) and mill bastard file (bottom).

Round files, or rat-tail files, also come in both cuts, and are used for cleaning inside tubing or inside a hole, particularly after cutting a fork steerer tube. For coarse work, use a 10–12" bastard cut. For fine work, use a chainsaw file or jeweler's file. A small triangular file is used for precision inside corners.

With all files, the power stroke is on the push. Applying pressure on the return stroke dulls the file. Files may be used on all types of metal. Wear eye protection when filing. A file card (a special wire brush) is used to clean filings from between the teeth of the file when the build-up reduces the effectiveness of the file.

GRINDER

The grinder is used when a file would be too time consuming, and when there is less need for precision. Only steel can be ground on the grinder; *do not grind aluminum*. Grinding aluminum causes the aluminum to melt, filling the pores of the grinding wheel with aluminum, which renders the wheel useless. Wear eye protection at all times with the grinder. Hold small objects firmly with a vise grip to prevent them from being wrenched from your hand. Reduce heat build-up (which occurs very rapidly with no visible change in the metal) by grinding with little pressure, frequent rests and periodic dips in a water bath to cool the item. *Never* apply pressure to the side of a grinding wheel—it will break. When using a new wheel, give it a hand spin before turning it on to make sure it does not wobble side-to-side, which could cause it to shatter at high speeds. If the grinder loses its flat edge, or becomes clogged with aluminum, it can be improved with a tool called a grinding wheel dresser, which is simply held against the grinding wheel while it is spinning.

DRILLING

Drilling some steels used in bicycle frames and components require the highest grade bits available. These will generally be described as “carbide.”

For accuracy, start the hole by making a prick mark with a center punch.

Heat generated by drilling hardens the material being drilled, which dulls the bit and lengthens the job. To prevent heat build-up, drill holes in stages, use moderate speed and pressure, and always use cutting oil. Drill larger holes by starting with a smaller bit first. For example, a 6mm hole might be drilled with a 2mm bit followed by a 4mm bit, and then finally a

6mm bit. This is called drilling in “stages.” Moderate the speed and pressure. A variable-speed drill is recommended. Surprisingly, a lower speed will often allow faster progress. Cutting oil should be flooded into the hole regularly because it not only lubricates, but it also cools the metal being drilled, and only a continuous flow of cool oil will accomplish this.

Most jobs will require metric drills. Half millimeter increments from 1mm through 9.5mm should be adequate, with an additional 4.2mm bit for drilling a hole for a 5mm tap.

Drill bits dull quickly. Although it is possible to sharpen them, it is an advanced technique, and it is more economical to simply replace them.

TAPS

When using a tap in existing threads, first verify it is the correct diameter and pitch to match the existing thread. When tapping in a hole without existing threads, first verify the hole is the correct diameter to accept the tap.

Taps break easily and then are almost impossible to remove, so the following precautions should always be observed. Always flood the hole with cutting oil. Repeated application of fresh cutting oil keeps the material that is being tapped cool and keeps it from hardening. When tapping existing threads, always tap from the end of the hole that has the threads in best condition to ensure good alignment. Never force a tap—it will break. When the cutting gets tough, advance the tap no more than one-quarter turn further, then back it out about one-half turn. Turn the tap in again until it gets tough again, and repeat the process. This procedure clears the cuttings away from the cutting edge of the tap so it does not jam.

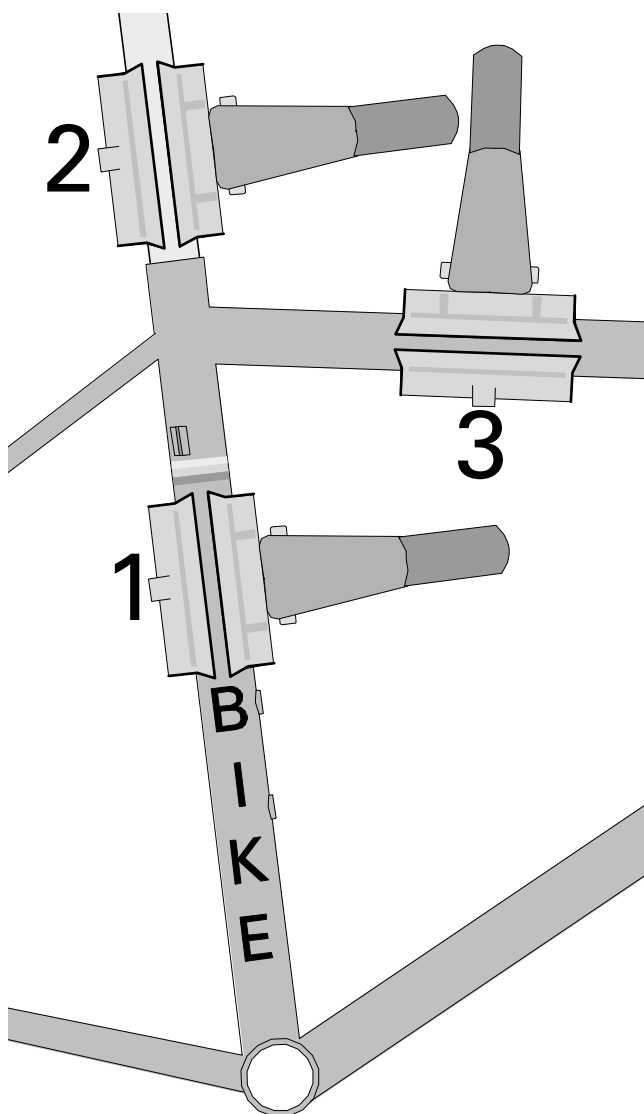
General-purpose cutting oil is suitable for tapping in steel, but specifically formulated cutting oil should be used when tapping aluminum, or total thread failure may occur.

Tapping aluminum is much more difficult than tapping steel, and requires more care. Make sure the tap starts cleanly in existing threads because it is easy to start the thread in a new spot, which creates a double thread, which is much weaker. Dull taps are far more likely to tear through, rather than cut through, aluminum. This is called galling. To prevent galling, never use a dull tap, especially on aluminum.

1 – BASIC MECHANICAL SKILLS

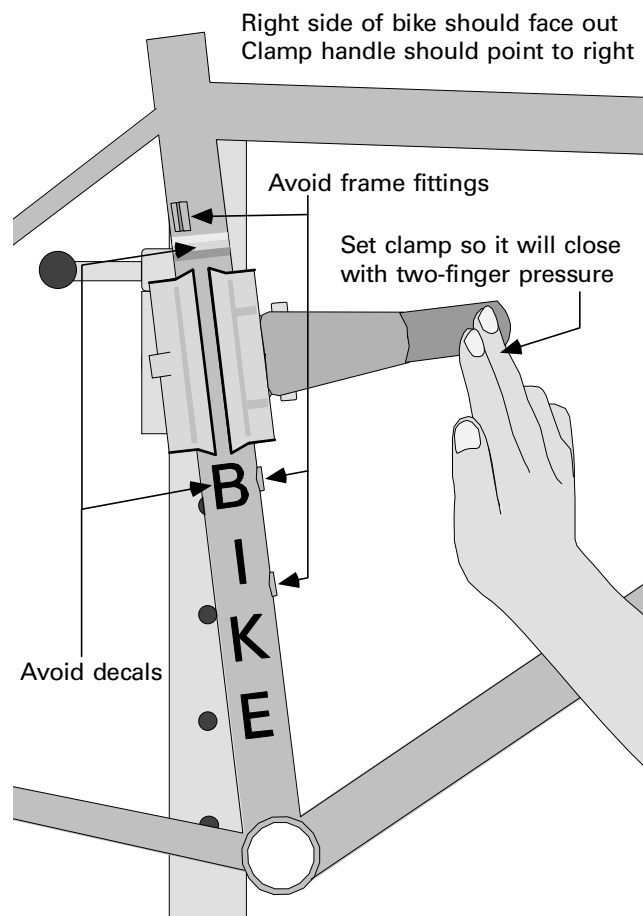
USING REPAIR STANDS

Depending on the clamp used and obstacles on the frame tubes, the clamp should be placed (in descending order of priority): onto the seat tube, the seat post, or the top tube. The clamp should never be placed on top of decals that are not under a clear coat of paint, braze-on fittings, or cables or housings. When possible, clamp onto the portion of the seat tube that is supported by the insertion of the seat post. Always set the clamp for the minimum force required to securely hold the frame in place; this helps prevent crushing a frame tube.



1.17 These are the three positions that the Park stand clamp can be clamped in. The positions are numbered in order of preference.

Place the bike in the stand so that the right side faces away from the stand with the bike in an upright position. With Park brand stands, position the clamp with the handle on the right (as you face the stand) before attaching the bike. Using a Park stand this way allows the handle to be accessed through the main triangle. Once the bike is correctly mounted, use all the adjustments built into the stand to put the bike in a convenient position. Avoid decals and braze-ons when placing the clamp on the tube.



1.18 This bike is properly positioned in a Park stand.

2—TAPPING BOTTOM-BRACKET-SHELL THREADS

ABOUT THIS CHAPTER

This section is about using bottom-bracket taps to improve the thread condition in a bottom-bracket shell.

GENERAL INFORMATION

TERMINOLOGY

Bottom-bracket shell: The part of the frame that houses the bearings that the crank arms rotate around.

Bottom-bracket tap: A tool used to chase the existing threads in a bottom-bracket shell.

Chasing: Using a tap to improve the condition of existing threads.

Tapping: In the broad sense, tapping is creating new threads. With regard to bottom brackets, the term “tapping” is used to signify the improvement of the condition of existing threads (chasing).

Pilot: A part of a bottom-bracket tap that is used to align the left and right taps to each other so that they will cut on a common axis. A pilot consists of a pilot shaft and a pilot hole.

PREREQUISITES

Usually the need for tapping the bottom-bracket shell is discovered in the course of doing another job, such as installing or overhauling a bottom bracket. In this case the condition of a bare bottom-bracket shell already exists, and the only prerequisite required for the job is an understanding of bottom-bracket thread types and directions. The additional prerequisites listed are only applicable in the case that it is your intent to tap the bottom-bracket threads before you have removed the bottom bracket.

Understanding bottom-bracket-thread types

There are several types of bottom-bracket threads. Bottom-bracket taps are not used to change from one thread type to another but to improve the condition of existing threads. For this reason it is vital to be sure of the existing thread type in the bottom-bracket shell. The following bottom-bracket-tapping procedure will provide an opportunity to

identify the threads. For reference information on bottom-bracket thread types, see the **ADJUSTABLE-CUP BOTTOM BRACKETS** chapter (page 9-5).

Crank-arm removal and installation

In order to tap the bottom-bracket shell it will be necessary to remove the bottom bracket, which starts with crank-arm removal. At the completion of the job it will be necessary to reinstall the crank arms.

Bottom-bracket overhaul

In order to access the threads it will be necessary to remove the bottom bracket. At the completion of the job it will be necessary to install and adjust the bottom bracket. These procedures are covered in the chapter **ADJUSTABLE-CUP BOTTOM BRACKETS**.

INDICATIONS

Symptoms indicating need for tapping bottom-bracket-shell threads

The usual reason for tapping bottom-bracket threads is the resistance encountered when removing or installing the bottom-bracket cups or cartridge bottom-bracket mounting rings. This resistance can be caused by several things. New bikes often have poorly cut bottom-bracket-shell threads, or good threads that are fouled with paint. Used bikes often have rust in the threads. Another possible cause of the resistance could be that a cup or mounting ring has been cross-threaded.

This resistance to unthreading is aggravating to the mechanic during the removal of parts; however, during installation of parts, this extra resistance will not just be aggravating, it can cause three problems.

The first problem that this extra resistance can cause is that it can make it difficult to tell whether the thread is starting correctly, possibly leading to cross-threading and further thread damage.

The second problem that this extra resistance can cause is when attempting to adjust an adjustable-cup bottom bracket, difficulty in rotating the adjustable cup can make it almost impossible to find a good starting point for the adjustment, leading to a prolonged and more difficult adjustment procedure.

2 – TAPPING BOTTOM-BRACKET-SHELL THREADS

The third problem that might be encountered when this type of resistance is being experienced is that poor thread condition can lead to failure of the threads on aluminum and plastic cups, or aluminum and plastic mounting rings. This failure may occur during installation or removal. If the factory installed an aluminum or plastic part into a poorly threaded shell, then the failure may occur while the parts are being removed. Nothing can be done to prevent this, but tapping should be done to prevent future failures.

Preparation for shell facing

The only other reason to tap the bottom-bracket-shell threads is that it is a necessary first step to facing the bottom-bracket shell; the reasons for facing a bottom-bracket shell are given later in this chapter.

TOOL CHOICES

The thread type of the bottom-bracket shell determines what tool you will need. The following list covers all tools for the job. The preferred choices are in **bold**. A tool is preferred because of ease of use, quality, versatility, and/or economy. See table 2-1.

TIME AND DIFFICULTY

Tapping a bottom bracket in a bare frame is a 10 minute job of moderate difficulty.

COMPLICATIONS

Titanium

Titanium has completely different metallurgical characteristics than steel or aluminum. It is necessary for a tap to be designed in a dramatically different way to be suitable for tapping titanium. Once a

tap has been designed to be suitable for titanium, it will no longer be suitable for other materials. Special taps for titanium are available, but the cost is prohibitive. Since titanium is not generally painted and does not rust, difficulty in threading parts in would most likely be due to poor manufacture and should be warrantable.

Aluminum

Aluminum is a perfectly suitable material for tapping, but presents some special concerns to the mechanic. First, *the type of cutting oil used is critical*. There are cutting oils made specifically for use on aluminum. Any cutting oil suitable for use on aluminum will say so on the container. Do not interpret words like “all-purpose” and “multi-purpose” to mean: includes aluminum. Second, *it is critical that the taps be sharp*. Aluminum has a higher tendency than steel to gall (tear). Dull taps increase the likelihood of galling, to a degree that the threads in the bottom-bracket shell may be destroyed.

Threads destroyed beyond repair

The most likely complication when tapping a bottom-bracket shell is that threads may be damaged beyond repair. Since the next solution after thread chasing is a drastic one, always attempt the repair by chasing first and test for success by torquing the bottom-bracket cups or retaining rings into the shell to the recommended torque and see if further stripping occurs. If the recommended torque cannot be achieved, the threads have stripped completely.

BOTTOM-BRACKET-TAPPING TOOLS (table 2-1)

Tool	Fits and considerations
Campagnolo 721	Piloted handles w/ 1.37" × 24tpi BSC/ISO taps , very expensive
Campagnolo 721/5-I	Italian 36mm × 24tpi tap only for 721, two needed
Campagnolo 721/5-F	French 35mm × 1mm tap only for 721, two needed
Cyclo 1042	1.37" × 24tpi double ended un-piloted chaser only
Hozan C402E	1.37" × 24 tpi un-piloted tap set
Hozan C402FS	Un-piloted tap set fits French and Swiss
Park BTS-1	Piloted tap handles w/ 1.37" × 24tpi BSC/ISO taps, includes facer also
Park 693	36mm × 24tpi Italian tap for BTS-1, two needed
Park 694	35mm × 1mm French tap for BTS-1, two needed
VAR 380/2/C	Piloted tap handle set w/ 1.37" × 24tpi BSC/ISO taps
VAR 42IR	36mm × 24tpi Italian tap for 380/2/C, two needed
VAR 42FR	35mm × 1mm French tap for 380/2/C, two needed

Unusual thread types

Only one brand of bottom-bracket tap (VAR) makes taps available for every conventional thread type. If you do not buy this brand you will not be able to tap all bikes. You should not buy this brand just to be able to tap all thread types, because several thread types are very rare and it could be financially unrewarding to buy the tools to tap these threads. About 95% of bikes have BSC or ISO thread type, which are interchangeable. Most of the remaining 5% are Italian thread. This is as far as it may be practical to be equipped with taps. Other thread types are French, Swiss, and English Whitworth (1-3/8" × 26tpi). These are all no longer manufactured, already rare, and getting rarer fast.

Obstructions

It is possible that there will be obstructions inside a bottom-bracket shell that will interfere with the insertion of the taps. The most likely obstruction is a bolt or fastener (rivet) that holds a cable guide to the bottom of the bottom-bracket shell. If it is a bolt, remove it. If the obstruction is some sort of pressed-in device or rivet, then it is possible that the pressed-in device or rivet will be destroyed if removed. If this happens it may be necessary to do some creative mechanics to re-secure the cable guide.

Another possible obstruction is frame tubes protruding into the shell. This type of obstruction occurs most commonly with lugged frame construction. Use a round file or a small grinding stone on a rotary tool or die grinder to remove this type of obstruction.

Difficult tapping

Difficult tapping may be caused by dull taps, excessive material needing to be removed, poor technique, or brass contamination in the threads. Brass has special properties that cause it to create a lot of resistance when being tapped. If brass is present on the bottom-bracket threads it means that the manufacturer was sloppy during the brazing process.

The most important things to be conscious of when tapping is difficult are *100% assurance of thread compatibility and good technique*. If tapping becomes difficult, then pull the taps out immediately and check for obstructions and brass in the threads. If these are not a problem, assume the taps are dull and do not continue without sharp taps.

CARE OF BOTTOM-BRACKET TAPS

Bottom-bracket taps are very expensive and easily damaged. Proper cutting technique is important to ensure good life, but that is not all. When storing taps, make sure they are clean and coated with oil. The cutting edges are easily chipped by light impact with other metal objects, so handle and store them in a way so this will not happen. On hooks on a peg-board is a good way to store taps.

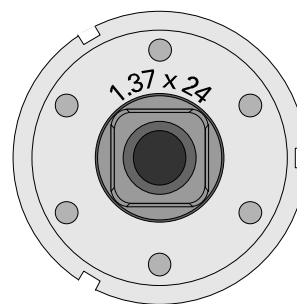
Clean taps with a brush and solvent. Blowing them clean with compressed air is not damaging to the taps, but it is dangerous. Coat the taps with a light oil after cleaning and drying to prevent rust.

Using taps on chrome-plated bottom-bracket shells will also dull them quickly. It can be done but it is not advised.

Using taps to cut new threads in an unthreaded shell, or to extend the length of existing threads will also dull them quickly. These procedures can be done, but they are not what the taps are designed for and are strongly recommended against.

BOTTOM-BRACKET-TAPPING PROCEDURE

1. [] See **TAPER-FIT CRANKARMS** chapter for removal of crankarms and **ADJUSTABLE-CUP BOTTOM BRACKETS** chapter for removal of bottom brackets, and remove crank arms and bottom bracket if necessary.
2. [] Inspect any cups or mounting rings that were removed for thread identification and note thread description here: _____, unless markings are inadequate.



2.1 Inspect cup faces for any markings that might indicate the thread type. The 1.37 × 24 marks on this cup indicate it is a BSC thread.

3. [] Only if cup markings were inadequate measure cup O.D. and pitch, then use table 9-2 (page 9-5) to determine nominal thread description and note here: _____.

2 – TAPPING BOTTOM-BRACKET-SHELL THREADS

Bottom-bracket-shell threads are identified by taking measurements in the bottom-bracket shell; however it is only necessary to do this if steps #1, #2, and #3 do not yield positive results. Usually all that is needed is inside diameter and pitch. In the case that the pitch is 1mm and you are prepared to tap French or Swiss bottom brackets, then you must be able to identify whether the threads in the right side of the shell or left-hand or right-hand. The technique for this is described in the **BASIC MECHANICAL SKILLS** chapter in the section called **THREADS** (page 1-4).

4. [] If no cups were removed from bottom bracket, measure shell I.D. and pitch inside shell, then use table 9-2 (page 9-5) to determine nominal thread description and note here: _____.

The next step is to check whether the correct thread type is on the tap handles. With Campagnolo and Park taps this is a simple matter of looking at the base of the tap (Campagnolo) or in the flutes between the lands (Park) for the thread description of the tap (see figure 2.2). Certain VAR taps may have either of two complications. VAR taps frequently have the thread description on the end of the tap where the description becomes hidden when the tap is installed. If this is the case, buy an engraving tool and write the thread description in the flutes between the lands. The other complication is that VAR is inclined to describe BSC or ISO thread types in an unconventional fashion with the diameter shown in millimeters instead of inches. If a VAR tap is marked 34.85×24 , it is suitable for a BSC (1.37×24) or ISO (1.375×24) threaded bottom bracket.

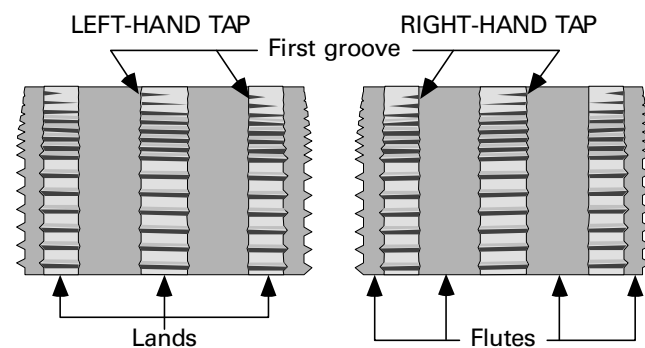
5. [] Verify that taps on tap handles are correct thread (replace with correct thread if not).

Campagnolo and VAR taps use a threaded retaining device to hold the tap on the handle. If the retaining device is loose it will compromise the precision of the tapping. Use a headset locking spanner to secure the taps on the Campagnolo tool and a large adjustable wrench to secure the nuts on a VAR tool.

6. [] Secure both tap retention nuts (skip if using Park tool).

If you are using a BSC, ISO, or Swiss tap set, the next step is to identify which tap is a left-hand thread and which is a right-hand thread. If the taps are the Campagnolo or the Park brand, there will be a RH or LH notation as part of the thread description marked on the tap. If you cannot find such a notation, or your taps are VAR (which are not marked), then use the following technique.

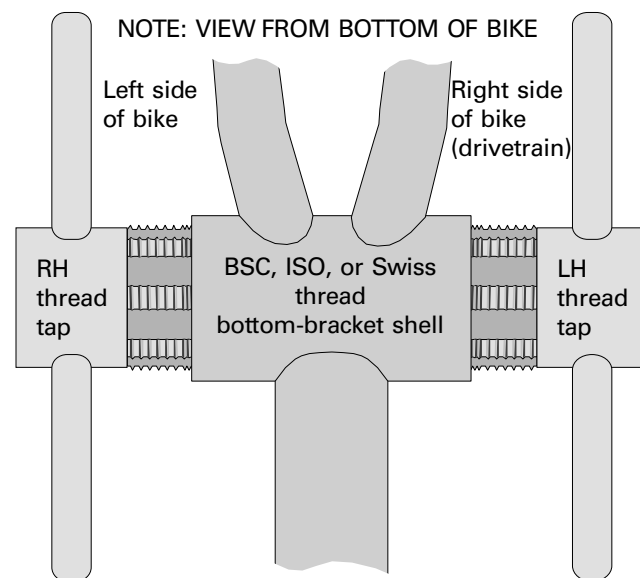
To identify whether an unmarked tap is a right-hand or left-hand thread, hold the tap so the leading end points up. Examine the top groove in any one of the lands. If the top groove is deep on the left and tapers off to the right, the tap is left-hand thread. If it is deep on the right and tapers off to the left, it is a right-hand thread. See figure 2.2.



2.2 Inspect which side of the lands the first grooves start on to determine whether the tap is left-hand or right-hand thread.

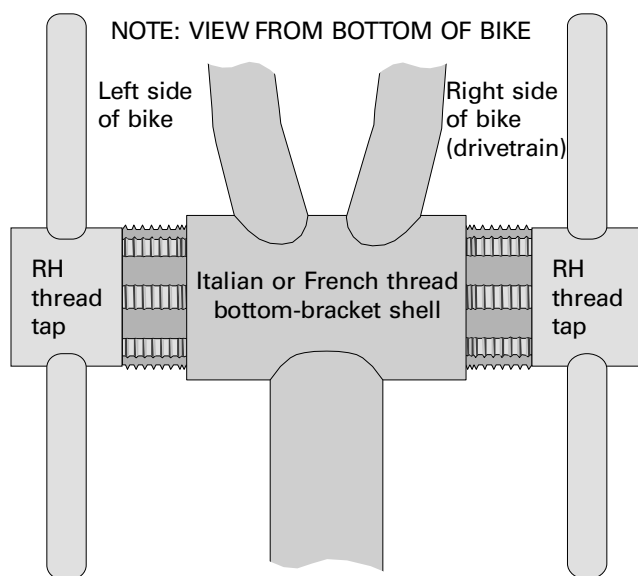
7. [] Identify which tap is left-hand thread and which is right-hand thread.

If tapping an ISO, BSC, or Swiss threaded bottom bracket, it is vitally important to get the correct taps on the correct sides of the bottom-bracket shell. All others have double right-hand thread, so the taps cannot be put in wrong. With ISO, BSC, and Swiss thread types the right side of the shell is a left-hand thread. The right side of the shell is right from the rider's viewpoint while riding the bike. It is the side that the chainrings, chain, and derailleurs go on.



2.3 If installing taps in a BSC, ISO, or Swiss-threaded bottom-bracket shell, the left-hand tap goes in the right (drivetrain) side of the bike, and the right-hand tap goes in the left side of the bike.

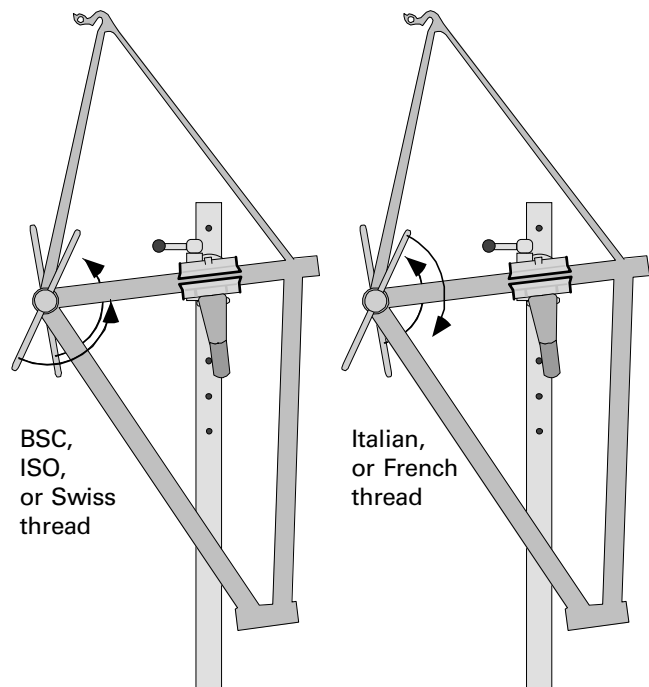
2 – TAPPING BOTTOM-BRACKET-SHELL THREADS



2.4 If installing taps in an Italian or French-threaded bottom-bracket shell, since both taps are right-hand thread, side of installation does not matter.

- 8. [] Place left-hand threaded tap (right-handed threaded if both taps are right-hand) in right side of the bottom-bracket shell, and place the other tap into left side of shell.**

The whole point to using a piloted tap set is to guarantee that threads on both sides of the shell have a common axis. For this reason in the next step the taps are started simultaneously. *Do not start one tap, and then start the other.*



2.5 To start the taps simultaneously, turn them in the directions shown.

- 9. [] Start both taps simultaneously so that they just engage shell threads.**

One of the most important things when cutting metal is the proper use of cutting oil. If cutting steel, the type of oil is not important (high speed or low speed), but if cutting aluminum it is critical to use oil labeled specifically for use on aluminum.

In addition to using the right oil, it is important to use enough of it. Cutting oil does not simply lubricate. One of its most important functions is to absorb heat generated by the cutting of the metal. If the heat builds up, the metal being cut gets harder. Tools dull quicker, and the quality of the threads will be compromised. By using ample quantities of cutting oil and re-applying it repeatedly, heat will be kept to a minimum. There should be a substantial quantity of oil on the floor when done if enough was used. Use a drip rag if you are concerned about this mess.

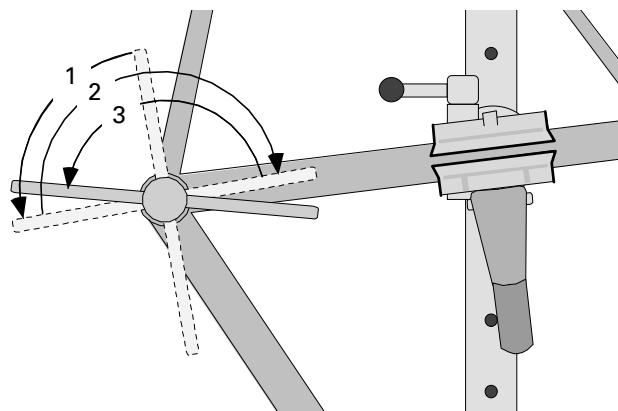
- 10. [] Add generous amounts of appropriate type of cutting oil to both taps.**

Sometimes all the threads in the shell will need chasing and sometimes just some of them will. As long as there is no significant resistance to threading the tap in, then no cutting is happening and no special technique is required to advance the tap. *No significant resistance is defined as when you can thread the tap in with one finger!*

- 11. [] Thread each tap in as far as it will go without encountering significant resistance.**

Once significant resistance is encountered then cutting has begun and a technique called cut-and-clear is needed to advance the tap.

To cut-and-clear with the tap, advance it approximately one quarter turn once resistance indicates the tap has begun to cut. Then back the tap out about one half turn to clear the cut fragments away from the leading edges of the cutters. Finally, advance the tap one half turn to be in position to start the cycle again.



2.6 The cut-and-clear technique: cut (1), clear (2), then advance (3).

2 – TAPPING BOTTOM-BRACKET-SHELL THREADS

- 12. [] Once resistance is encountered use cut-and-clear technique to advance each tap, repeatedly flooding each tap with cutting oil (about every 2–3 full revolutions of tap).**

Depending on several circumstances, the point at which the tapping is complete varies. With all types of taps, the objective is to clean all of the threads. When the last thread has been reached, it will feel as though the tap has “hit-the-wall” (extremely high resistance to further tapping). If Park-brand taps are being used, and the bottom-bracket shell is to be faced with a Park BTS-1 facing tool, then the taps must end up fully inside the bottom-bracket shell. Due to the short length of the Park taps, this objective should always be easy to achieve. If a Campagnolo 725 bottom-bracket-facing tool is to be used, then the criteria is that a thread depth of 17mm must be achieved. Since every tap has 5–7mm of taper at the leading end, this means that 22–24mm of tap must end up inside the shell. This objective may be difficult to achieve, because the 17mm of threading is more than most bottom-bracket cups require and, consequently, more threading than exists in many bottom-bracket shells. To achieve this 17mm thread depth in some cases, new threads must be cut. You must go past the point the taps “hit-the-wall.” This will require considerable effort on your part, and will be hard on the taps as well.

- 13. [] Continue cut-and-clear technique and repeated flooding with cutting oil with each tap until both taps have reached the last existing thread.**

NOTE: In order to face the bottom-bracket shell with a VAR tap set modified for facing, proceed at this point to MODIFIED VAR 380/2/C FACING PROCEDURE (page 3-5).

NOTE: In order to face bottom-bracket shell with a Park BTS-1, proceed at this point to PARK BTS-1 FACING PROCEDURE (page 3-4).

- 14. [] If taps are unevenly engaged, unthread one until taps are evenly engaged.**
- 15. [] Unthread both taps simultaneously until they both will pull out, then pull taps out of bottom-bracket shell together.**
- 16. [] Clean bottom-bracket threads with tooth-brush and solvent.**
- 17. [] Clean outside of bottom-bracket shell and rest of frame as necessary.**
- 18. [] Clean bottom-bracket taps.**
- 19. [] Use appropriate procedures/worksheets to install bottom bracket and crank arms as necessary, unless shell facing will be done next.**

3 – FACING THE BOTTOM-BRACKET SHELL

ABOUT THIS CHAPTER

This chapter is about a milling procedure (called *facing*) that is done to bottom-bracket shells. Facing the bottom-bracket shell improves the alignment of the bearing parts that are installed in the bottom-bracket shell. Improving the alignment of the bearing parts improves the quality of the adjustment and the longevity of the parts.

After the **GENERAL INFORMATION** section, there are separate sections for using three different types of bottom-bracket shell facing tool systems. These sections are:

PARK BTS-1 FACING PROCEDURE
MODIFIED VAR 3802/2/C FACING PROCEDURE
PARK BFS-1 & CAMPAGNOLO 725 FACING PROCEDURE

GENERAL INFORMATION

TERMINOLOGY

Facing: To cut the end of a cylinder (the bottom-bracket shell in this case) so that it is flat and precisely perpendicular to the axis of the cylinder.

Facer: The cutter that is used to do facing. The facer may also be called a facing mill.

Bottom-bracket shell: The part of the frame that houses the bearings that the crank arms rotate around.

Pilot: A part of a bottom-bracket facer that is used to align the facer so that it will cut precisely perpendicular to the axis of the bottom-bracket-shell threads. The pilot consists of the pilot shaft and the pilot hole.

INDICATIONS

Symptoms indicating need of facing

There is only one symptom that indicates the need for facing the bottom-bracket shell. When attempting to adjust a high-quality adjustable-cup bottom bracket with new parts, the spindle feels smooth through a portion of its rotation and tight in another portion of its rotation. This is called a tight/loose pattern. The tight/loose pattern can also be caused by conditions other than a bottom-bracket shell that needs facing, such as: low precision parts, worn out parts, bent spindles, and cross-threaded cups. Under these conditions, the tight/loose pattern is due to poor quality of manufacturing, not abuse or wear.

Other reasons for facing the bottom-bracket shell

When tapping a bottom-bracket shell (particularly with a Park BTS-1) it is a simple matter to go a step further and face the bottom bracket as well. This is cheap insurance to enable easy adjustment of the bottom bracket and maximize the longevity of bottom-bracket parts. For this reason, some shops will routinely tap and face bottom-bracket shells on high-end bikes.

In the case that a shop sells bare framesets, it is a good marketing technique to face them before putting them out for display. Knowledgeable customers will look for whether facing has been done to evaluate whether the frame has been properly prepped for assembly.

Cartridge-bearing bottom brackets

When a cartridge-bearing bottom bracket has bearings mounted in cups with flanges or lockrings that bear against the ends of the bottom-bracket shell, facing the bottom-bracket shell is just as important as with cup and cone type bottom brackets.

Some cartridge-bearing bottom brackets are an enclosed unit. The bearings and spindle are inseparable, and the bearings are inside a cylinder. This type might be held in the bottom-bracket shell by two mounting rings, or one end of the unit might be threaded, and the other end is secured by a separate mounting ring. With this enclosed-

3 – FACING THE BOTTOM BRACKET SHELL

unit type of cartridge-bearing bottom bracket, an out-of-face shell will not affect the bearing and spindle alignment. If this is the case, then there is no value to facing the bottom-bracket shell.

TOOL CHOICES

The thread type of the bottom-bracket shell is what determines what tool you will need. The following list (table 3-1, below) covers all tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy.

TIME AND DIFFICULTY

Facing a bottom bracket is a job of little difficulty. With tapping already done it should take an additional 10–15 minutes.

COMPLICATIONS

Titanium

Titanium has completely different metallurgical characteristics than steel or aluminum. It is necessary for a facer to be designed in a dramatically different way to be suitable for facing titanium. Once designed to be suitable for titanium, a facing tool will no longer be suitable for other materials. Special facers for titanium are not available at the time of this writing; if they do ever become available, whether enough titanium frames will be encountered that need facing is a significant question.

Aluminum

Aluminum is a perfectly suitable material for facing, but presents some special concerns to the mechanic. *The type of cutting oil used is critical.* There are cutting oils made specifically for use on aluminum. Any cutting oil that is suitable will specify for use on aluminum on the container. Words like “all-purpose” and “multi-purpose” should not be interpreted to mean including aluminum.

Chrome plating

Chrome-plated bottom brackets cannot be faced unless the chrome is first removed, a potentially difficult procedure. A file or grinding stone can be used for chrome removal.

Failure of Campagnolo threaded inserts to install fully

Campagnolo threaded inserts are the female pilot of the facing tool. Their design creates several problems. These threaded inserts must be installed so that they are completely inside the bottom-bracket shell. The insertion of threaded inserts requires at least 17mm of thread length on both sides of the bottom-bracket shell, whereas few cups require more than 13mm of thread depth; consequently, many bottom-bracket shells do not have enough thread length to use the Campagnolo 725 facing tool. Adding threads is a difficult procedure and hard on the taps.

The threaded inserts are also very fat and interfere with anything that protrudes into the bottom-bracket shell, such as fasteners for bottom-bracket cable guides and excess tubing length on lugged frames.

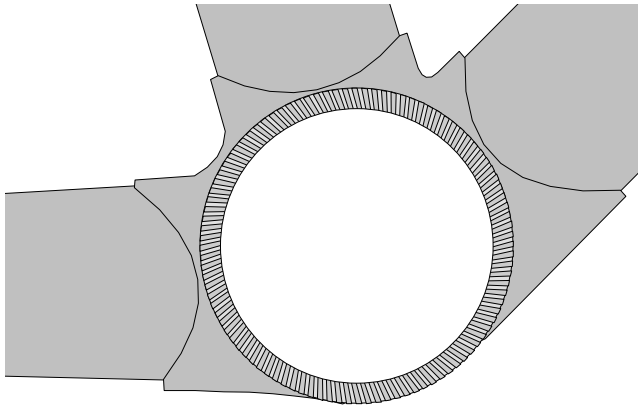
BOTTOM-BRACKET-FACING TOOLS (table 3-1)

Tool	Fits and considerations
Campagnolo 725	Piloted handles w/ 1.37" × 24tpi BSC/ISO inserts, very expensive.
Campagnolo 724I	Italian 36mm × 24tpi inserts for 725.
Campagnolo 724F	French 35mm × 1mm inserts for 725.
Campagnolo 730	Spanners used for installing 725 inserts.
Park BFS-1	Heavy duty facing tool made for frame manufacturers to shorten shells (can be used with its own BSC threaded guides or any Park taps as guides).
Park BTS-1	Same tool as bottom-bracket tap, faces 1.37" × 24tpi shells, excellent quality and convenience.
Park 693	36mm × 24tpi taps needed to use BTS-1 to face Italian shells.
Park 694	35mm × 1mm taps needed to use BTS-1 to face French shells.
VAR 380/2/C	Same as tap set, can be modified to use as a facer with addition of VAR 37DL2 and United Bicycle Tool 37B.
VAR 37DL2	Used with VAR 380/2/C tap set to convert to a facer.
United Bicycle Tool 37B	Used with VAR 380/2/C tap set to convert to a facer.
VAR 380/3/C	Facer set uses unthreaded pilots, low precision.

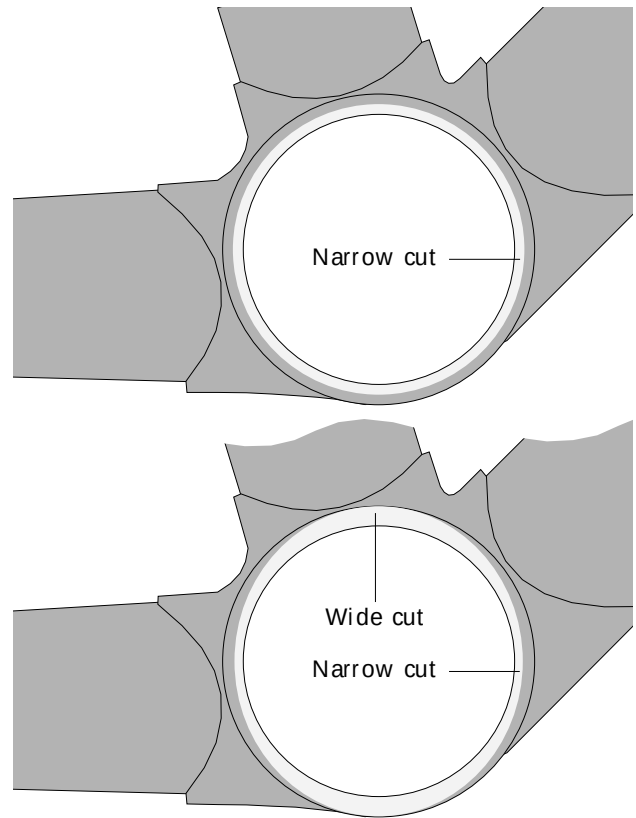
3- FACING THE BOTTOM BRACKET SHELL

Facing-tool chatter

Facing-tool chatter is the tendency of the facing tool to bite and jump at rapid frequency. This tendency leaves a series of radial lines in the face of the bottom-bracket shell. These radial lines are a cosmetic flaw, not a mechanical flaw. To some degree the chatter marks are preventable, but circumstances outside the control of the mechanic make chatter marks unavoidable at times. Proper facing technique can reduce the likelihood of chatter occurring, but if the type and hardness of the bottom-bracket shell material is not compatible with the design of the facing tool, then chatter cannot be prevented. In the facing procedures there are detailed instructions of the technique that reduces the likelihood of chatter occurring. See figure 3.1 below.



3.1 *The radial lines in the face of this shell are the result of chatter.*



3.2 *As long as the facing cut is a full 360°, it does not matter if the cut is narrow, or not a uniform width. Both the shell faces shown here are acceptably faced.*

Uniform width of cut

When facing a bottom-bracket shell, the objective is to complete a cut that is a full 360° around the face of the shell. Sometimes, once the 360° cut is achieved, the cut is not a uniform width; in fact, the cut may be very narrow at points, and not near as wide as the shell face. There is a tendency to conclude that more facing is needed when this occurs. It is not a mechanical necessity to achieve a uniform, full-width cut; the only reason to attempt to create a uniform, full-width cut is to improve the cosmetics. It may take several extra minutes of work to achieve a cosmetically-superior facing cut. If the appearance of the cut can be substantially improved by working 1–2 extra minutes, fine; otherwise, leave the cut with a non-uniform width, as long as it is a full 360°. See figure 3.2 (below and in left column).

3 – FACING THE BOTTOM BRACKET SHELL

CARE OF FACING TOOLS

Facing tools are very expensive and easily damaged. Proper cutting technique is important to get good life from them, but that is not all. When storing facers, make sure they are clean and coated with oil. The cutting edges are easily chipped by light impact with other metal objects, so handle and store them in a way that this kind of accidental contact will not happen. On hooks on a peg-board is a good way to store facing tools.

When cleaning facing tools use a brush and solvent. Blowing them clean with compressed air is not damaging to the facer but is dangerous. Coat the cutter with a light oil after cleaning and drying.

Using a facer on chrome-plated bottom-bracket shells will dull it quickly, and is almost impossible to do. The facer will fail to get a bite on a chrome-plated bottom-bracket shell at normal pressure. In some cases a chrome-plated bottom-bracket shell can be faced by using very high cutting pressure, but facing chrome-plated bottom-bracket shells is strongly advised against; *tool damage is likely!*

PARK BTS-1 FACING PROCEDURE

If the shell face is clean raw metal, it can be difficult to track facing progress. In this case, use a material called machinist's dykem (available from general tool supply stores or machinist's supply stores) to paint the shell face before proceeding. Handle dykem carefully, as it can stain almost anything.

1. [] **Complete BOTTOM-BRACKET-TAPPING PROCEDURE (page 2-3) through step 13 before proceeding.**

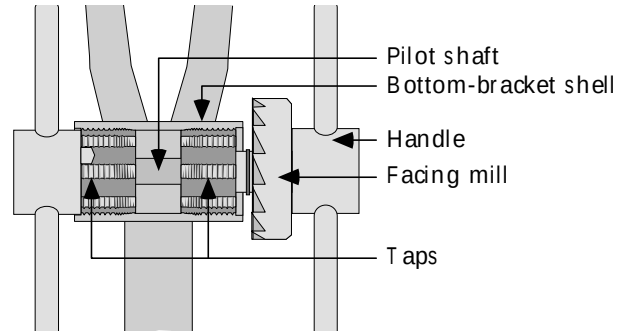
The Park BTS-1 uses the taps as the pilot hole for the pilot shaft of the facing tool. If the taps are left protruding from the ends of the shell then the facer will cut against them instead of against the end of the shell. The taps have a very short length, so it is unlikely once the taps are all the way into the existing thread that they will need to go in further to be recessed in the shell.

2. [] **If either or both taps are protruding from end of shell, continue tapping procedure until each tap is recessed in end of shell.**

Park BTS-1 tap handles are not retained in the taps by a threaded device, but by internal spring clips. Just pull out firmly on a handle and it will leave the tap behind.

3. [] **Withdraw one tap handle.**

4. [] **Place facer on withdrawn handle and insert handle back into taps.**



3.3 Cut-away view of a bottom-bracket shell with a Park BTS-1 facing tool in place.

Cutting oil needs to be added in the next step to assure the ease and quality of the cut, as well as to preserve the sharpness of the tool.

5. [] **Add generous amount of appropriate type of cutting oil to facer teeth.**

A very important part of the remaining steps is that the facer should be turned clockwise *only*. Unlike taps, the design of facer teeth causes them to dull easily if rotated counterclockwise.

It is also important to use correct pressure and speed, as little pressure is required to get a sharp tool to cut. Pressing in with one hand at the center of the tool is generally enough pressure. There is very little leverage needed to face, so there is no reason to turn the handles with both hands. A slow steady speed should be adequate.

Fine modulations of the cutting pressure and slower cutting speed should be used to prevent or reduce a phenomenon called *chatter*. Chatter is the tendency of the tool to bite and jump at a rapid frequency, resulting in a chattering feeling and noise from the tool as it cuts. For every metal there is an optimum pressure; try reducing or increasing the pressure to eliminate chatter. If chattering occurs it will leave a series of radial lines in the face of

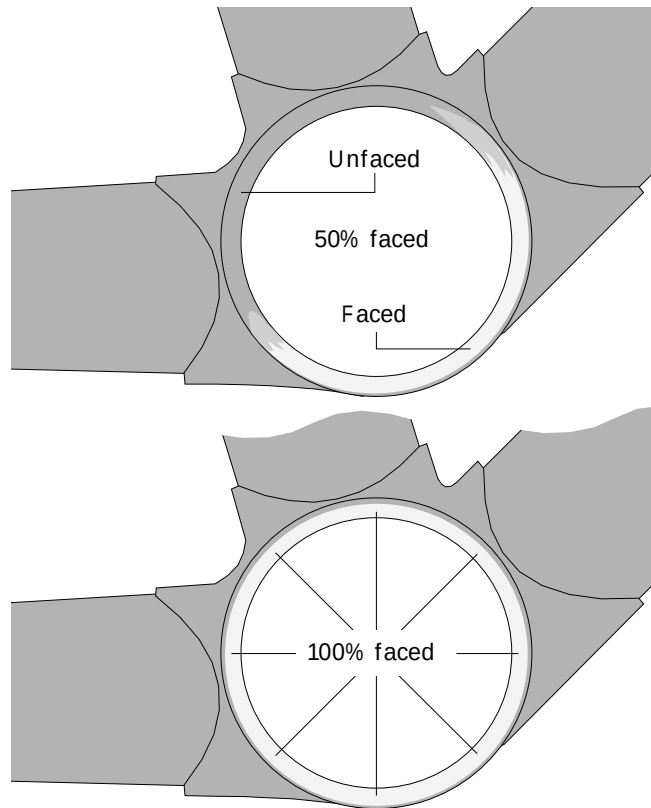
3- FACING THE BOTTOM BRACKET SHELL

the bottom-bracket shell, which is a cosmetic flaw, not a mechanical one (see figure 3.1). Chatter cannot always be prevented, but it can be minimized by modulating the cutting pressure and speed. In addition to pressure and speed being factors, the design of the facer teeth has to be suitable to the particular hardness of metal being cut. When the design of the facer teeth is too aggressive for the hardness of the metal being cut, then some chatter is inevitable and must be lived with.

6. [] **Rotate facer *clockwise only* at moderate pressure and speed for approximately four full revolutions.**

In the next step, the progress of the facing is inspected. A partially faced bottom bracket will have freshly cut metal only for a portion of the 360° shell face. It is no concern whether the width of the cut is uniform, only whether there is freshly cut metal for a full 360°. If it is not a full circle, proceed to step #8.

7. [] **Pull facer away from end of shell and inspect progress of cut.**



3.4 The cut needs to be a full 360° to be complete. Uniform width of cut is meaningless.

8. [] **If more facing is needed, repeat steps 5–7.**

Under the pressure needed to cut metal, the facer can leave burrs when it stops. The next step is to spin the facer one more revolution under very light pressure to knock off any burrs.

9. [] **When first side is adequately faced, use facer for one more revolution under very light pressure.**
10. [] **Pull both handles out and reinstall each handle on opposite side.**
11. [] **Repeat steps 5–8 for second side until second side is adequately faced.**
12. [] **When second side is adequately faced, use facer for one more revolution under very light pressure.**

3 – FACING THE BOTTOM BRACKET SHELL

13. [] Remove handle that has facer mounted and remove facer.
14. [] Put handle back into taps and shell.
15. [] Turn both tap handles until taps are almost fully out and are evenly protruding from shell.
16. [] Rotate both handles simultaneously enough to be sure that both taps are fully unthreaded, then withdraw both taps at same time.
17. [] Clean bottom-bracket threads with tooth-brush and solvent.
18. [] Clean outside of bottom-bracket shell and rest of frame as necessary.
19. [] Clean bottom-bracket taps and facer.
20. [] Use appropriate procedures/worksheets to install bottom bracket and crank arms as necessary.

MODIFIED VAR 380/ 2/C FACING PROCEDURE

The VAR 380/2/C piloted bottom-bracket taps can be converted into an economical and effective facing tool. One handle is converted into a facing tool, while the other tap handle and tap is left inside the bottom-bracket shell to act as a pilot mechanism. The conversion requires a VAR 37DL2 facer and a spacer made and sold by United Bicycle Tool called the 37B. The spacer is needed because the 37DL2 is shorter than the tap that is being replaced when modifying.

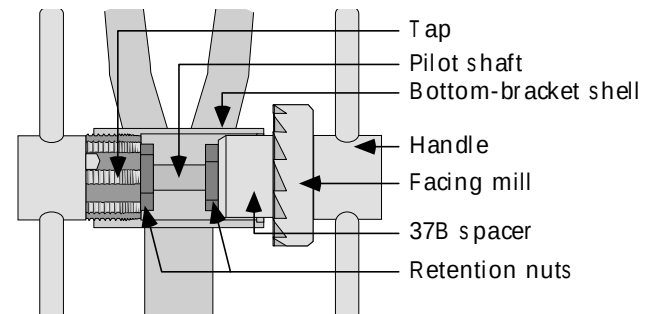
If the shell face is clean raw metal, it can be difficult to track facing progress. In this case, use a material called machinist's dykem (available from general tool supply stores or machinist's supply stores) to paint the shell face before proceeding. Handle dykem carefully, as it can stain almost anything.

1. [] Complete **BOTTOM-BRACKET-TAPPING PROCEDURE** (page 2-3) through step 13 before proceeding.
2. [] Unthread one tap and handle from the shell.
3. [] Unthread retaining nut from handle and remove tap from handle.

To convert the tap handle to a facer the tap is removed, the facer is installed, a spacer is installed, and the retaining nut is installed. In some cases the peg on the tap handle is too long to fit in the hole in the backside of the facer and needs to be filed shorter. This has no effect on using the handle for a tap later. The spacer is not symmetrical and must be installed correctly. *The end of the spacer*

with the reduced diameter goes against the facer. If the spacer is put on backwards then the retaining nut will not engage the handle thread fully.

4. [] Place 37DL2 facer and spacer on withdrawn handle, secure retaining nut, and insert handle back into remaining tap and handle already in shell.



3.5 Cut-away view of a bottom-bracket shell with a modified VAR 380/2/C facing tool in place.

Cutting oil needs to be added in the next step to assure the ease and quality of the cut, as well as to preserve the sharpness of the tool.

5. [] Add generous amount of appropriate type of cutting oil to facer teeth.

A very important part of the remaining steps is that the facer should be turned clockwise *only*. Unlike taps, the design of facer teeth causes them to dull easily if rotated counterclockwise.

It is also important to use correct pressure and speed, as little pressure is required to get a sharp tool to cut. Pressing in with one hand at the center of the tool is generally enough pressure. There is very little leverage needed to face, so there is no reason to turn the handles with both hands. A slow steady speed should be adequate.

Fine modulations of the cutting pressure and lower cutting speed should be used to prevent or reduce a phenomenon called *chatter*. Chatter is the tendency of the tool to bite and jump at a rapid frequency, resulting in a chattering feeling and noise from the tool as it cuts. For every metal there is an optimum pressure; try reducing or increasing the pressure to eliminate chatter. If chattering occurs it will leave a series of radial lines in the face of the bottom-bracket shell, which is a cosmetic flaw, not a mechanical one (see figure 3.1). Chatter cannot always be prevented, but it can be minimized by modulating the cutting pressure and speed. In addition to pressure and speed being factors, the design of the facer teeth has to be suitable to the particular hardness of metal being cut.

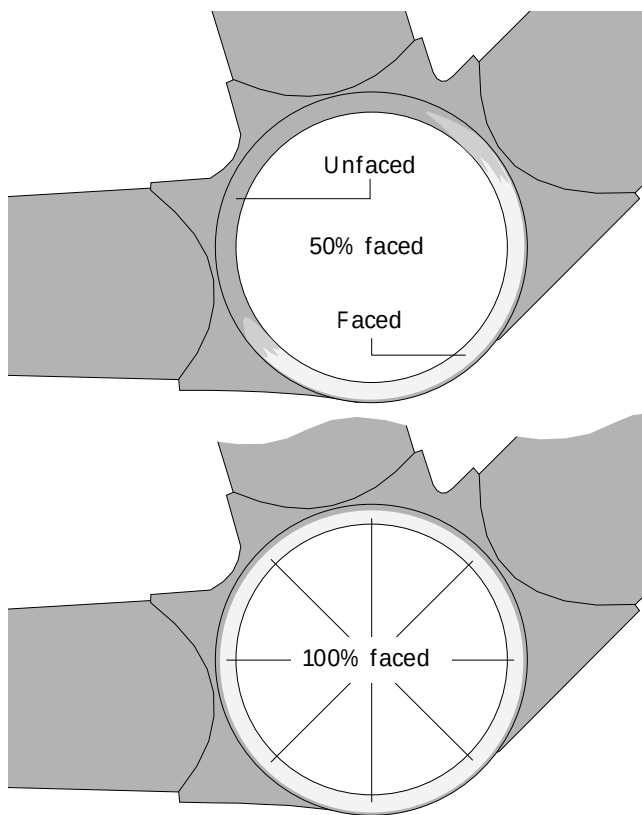
3- FACING THE BOTTOM BRACKET SHELL

When the design of the facer teeth is too aggressive for the hardness of the metal being cut, then some chatter is inevitable and must be lived with.

6. [] Rotate facer **clockwise only at moderate pressure and speed for approximately four full revolutions.**

In the next step, the progress of the facing is inspected. A partially faced bottom bracket will have freshly cut metal only for a portion of the 360° shell face. It is no concern whether the width of the cut is uniform, only whether there is freshly cut metal for a full 360°. If it is not a full circle, proceed on to step #8.

7. [] Pull facer away from end of shell and inspect progress of cut.



3.6 The cut needs to be a full 360° to be complete. Uniform width of cut is meaningless.

8. [] If more facing is needed, repeat steps 5–8.

Under the pressure needed to cut metal, the facer can leave burrs when it stops. The next step is to spin the facer one more revolution under very light pressure to knock off any burrs.

9. [] When first side is adequately faced, use facer for one more revolution under very light pressure.
10. [] Remove handle with facer and remove retaining nut, spacer, and facer.

In the next two steps the handle that was used as a facer is converted back into a tap and installed in the bottom-bracket shell *before the other tap is removed*. This prevents a tap from cross-threading on the way out due to lack of piloting.

11. [] Install and secure tap back on handle.
12. [] Thread tap back into shell fully.
13. [] Remove other tap and handle from shell.
14. [] Convert removed handle into facer, same as in step 4.
15. [] Repeat steps 5–8 for second side until second side is adequately faced.
16. [] When second side is adequately faced, use facer for one more revolution under very light pressure.
17. [] Remove handle that has facer mounted and remove facer.

In the next two steps the facer is converted back to a tap and put back in the shell *before the other tap is removed from the shell*. This prevents a tap from cross-threading on the way out due to lack of piloting.

18. [] Convert handle that was facer back to a tap.
19. [] Thread tap 1–2 full turns into shell.
20. [] Back other tap out of shell until both taps are equally outside of shell.
21. [] Rotate both handles simultaneously enough to be sure that both taps are fully unthreaded, then withdraw both taps at same time.
22. [] Clean bottom-bracket threads with toothbrush and solvent.
23. [] Clean outside of bottom-bracket shell and rest of frame as necessary.
24. [] Clean bottom-bracket taps and facer.
25. [] Use appropriate procedures/worksheets to install bottom bracket and crank arms as necessary.

PARK BFS-1 & CAMPAGNOLO 725 FACING PROCEDURE

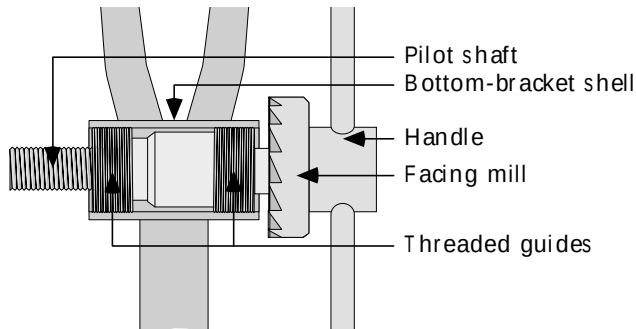
The Park BFS-1 and Campagnolo 725 facers are identical tools except for one thing: the Park BFS-1 utilizes the taps as guides, and the Campagnolo 725 uses special threaded guides that are not taps. The difference in use is that when using Park BFS-1 taps to tap the bottom-

3 – FACING THE BOTTOM BRACKET SHELL

bracket-shell threads, the taps are left in the shell to provide the pilot hole. Installing and removing the threaded guides that the Campagnolo 725 uses is an additional step.

If the shell face has clean raw metal, it can be difficult to track facing progress. In this case, use a material called machinist's dykem (available from general tool supply stores or machinist's supply stores) to paint the shell face before proceeding. Handle dykem carefully, as it can stain almost anything.

1. [] If using Park BTS-1 for tapping, complete **BOTTOM-BRACKET-TAPPING PROCEDURE** (page 2-3) through step 13 before proceeding; otherwise, complete the entire tapping procedure.
2. [] Thread appropriate thread guides into shell until both are recessed into shell and securely fixed.
3. [] If either or both guides are protruding from end of shell remove guides and continue tapping procedure until each guide is able to recess in end of shell.
4. [] Insert facer in either side and assemble tension device (large pressure washer, small lockwasher, spring, and tension nut) if desired.



3.7 Cut-away view of a bottom-bracket shell with a Campagnolo 725 facer in place.

Cutting oil needs to be added in the next step to improve the ease and quality of the cut, as well as to preserve the sharpness of the tool.

5. [] Add generous amount of appropriate type of cutting oil to facer teeth.

A very important part of the remaining steps is that the facer should be turned clockwise *only*. Unlike taps, the design of facer teeth causes them to dull easily if rotated counterclockwise.

It is also important to use correct pressure and speed, as little pressure is required to get a sharp tool to cut. Pressing in with one hand at the center of the tool is generally enough pressure. There is very little leverage needed to face, so there is no reason to turn the handles with both hands. A slow steady speed should be adequate.

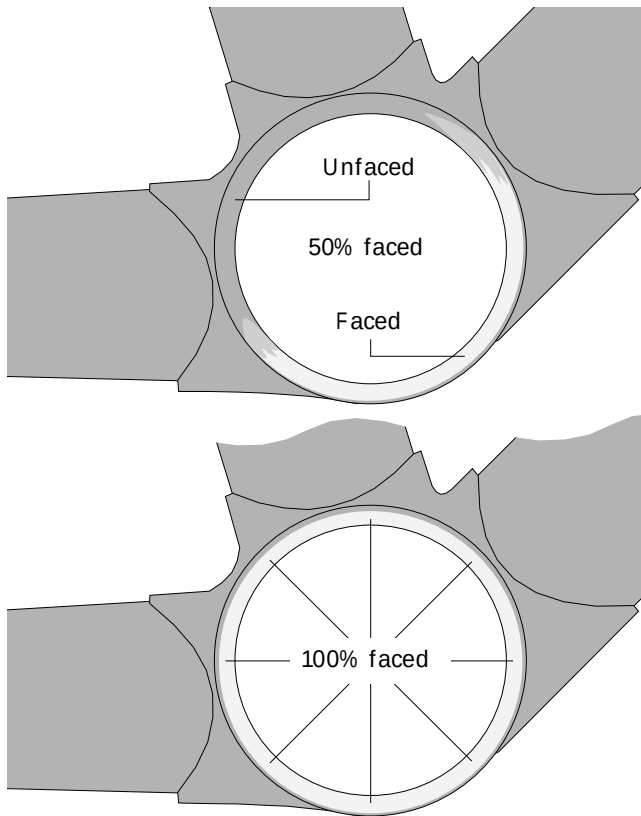
Fine modulations of the cutting pressure and lower cutting speed should be used to prevent or reduce a phenomenon called *chatter*. Chatter is the tendency of the tool to bite and jump at a rapid frequency, resulting in a chattering feeling and noise from the tool as it cuts. For every metal there is an optimum pressure; try reducing or increasing the pressure to eliminate chatter. If chattering occurs it will leave a series of radial lines in the face of the bottom-bracket shell, which is a cosmetic flaw, not a mechanical one (see figure 3.1). Chatter cannot always be prevented, but it can be minimized by modulating the cutting pressure and speed. In addition to pressure and speed being factors, the design of the facer teeth has to be suitable to the particular hardness of metal being cut. When the design of the facer teeth is too aggressive for the hardness of the metal being cut, then some chatter is inevitable and must be lived with.

It is difficult to modulate the pressure responsively when using these tools' tensioning device. Hand pressure should be adequate unless the facer is dull.

6. [] Rotate facer **clockwise only** at moderate pressure and speed for approximately four full revolutions.

In the next step, the progress of the facing is inspected. A partially faced bottom bracket will have freshly cut metal only for a portion of the 360° shell face. It is no concern whether the width of the cut is uniform, only whether there is freshly cut metal for a full 360°. If the cut metal is not a full circle, proceed to step #8.

3- FACING THE BOTTOM BRACKET SHELL



3.8 *The cut needs to be a full 360° to be complete. Uniform width of cut is meaningless.*

If the tension device is engaged and not set too tightly, it should be possible to pull the facer away from the shell without un-setting the tension. If the tension device is not being used, then just slide the facer out of the shell to inspect the cutting progress.

7. [] Pull facer away from end of shell and inspect progress of cut.

8. [] If more facing is needed, repeat steps 5–8.

Under the pressure needed to cut metal, the facer can leave burrs when it stops. The next step is to spin the facer one more revolution under very light pressure to knock off any burrs.

9. [] When first side is adequately faced, use facer for one more revolution under very light pressure.

10. [] Remove tension device (if used) and pull facer out of pilot hole.

11. [] Repeat steps 5–8 for second side until second side is adequately faced.

12. [] When second side is adequately faced, use facer for one more revolution under very light pressure.

13. [] Remove tension device (if used) and pull facer out of pilot hole.

There are two choices in the next step. Choosing the correct one determines which of the following steps need to be done. The choice is based on whether the pilot system being used up to this point had threaded guides, or whether the Park BTS-1 taps were left in place after tapping.

3 - FACING THE BOTTOM BRACKET SHELL

4 – REAMING AND FACING THE HEAD TUBE

ABOUT THIS CHAPTER

This chapter is about two head-tube milling procedures: reaming the head tube, and facing the head tube. Reaming the head tube is done to improve, or change, the fit of a headset pressed-race into the head tube. Facing the head tube is done to improve the alignment of a headset pressed-race. Improving the alignment of the headset parts improves the quality of the adjustment and the longevity of the parts.

GENERAL INFORMATION

TERMINOLOGY

Reaming: To enlarge the diameter of a hole.

Reamer: A cutting tool that enlarges the inside diameter of a hole.

Facing: To cut the end of a cylinder (the head tube in this case) so that it is flat and precisely perpendicular to the axis of the cylinder.

Facer: The cutting tool that is used to face the head tube, also called a facing mill.

Head tube: The near-vertical frame tube at the front of the frame in which the fork column rotates.

Pilot: There are two different pilot systems for a headtube reaming/facing tool. There is always a conical pilot insert that goes into the end of the tube not being reamed or faced. This pilot keeps the tool shaft centered in the head tube. In addition to this pilot, there may be a pilot built into the cutting end of the tool. This other pilot may be below the reamer or below the facer in place of the reamer. In either case, the pilot that is built into the cutting end of the tool should be a close fit to the inside diameter of the head tube.

1" headset: A headset that fits on a fork column with a diameter of approximately 1".

1-1/8" headset: A headset that fits on a fork column with a diameter of approximately 1-1/8".

1-1/4" headset: A headset that fits on a fork column with a diameter of approximately 1-1/4".

PREREQUISITES

Stem removal and installation

Before removing the headset and fork, the stem must be removed. After the head tube has been reamed or faced, and after the headset has been installed, the stem will need to be installed. If unfamiliar with stem removal and installation, see the **HANDLEBARS, STEMS AND EXTENSIONS** chapter. In some cases the brake cable or front brake may need to be detached at some point, or removed completely, in order to remove the stem.

Headset removal and installation

In order to ream or face the head tube, the headset and fork must be removed. After the head tube has been reamed or faced, the headset and fork need to be reinstalled. If unfamiliar with these procedures, see the **HEADSETS** chapter.

INDICATIONS

Symptoms indicating need of reaming

The most likely reason that a head tube must be reamed is that a JIS dimension headset (a headset made to Japanese industrial standard race dimensions of 30.0mm and 27.0mm) has been removed, and the replacement headset is of a different fit standard. It is possible, however unlikely, that a head tube will deviate so much from the ideal dimension that a correctly fit headset will be too difficult to press in. In this case, reaming will be required to improve the fit.

Symptoms indicating need of facing

There is only one symptom that indicates the need for facing the head tube. When attempting to adjust a high-quality cup and cone headset with new parts, the fork feels smooth through a portion of its rotation and tight in another portion of its rotation. This is called a tight/loose pattern. The tight/loose pattern can also be caused by conditions other than a head tube that needs facing, such as: low precision parts, worn out parts, a bent fork column, a crown race seat that needs facing,

4 – REAMING AND FACING THE HEAD TUBE

and mis-installed cups or crown race. When a head tube needs facing, it is due to poor quality of manufacturing, not abuse or wear.

Other reasons for facing the head tube

Facing the head tube is cheap insurance to enable easy adjustment of the headset and maximize parts longevity. On higher priced bikes some shops will routinely ream and face head tubes.

In the case that a shop sells framesets bare, it is good marketing technique to face them before putting them out for display. Knowledgeable customers will look for whether facing has been done to evaluate whether the frame has been properly prepped for assembly.

TOOL CHOICES

The fit dimensions of a pressed head-tube race are what determines what tool is required. The following list (table 4-1) covers all the tools available for reaming and

HEAD-TUBE REAMING/FACING TOOLS(table 4-1)

Tool	Fits and considerations
Bicycle Research HT1	Complete reaming/facing tool with 30.0mm reamer
Bicycle Research HT1/4	Additional 29.8mm reamer required if using Bicycle Research HT1 to face head tube with JIS dimensions
Bicycle Research HR3	Additional 33.8mm reamer required if using Bicycle Research HT1 to face head tube with 1–1/8" oversize headset
Bicycle Research HT1	Additional 36.8mm reamer required if using Bicycle Research HT1 to face head tube with 1–1/4" oversize headset
Campagnolo 733	Complete reaming/facing tool with 30.0mm reamer, cannot be used to face JIS head tube
Campagnolo 7185016	Additional 33.8mm reamer required if using Campy 733 to face head tube with 1–1/8" oversize headset
Fisher 15	Additional 36.8mm reamer required if using Campy 733 to face head tube with 1–1/4" oversize headset
Park HTR-1	Complete reaming/facing tool w/30.0mm reamer, includes all necessary pilots to face head tubes, instead of requiring additional 29.8mm, 33.8mm, and 36.8mm reamers
Park 754	33.8mm reamer for Park HTR-1, only needed if preparing head tube at frame manufacturing level
Park 755	36.8mm reamer for Park HTR-1, only needed if preparing head tube at frame manufacturing level
VAR 32C	Complete reaming/facing tool with 30.0mm reamer
VAR 968	Additional 33.8mm reamer required if using VAR 32C to face head tube with 1–1/8" oversize headset
VAR 969	Additional 36.8mm reamer required if using VAR 32C to face head tube with 1–1/4" oversize headset
VAR 970	Oversize facer for VAR 32C required to face head tube with 1–1/4" oversize headset
United Bicycle Tool 32BUSH/8	Bushing required if using VAR 32C to face head tube with 1–1/8" oversize headset instead of more expensive VAR 968
United Bicycle Tool 32BUSH/4	Bushing required if using VAR 32C to face head tube with 1–1/4" oversize headset instead of more expensive VAR 968

facing the head tube. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy.

All dimensions are in millimeters because these are the only units used by manufacturers.

TIME AND DIFFICULTY

Reaming and facing the head tube is a moderately difficult job that takes 15–25 minutes on a bare head tube.

COMPLICATIONS

Whether to use a reamer or a pilot

Some tools give you a choice between using a reamer or just a pilot on the reaming/facing tool. You *must* use a reamer if converting the head tube from one size standard to another. Otherwise the reamer is probably not required and a pilot will do.

When not converting the size, the decision can be made by trial and error, or measurement. To make the choice by trial and error, test install the headset pressed races with proper technique and tools (see page 11-16). If the headset pressed-races are unusually difficult to install, stop and remove them. Reaming is required.

To determine if reaming is required by measurement, use the **REAMER & PILOT SIZES** table 4-2 (page 4-5) to determine the correct reamer size, then take two inside diameter measurements of the head tube (90° apart) and average the two measurements. If the average of the two measurements is less than the recommended reamer size by .05mm or more, reaming is required.

Titanium

Titanium has completely different metallurgical characteristics than steel or aluminum. It is necessary for the reamer and facer to be designed in a dramatically different way to be suitable for reaming and facing titanium. Once designed to be suitable for titanium, the reamer/facer will no longer be suitable for other materials. If special facers for titanium become available, whether enough titanium frames will be encountered that need reaming and facing is a significant question.

Aluminum

Aluminum is a perfectly suitable material for reaming and facing, but presents some special concerns to the mechanic. *The type of cutting oil used is critical.* There are cutting oils made specifically for use on aluminum. Any

cutting oil suitable for use on aluminum will say so on the container. Do not interpret words such as “all purpose” and “multi-purpose” to mean: includes aluminum.

Chrome plating

Chrome-plated head tubes cannot be faced unless the chrome is first removed, a potentially difficult procedure. A file or grinding stone can be used for chrome removal. Reaming chrome head tubes can be done without facing, but severely wears out the reamer.

Failure of VAR pilot to install fully

Stock VAR pilots (fat shaft below the reamer) can be too fat and/or too long for many head tubes. If the pilot is too fat, it will interfere with any imperfection in a head tube, including a tube seam. The stock VAR pilot is too long for very short head tubes and interferes with the conical pilot at the other end of the head tube. United Bicycle Tool Supply has modified the VAR bushing to a trouble-free length and diameter. This modified bushing is available separately (VAR-971/3), but it is the stock bushing on all VAR 32C reamer/facers sold by United Bicycle Tool Supply.

Incomplete reaming

After completing the reaming and facing, it may appear that the reaming was not completed because the reamer has not left a 360° cut. This is normal and happens because few head tubes are truly round; in fact, in the case of 360° of clean metal on the inside of the head tube, the reaming that has occurred may be excessive.

Excessive reaming

Even after using the correct reamer, the headset part may end up fitting loose. This usually occurs when an out-of-round head tube that did not actually need reaming has been reamed. The reamer removes metal at the low points so that the average inside diameter is increased when it was not required. An out-of-round head tube will become round when the head-tube race is installed. Out-of-round head tubes are not a problem. Avoid excessive reaming by using the Park HTR-1 (with stock pilots) or VAR 32C (with custom United Bicycle Tool pilots) when facing an out-of-round head tube that has an acceptable average inside diameter.

Excessive reaming time

Most head tubes have already been reamed to close to the correct size before the mechanic ever sees them. Using a reamer in one of these will be a very quick process. On the other hand, the reamer is sometimes used to convert a head tube from a 29.8mm hole size to a 30.0mm

4 – REAMING AND FACING THE HEAD TUBE

hole size. When using a reamer to make this conversion, instead of simply to improve an existing fit, expect reaming to take 5–10 minutes extra.

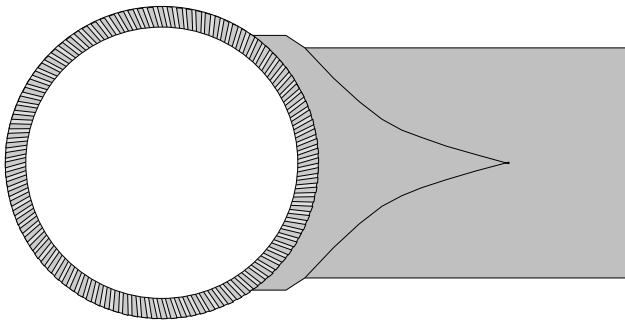
Facer interference with down tube

Avoid certain combinations of large diameter facers (suitable for bikes that use 1–1/4" headsets) with head tubes that do not extend very far below the bottom side of the down tube. This combination of wide facer and short head tube may result in the facer cutting into the down tube or down tube lug/joint. *This will destroy a frame!*

NOTE: When facing the bottom end of every head tube, check that there is adequate clearance between the facer and the down tube or down tube lug/joint.

Facing tool chatter

Facing tool chatter is the tendency of the facing tool to bite and jump at rapid frequency. This tendency leaves a series of radial lines in the face of the head tube. These radial lines are a cosmetic flaw, not a mechanical flaw. To some degree the chatter marks are preventable, but circumstances outside the control of the mechanic make make chatter marks unavoidable at times. Proper facing technique can reduce the likelihood of chatter occurring, but if the type and hardness of the head-tube material is not compatible with the design of the facing tool, then chatter cannot be prevented. In the facing procedures there are detailed instructions of the technique that reduces the likelihood of chatter occurring. See figure 4.1 below.

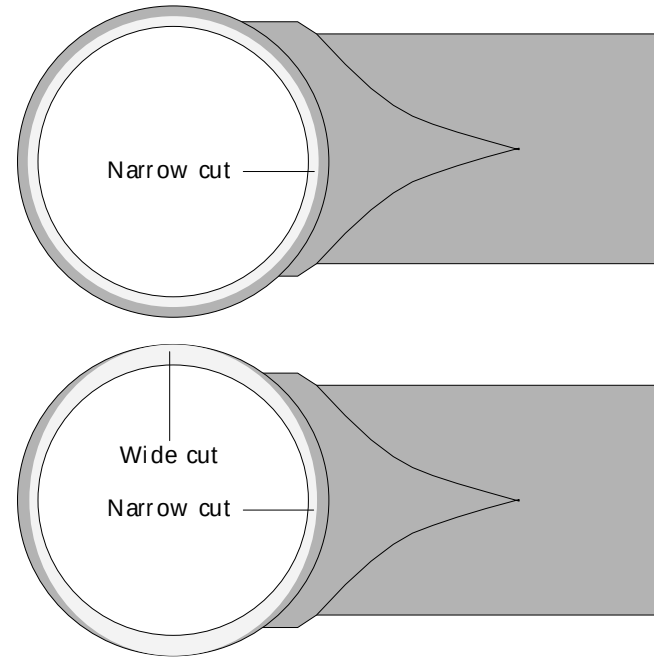


4.1 *The radial lines in the face of this shell are the result of chatter.*

Uniform width of cut

When facing a head tube, the objective is to complete a cut that is a full 360° around the face of the head tube. Sometimes, once the 360° cut is achieved, the cut is not a uniform width; in fact, the cut may be very narrow at points, and not near as wide as the head-tube face. There is a tendency to conclude that more facing is needed when this occurs. It is not a mechanical necessity to achieve a uni-

form, full-width cut; the only reason to attempt to create a uniform, full-width cut is to improve the cosmetics. It may take several extra minutes of work to achieve a cosmetically-superior facing cut. If the appearance of the cut can be substantially improved by working 1–2 extra minutes, fine; otherwise, leave the cut with a non-uniform width, as long as it is a full 360°. See figure 4.2.



4.2 *As long as the facing cut is a full 360°, it does not matter if the cut is narrow, or not a uniform width. Both the head-tube faces shown here are acceptably faced.*

CARE OF REAMING AND FACING TOOLS

General tool care

Reaming and facing tools are very expensive and easily damaged. Proper cutting technique is important to ensure good life, but that is not all. When storing reamers and facers make, sure they are clean and coated with oil. The cutting edges are easily chipped by light impact with other metal objects, so handle them and store them in a way that this will not happen. On hooks on a pegboard is a good way to store reaming and facing tools.

When cleaning reaming and facing tools use a brush and solvent. Blowing them clean with compressed air is not damaging to the cutters but is dangerous because of flying metal debris. Coat the cutter with a light oil after cleaning and drying.

Reaming and facing chrome-plated head tubes

Using a reamer or facer on chrome-plated head tubes will dull the tool quickly. Reaming and facing a chrome-plated head tube is impossible because the facer fails to get a bite at normal pressure. With very high cutting pressure reaming and facing the head tube can be done in some cases, but it is strongly advised against. Try using a file to remove chrome from the face of the head tube.

REAMER AND PILOT SIZE REQUIREMENTS

The outside diameter of the inserted portion of the headset race, which will be pressed into the head tube, determines the correct size of reamer or pilot to use. If replacing the headset, be sure to measure the new headset. *Do not measure the inside diameter of the head tube to determine the reamer/pilot size.* This measurement is only needed in order to determine whether to use a reamer or a pilot.

Measure the diameter of the inserted portion of the race that will be pressed into the head tube (see figure 4.3), find the range that includes this measurement in the **Race insert O.D.** column of table 4-2 below, then look to the right in the **Reamer size** or **Pilot size** columns to determine the correct size to use.

All dimensions are in millimeters because these are the only units used by manufacturers.

HEAD-TUBE REAMING AND FACING PROCEDURE

Head-tube reaming and facing can be done at the same time with a single tool, or facing can be done without reaming, depending on the tool used. It is theoretically possible to ream without facing, but pointless to do so. Only one procedure is described here despite the above-mentioned choices because the difference in the required procedure for each choice is minimal. This procedure is written on the assumption that reaming and facing will be done at the same time. If facing is the only procedure done (with a suitable brand of tool), simply substitute the correct-size pilot for the correct-size reamer, and skip the procedure that says to apply cutting oil to the reamer.

If the head tube being faced has clean raw metal showing on the face, it can be difficult to track facing progress. In this case, use a material called machinist's dykem (available from a general tool supply or from a machinist's supply) to paint the head-tube face before proceeding.

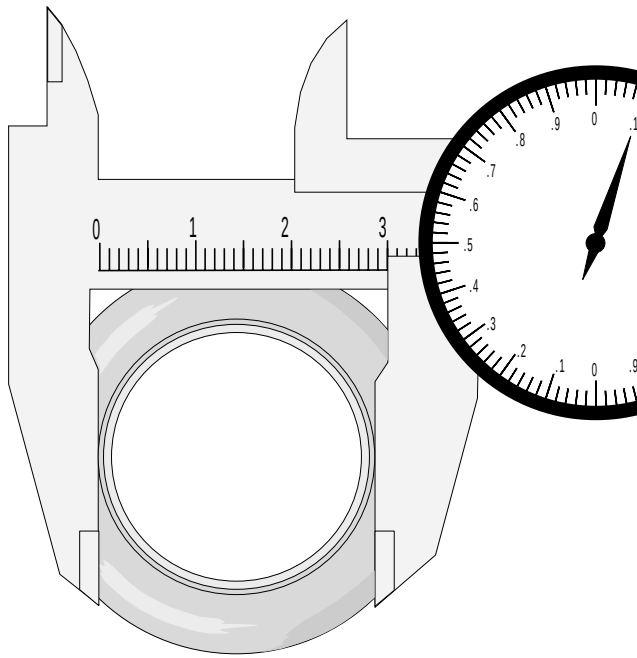
All dimensions are in millimeters because these are the only units used by manufacturers.

1. [] Use appropriate procedure/worksheet to remove headset and fork.
2. [] Measure O.D. of inserted portion of race to be pressed into head tube and record measurement here: _____ mm.

REAMER & PILOT SIZES(table 4-2)

Race insert O.D.	Reamer size	Pilot size
29.95–30.10mm	29.8mm	29.75mm
30.15–30.30mm	30.0mm	29.95mm
32.65–32.80mm	32.5mm	none available
33.95–34.10mm	33.8mm	33.75mm
36.95–37.10mm	36.8mm	36.75mm

4 – REAMING AND FACING THE HEAD TUBE



4.3 Measure the O.D. of the inserted portion of the race in this way to determine the appropriate reamer/pilot size.

Use the measurement you have just taken to determine *both* the correct reamer and pilot sizes. Whether you will use a reamer or pilot is determined in step #5.

- 3. [] Look up appropriate reamer/pilot size in REAMER & PILOT SIZES table (4-2) and record correct sizes here:**
_____ mm reamer.
_____ mm pilot.

In the next step calculate whether reaming is necessary. If the reamer will remove material, then the sum of the calculation will be a negative number (if that number is between .00 and $-.05\text{mm}$ then the amount of material removed is insignificant). If the number is equal to or greater than $.00\text{mm}$, then no material will be removed by the reamer. If the number is $-.05$ or less, then a significant amount of material will be removed by the reamer.

- 4. Calculate material reamer will remove:**

Head tube ID #1	_____ mm
Head tube ID #2	+ _____ mm
Total of ID#1 + ID#2	= _____ mm
Divide total by 2	$\div 2$

Average ID	= _____ mm
Subtract reamer size	- _____ mm
Material removed by reamer	= _____ mm

- 5. Check one of following choices with regard to reaming:**

- [] Step 4 final sum is $> -.05\text{mm}$, *reaming is not required.*
[] Step 4 final sum is $\leq -.05\text{mm}$, *reaming is required.*

In the next step you make sure that the reamer/pilot on the tool is the correct size and replace it if necessary. Reamer/pilot dimensions cannot be seen when the reamer or pilot is installed on the handle. *Reamers cannot be measured to determine their dimension.* Most bike shop have one set of reamers/pilots. Often, the easiest way to determine which reamer/pilot *is* on the handle, is to look at the markings on the reamers and pilots *that are not on the handle*. Use a process of elimination to determine which size must be on the handle.

- 6. [] Check or install correct reamer/pilot on reaming/facing tool.**
7. [] Install reamer/facer into top end of head tube.

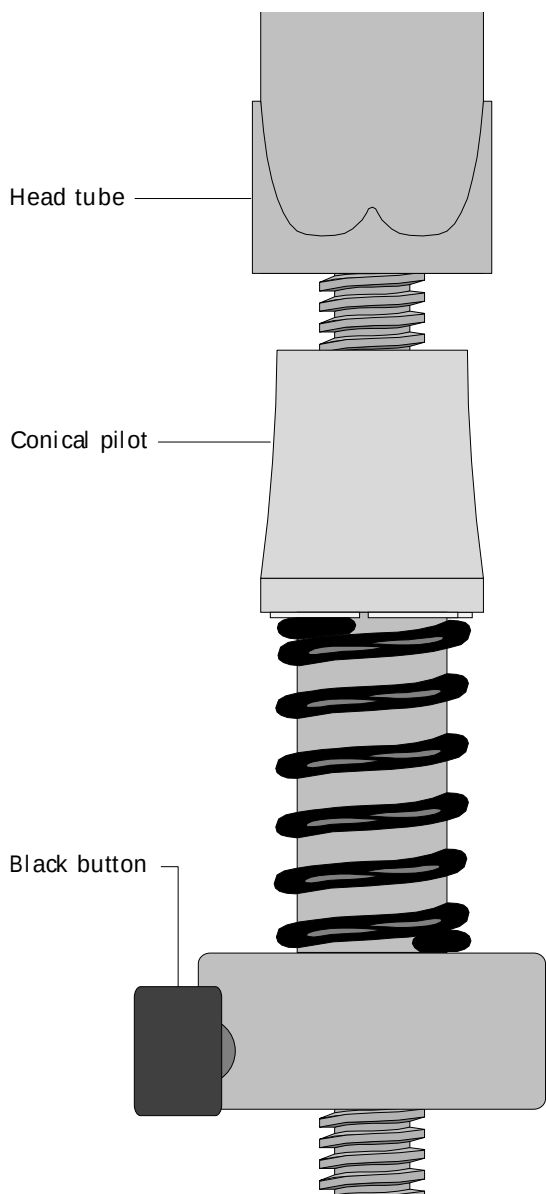
In step #8, the tension device is assembled to the tool shaft. Assembly is done differently on different brands of tools.

Park HTR-1:

Depress the large black button on the base of the one-piece tension device.

Slide the device all the way up the shaft and release the button.

4 – REAMING AND FACING THE HEAD TUBE



4.4 *Tension device for the Park HTR-1.*

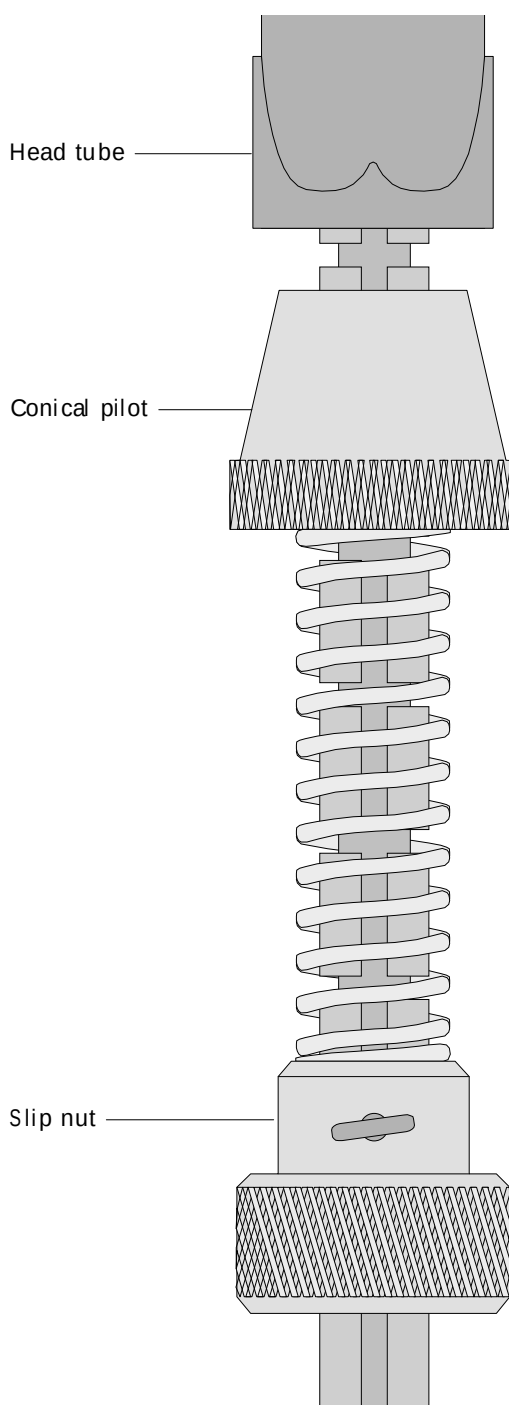
VAR 32C:

Slide the conical pilot up the shaft into the head tube.

Slide the spring onto the shaft.

Rotate the slip nut so that the internal prong lines up with the vertical slot in the shaft and slide the slip nut onto the shaft.

Rotate the slip nut so that the internal prong engages a horizontal slot in the shaft.



4.5 *Tension device for the VAR 32C.*

Campagnolo 733 & Bicycle Research HT:

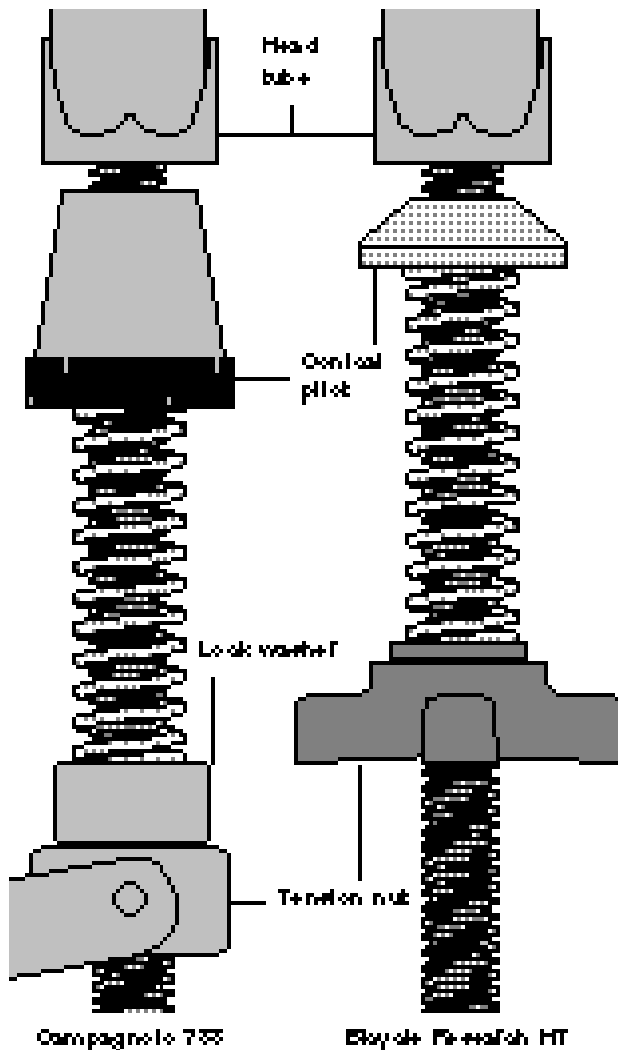
Slide the conical pilot up the shaft into the head tube.

Slide the spring onto the shaft.

Campagnolo only: slip the lockwasher onto the shaft.

Both: thread the tension nut onto the shaft.

4 – REAMING AND FACING THE HEAD TUBE



4.6 Tension device(s) for Campagnolo 733 and Bicycle Research HT models.

8. [] Assemble conical pilot and tension device to end of reamer/facer tool.

When adjusting spring tension on a reamer/facer tool, it is important to not have too much or too little tension. If there is not enough tension, the conical pilot will be loose and jiggling in the head tube and a sloppy cutting job will be done. If there is excessive tension, then too much cutting will happen at once, resulting in greater heat, a rougher cut, and more wear and tear on the cutters.

9. [] Adjust spring tension to be just tight enough to keep conical pilot from moving when jiggled.

NOTE: If using a pilot and not a reamer, skip to step 13.

In step #10 generous amounts of cutting oil should be applied to the reamer. This is most easily done by rotating the frame so that the head tube is parallel to the floor. The addition of cutting oil improves the ease and quality of the cut and preserves the sharpness of the tool.

10. [] Apply generous amounts of cutting oil to reamer.

Whenever turning a reamer/facer, remember to always turn the tool clockwise, otherwise the tool will dull quickly.

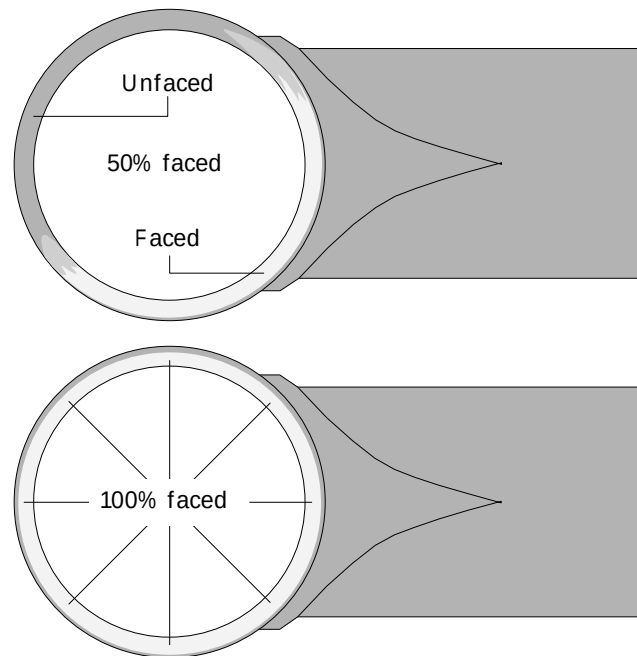
11. [] Turn reamer/facer handle *clockwise* several turns, then check whether conical pilot is still secure (if not, tighten tension device).

12. [] Add more cutting oil to reamer and repeat steps 10–12 until facer is in contact with end of head tube.

13. [] Apply generous amounts of appropriate type of cutting oil to facer.

14. [] Turn reamer/facer *clockwise* several turns.

In the next step, inspect the facing progress. A partially faced head tube will have freshly cut metal only for a portion of the 360° face. It is of no concern whether the width of the cut is uniform, only whether there is freshly cut metal for a full 360°. If it is not a full circle, continue on to step #16.



4.7 The cut needs to be a full 360° to be complete.

15. [] Loosen tension device, then pull facer away from head tube and check progress of cut.

16. [] If more facing is needed, repeat steps 13–16.

Under the pressure needed to cut metal, the facer can leave burrs when it stops. The next step is to spin the facer one more revolution under very light pressure to knock off any burrs. The brand of tool being used determines the appropriate technique for burr removal.

5 – MILLING THE FORK CROWN

ABOUT THIS CHAPTER

Milling the fork crown consists of two procedures. One is facing, which cuts the surface that the headset crown race sits on so that the surface is flat and perpendicular to the axis of the fork column. The other is counter-reaming, which is to cut the outside diameter of the fork-column base to change the fit of the fork-crown race.

Counter-reaming can be done without facing, but facing cannot be done without counter-reaming.

GENERAL INFORMATION

TERMINOLOGY

Counter-reaming: To reduce the outside diameter of a cylinder. In this case it is specific to the fork-column base where the fork-crown race fits.

Counter-reamer: A cutting tool that reduces the outside diameter of the fork-column base. The cutter teeth that do the counter-reaming also do the facing.

Facing: With regard to milling a fork crown, facing means to cut the top surface of the crown-race seat, so that the crown-race seat is flat and precisely perpendicular to the axis of the fork column.

Facer: The cutter that is used during facing. The teeth that do the facing also do the counter-reaming, also called a facing mill.

Fork crown: The large joining piece between the base of the fork column and the top of the fork blades.

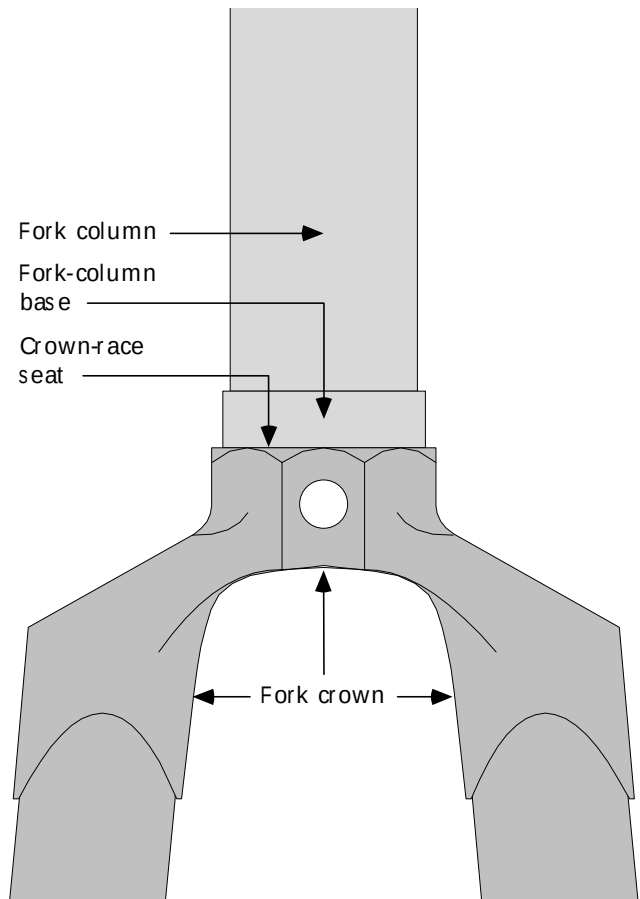
Fork column: The tube on top of the fork that goes inside the frame's head tube.

Fork-column base: The largest diameter portion of the fork column at its absolute bottom. The fork-crown race presses onto the fork-column base.

Crown-race seat: The top surface of the fork crown that the fork-crown race sits on.

Fork-crown race: The bottom piece of the headset, which presses onto the fork-column base. The fork-crown race is sometimes called the crown race.

Crown race: See fork-crown race.



5.1 Parts of the fork.

Pilot: The main body of the counter-reaming/facing tool. Some counter-reaming/facing tools have a hole through the body that acts as the pilot, and some counter-reaming/facing tools have an insert that is held in place by a set screw. The inserts can be changed to accommodate different sizes of fork columns.

1" fork: A fork column with a diameter of approximately 1". Headsets of several press-fit standards fit 1" forks.

1-1/8" fork: A fork column with a diameter of approximately 1-1/8". Headsets called 1-1/8" fit these forks.

1-1/4" fork: A fork column with a diameter of approximately 1-1/4". Headsets called 1-1/4" fit these forks.

PREREQUISITES

Stem removal and installation

In order to counter-ream or face the fork, the headset and fork must be removed. The stem must be removed before counter-reaming/facing can begin. At the completion of the job the stem will need to be replaced. If you are unfamiliar with stem removal and installation, see the **HANDLEBARS, STEMS, AND EXTENSIONS** chapter. In some cases the brake cable or front brake may need to be detached, or removed completely, in order to remove the stem.

Headset removal and installation

In order to counter-ream or face the fork, the headset and fork must be removed. At the completion of the job, the headset and fork will need to be replaced. If you are unfamiliar with these procedures see the **HEADSETS** chapter.

INDICATIONS

Symptoms indicating need of counter-reaming

One likely reason that a fork should be counter-reamed is that a JIS dimension headset has been removed and the replacement headset is of a different fit standard. Another likely reason is that a replacement fork is being installed that has a fork-column-base diameter that is too large for the existing fork-crown race.

Symptoms indicating need of facing

There is only one symptom that indicates a need for facing the crown-race seat. When attempting to adjust new, high-quality headsets, a condition becomes apparent in which the headset feels smooth through a portion of its rotation and tight in another portion of its rotation. This is called a tight/loose pattern. The tight/loose pattern can be caused by things other than a crown-race seat that needs facing, such as: low precision parts, worn out parts, bent fork column, head tube that needs facing, and mis-installed head-tube races or crown race. When a fork crown needs facing, it is due to poor quality of manufacturing, not abuse or wear.

When the head tube has been faced to eliminate a tight/loose pattern, the job is not complete until the crown-race seat has been faced as well.

Other reasons for facing the crown-race seat

Facing the crown-race seat is cheap insurance to enable easy adjustment of the headset and maximize parts longevity. For this reason, some shops will routinely counter-ream and face forks on higher priced bikes.

In the case that a shop sells framesets bare, it is good marketing technique to face forks before putting them out for display. Knowledgeable customers will look for whether facing has been done to evaluate whether the frame has been properly prepped for assembly.

TOOL CHOICES

The fit dimension of the headset crown race and the fork-column diameter are what determines what tool will be needed. The following list (table 5-1, page 5-2) covers all tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among ease of use, quality, versatility, and economy. When more than one tool for one function is **bold**, it means that several tools are required for different configurations of parts.

All dimensions are in millimeters because these are the only units used by manufacturers.

TIME AND DIFFICULTY

Milling the fork column is a job of moderate difficulty that takes approximately 10 minutes on a bare fork.

COMPLICATIONS

Multiple 1" fork-column standards

The traditional 1" fork-column size has multiple standard dimensions for the fork-column base. They are as follows:

26.5mm: Traditional size associated with Campagnolo and other professional quality headsets. Virtually all quality replacement headsets for 1" forks require this dimension.

26.6mm: Common to most Peugeot bicycles made in France, this size is close to, but not interchangeable with, the 26.5mm size. The counter-reamer for this dimension is required whenever installing a replacement fork on a Peugeot while keeping the original headset. This size counter-reamer is not needed if the customer is willing to always install new headsets with new forks on Peugeots.

27.1mm: Common to all Taiwanese and Japanese original equipment and replacement forks. This size counter-reamer is needed if this size fork is to be faced without having to change the headset.

Numerous others: Other sizes periodically pop up on obscure brands from Europe and American-made discount store bicycles. Counter-reamers are not available, so converting to the next smaller common size is the usual option.

Bulge-base and oversized fork columns

The counter-reamer body has a close tolerance hole for the fork column. Some fork columns are fatter than the standard that some counter-reamer pilots will not clear.

Suspension forks are the most common forks with bulged bases, but these are not much of a problem because their un-welded fabrication process allows greater precision during manufacturing.

Aluminum and carbon fiber forks often have a fatter fork column than normal. These forks may need counter-reaming or facing and the VAR 963 is the only tool that will fit.

Heavy build-ups of chrome or paint can also cause interference with the counter-reamer pilot. There is nothing that can be done about chrome, but paint can be sanded off with patience.

Titanium

Titanium has completely different metallurgical characteristics than steel or aluminum. It is necessary for the counter-reamer and facer to be designed in a

dramatically different way to be suitable for counter-reaming and facing titanium. Once a counter-reamer/facer is designed to be suitable for titanium it will no longer be suitable for other materials. Special facers for titanium may become available, but whether enough titanium forks will be encountered that need counter-reaming and facing is a significant question.

Aluminum

Aluminum is a perfectly suitable material for counter-reaming and facing, but presents some special concerns to the mechanic. *The type of cutting oil used is critical.* There are cutting oils made specifically for use on aluminum. Any cutting oil that is suitable will specify for use on aluminum on the container. Words like “all-purpose” and “multi-purpose” should not be interpreted to mean: includes aluminum.

Chrome-plating

Using a counter-reamer or facer on a chrome-plated fork crown will also dull it quickly. Facing a chrome-plated fork crown is very difficult to do, with the facer failing to get a bite at normal pressure. This job can be done with extremely high cutting pressure, but it is strongly advised against.

Chrome-plated crown-race seats should not be faced unless the chrome is first removed, a potentially difficult procedure. A file or grinding stone can be used for chrome removal. Counter-reaming can be done without facing, but it wears the tool severely.

FORK-COUNTER-REAMING/FACING TOOLS(table 5-1)

Tool	Fits and considerations
Bicycle Research FCS	Complete counter-reaming/facing tool with 26.5mm, 30.1mm, and 33.1mm counter-reamers
Bicycle Research FC2	Additional 27.1mm counter-reamer required if using Bicycle Research FCS to face 1" fork column with JIS dimensions
Campagnolo 718	Complete counter-reaming/facing tool with 26.5mm counter-reamer for 1" fork column
Campagnolo 718/80S	Complete counter-reaming/facing tool with 30.1mm counter-reamer for 1-1/8" fork column
VAR33AC (w/26.6 & 27.1 mills)	Complete counter-reaming/facing for JIS and French 1" fork columns
VAR 38D/4E	Additional 26.5mm & 27.2mm double-sided cutter needed for 1" fork columns if not using VAR 963C or Bicycle Research FCS, which include critical 26.5mm size
VAR 963C	Complete counter-reaming/facing tool with 26.5mm, 30.1mm, and 33.1mm counter-reamer (least interference w/ bulge-based fork columns of all models)
VAR 965	Complete counter-reaming/facing tool for 1-1/4" fork columns
VAR 966	Complete counter-reaming/facing tool for 1-1/8" fork columns

5 – MILLING THE FORK CROWN

Incomplete counter-reaming

After completing the counter-reaming and facing, it may appear that the counter-reaming was not completed because the counter-reamer has not left a 360° cut. This is normal and happens because the fork-column base is off-center to the axis of the fork column. In fact, in this case the counter-reaming that has occurred may be excessive.

Excessive counter-reaming

After using the correct counter-reamer, the fork-crown race may end up fitting loose. This usually occurs when an off-center fork-column base that did not actually need counter-reaming has been counter-reamed. The counter-reamer removes metal at the high points so that the average outside diameter is reduced when it was not required. There is no simple way to avoid this, except to eliminate paint when it causes the pilot to fit too closely. When excessive counter-reaming happens, the fork-crown race will need to be installed with Loctite RC680.

Excessive counter-reaming time

Most fork-column bases have already been counter-reamed to close to the correct size before the mechanic ever sees them. Using a counter-reamer on one of these will be a very quick process. On the other hand, the counter-reamer is sometimes used to convert a fork-column base from a 27.1mm size to a 26.5mm size. When using a counter-reamer to make this conversion, instead of simply to improve an existing fit, then expect it will take 5–10 extra minutes to cut this much metal.

Unusable tension devices

It is not unusual for the fork-column length to be too short or too long to use a tension device on the counter-reaming tool. This is not a problem, and the procedure can be done easily without the use of a tension device.

CARE OF COUNTER-REAMING AND FACING TOOLS

Counter-reaming and facing tools are very expensive and easily damaged. Proper cutting technique is important to get good life from them, but that is not all. When storing counter-reamer/facers make sure they are clean and coated with oil. The cutting edges are easily chipped by light impact with other metal objects, so handle them and store them in a way that this will not happen. On hooks on a pegboard is a good way to store facing tools.

When cleaning counter-reamers and facing tools use a brush and solvent. Blowing them clean with compressed air is not damaging to the cutting edges but is dangerous because of flying metal debris. Coat the cutter with a light oil after cleaning and drying.

COUNTER-REAMER SIZE REQUIREMENTS

The I.D. of the fork-crown race that will be pressed onto the fork-column base determines the correct size of counter-reamer to use. If replacing the headset, be sure to measure the new headset. *Do not measure the O.D. of the fork-column base to determine the counter-reamer size.*

Measure the I.D. of the fork-crown race (see figure 5.2) that will be pressed onto the fork-column base, find the range that includes this measurement in the **Race I.D.** column in table 5-2, and look to the right in the **Counter-reamer size** column in table 5-2 to determine the correct size to use.

All dimensions are in millimeters because these are the only units used by manufacturers.

COUNTER-REAMER SIZES (table 5-2)

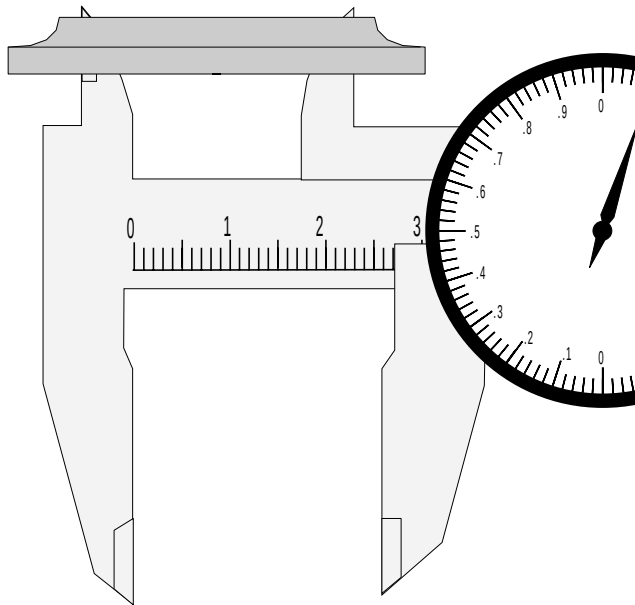
Race I.D.	Counter-reamer size
26.30–26.40mm	26.5mm
26.41–26.50mm	26.6mm
26.90–27.00mm	27.1mm
29.90–30.00mm	30.1mm
32.90–33.00mm	33.1mm

FORK COUNTER-REAMING AND FACING PROCEDURE

Fork counter-reaming and facing can be done at the same time with a single tool, or counter-reaming can be without facing (depending on the desire for facing). Only one procedure is described here, despite the above-mentioned choices, because the difference in the required procedure for each choice is minimal. This procedure is written on the assumption that counter-reaming and facing will be done at the same time. If counter-reaming only, simply stop the procedure when the counter-reaming has been completed.

All dimensions are in millimeters because these are the only units used by manufacturers.

1. [] Use appropriate procedure/worksheet to remove headset and fork.



5.2 Measuring the fork-crown race to determine the correct counter-reamer size.

2. [] Measure I.D. of fork-crown race to be installed and record here: _____ mm.

Some sizes of fork-crown races are extremely close without being interchangeable. Measurement to the nearest .05mm is required.

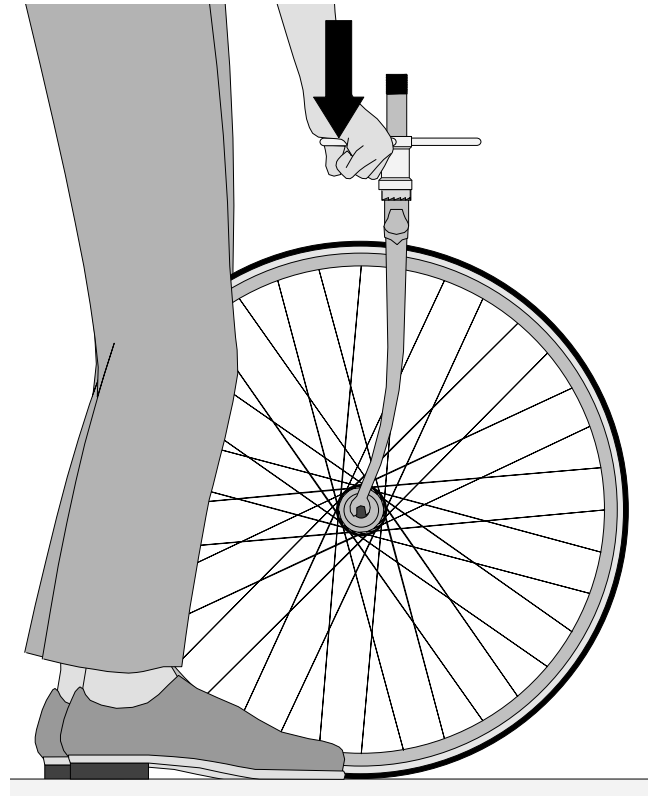
3. [] Look up appropriate counter-reamer dimension on COUNTER-REAMER SIZES table 5-2 and record here: _____ mm.

The only way to determine the size of some counter-reamers is to measure the I.D. with a caliper. This is particularly true when determining the size of VAR double-ended counter-reamers, which are marked with two sizes, but are not marked as to which end is which size.

4. [] Check or install correct size counter-reamer on tool.

There are two good ways to hold the fork while doing the procedure.

The simplest way is to mount the fork on a quick release front wheel (it's best to have an old dead wheel around just for this purpose). Stand facing the front of the fork. With the wheel on the floor, stand straddling the front of the wheel to stabilize it. Lean over the fork and wheel to use the tool and apply cutting pressure.



5.3 Using a wheel to hold a fork that is being counter-reamed and faced.

Another very effective method for holding the fork is to salvage any old quick release hub and use some sort of metal straps to secure it to the middle of a 2' x 2' piece of plywood or chip board. Clamp the fork (standing straight up) to the hub and lean over the fork to operate the tool and apply cutting pressure. This system is more stable than the wheel mounting system, but requires bending over further.

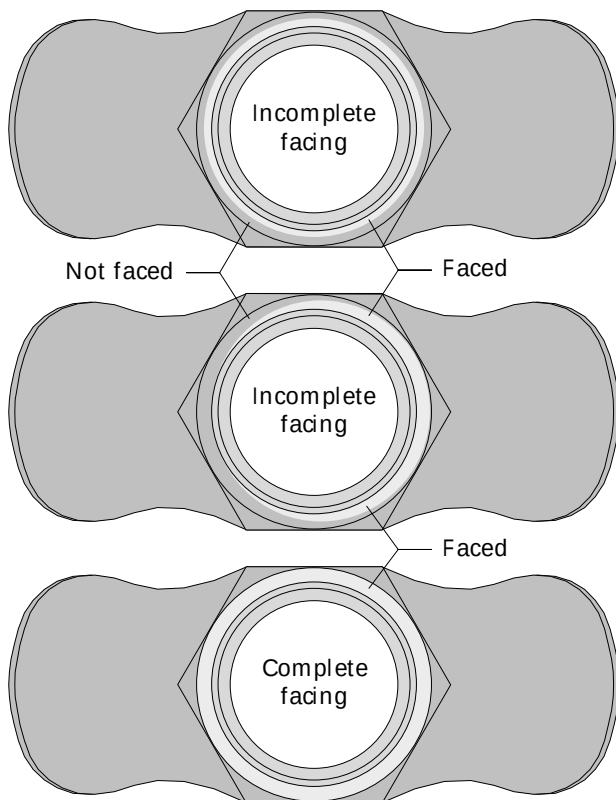
5. [] Mount fork on front wheel or fork platform (see explanatory notes).

Cutting oil is vital to the quality of the cutting and the life of the cutting tools. Apply oil liberally when starting and as you continue to cut. Use oil labeled for use on aluminum when cutting aluminum.

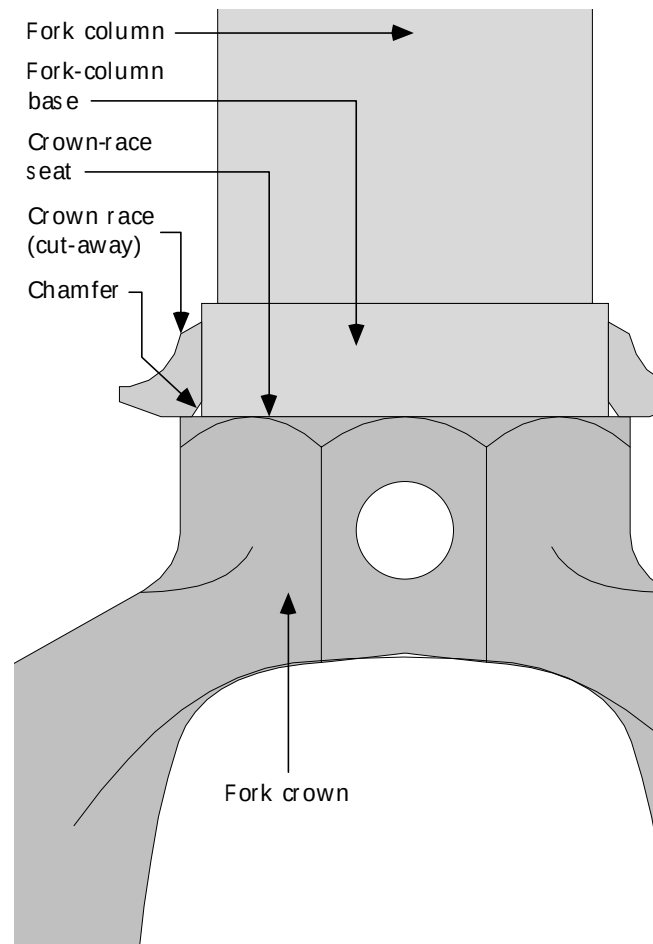
5 – MILLING THE FORK CROWN

6. [] Apply ample cutting oil to crown-race seat and counter-reamer.
7. [] Place tool on fork column.
8. [] With weight on handles, turn tool clockwise several full turns.
9. [] Pull tool up to check progress of counter-reaming or facing.
10. [] If counter-reaming only, repeats steps 6–10 until fork-column base is counter-reamed fully at outer perimeter.

With bottom bracket and head-tube facing, the only factor determining whether the facing is completed is whether fresh metal has been cut for a full 360°. The nature of the fork-crown race requires that this complete 360° cut be at the outer perimeter of the crown-race seat or it may be ineffective. A continuous 360° cut adjacent to the fork-column base, but not complete all the way around the outer perimeter of the crown-race seat, will not do the job. This is because many fork-crown races have a chamfer on the inner perimeter of the bottom face of the race (see figure 5.5). If the cut portion of the crown-race seat does not extend beyond the diameter of this chamfer, then the fork-crown race may not be sitting on faced surface at all.



5.4 Face the crown-race seat until there is a complete 360° cut at the outer perimeter of the crown-race seat.



5.5 The chamfer at the inner edge of the bottom face of the crown race makes it necessary to face the crown-race seat all the way to the outer perimeter of the crown-race seat.

11. [] If facing, repeats steps 6–11 until facing cut is a complete 360° at outer perimeter of crown-race seat.
12. [] Remove tool from fork.
13. [] Remove fork from front wheel or from fork platform.
14. [] Clean fork and tool.
15. [] Use appropriate procedures/worksheets to install fork, headset, and stem as necessary.

6 – SIZING AND THREADING FORK COLUMNS

ABOUT THIS CHAPTER

This chapter is divided into two sections. The first is about sizing the fork column, which includes procedures for threaded and unthreaded columns, and the second section is about repairing fork-column threads or adding fork-column threads.

SIZING FORK COLUMNS

TERMINOLOGY

Fork column: The tube on the top of the fork that goes inside the head tube of the frame.

Screwed race: The portion of a threaded headset that threads onto the fork column directly against the upper bearings.

Threadless headset: A headset that does not thread onto a fork column; instead, the stem slips over the upper end of the fork column and is set against the topmost race of the headset and secured, which in turn sets the headset adjustment.

Threadless-fork column: A fork column that has no threads. A threadless-fork column must be used with a threadless headset.

PREREQUISITES

Stem and headset removal and installation

Sizing a fork column is generally done when installing a new fork in a bike. To do this, the stem and headset must be removed. At the completion of the fork sizing, the stem and headset will need to be installed. If unfamiliar with stem removal and installation, see the **HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS** chapter (page 28-5). If unfamiliar with headset removal and installation, see the **HEADSET** chapter (page 11-9). In some cases the brake cable or front brake may need to be detached or removed in order to remove the stem.

INDICATIONS

The only reason for sizing a fork column is because a replacement fork is being installed and its fork column is too long for the combination of head tube length and headset height being used. A replacement fork might be installed because: the original one is damaged, the original one has a fork column that is too short, and the original one is being upgraded.

TOOL CHOICES

The diameter of the fork column determines which of several tool choices you will need. In the below list (table 6-1) there are several mitre jigs listed for aligning the saw blade when cutting the fork. These jigs for threaded-fork columns are unneces-

FORK-COLUMN-SIZING TOOLS (table 6-1)

Tool	Fits and considerations
Park FCG-1 plus 637 & 638	Fork alignment jig with inserts for all sizes of fork columns that doubles as a holder for fork column sizing
Bicycle Research FB1, FB2, & FB3	1", 1-1/8", and 1-1/4" clamp blocks that can be used as an inexpensive alternative to the Park FCG-1
Used 1" steel screwed race	Free guide used with Park FCG-1 for cutting 1" fork columns
Used 1-1/8" steel screwed race	Free guide used with Park FCG-1 for cutting 1-1/8" fork columns
Used 1-1/4" steel screwed race	Free guide used with Park FCG-1 for cutting 1-1/4" fork columns
Hacksaw	28–32 teeth per inch
Stein CG-3	Threadless-fork mitre that fits 1", 1-1/8", and 1-1/4" forks
Park SG-5	Threaded-fork mitres that fit 1", 1-1/8", and 1-1/4" forks
Stein CG-1	Threaded mitre for 1" × 24tpi
Stein CG-8	Threaded mitre for 1-1/8" × 26tpi
Stein CG-4	Threaded mitre for 1-1/4" × 26tpi
Park SG-6	Threadless-fork mitre that fits 1", 1-1/8", and 1-1/4" forks

6 – SIZING AND THREADING FORK COLUMNS

sary if the shop is equipped with a Park FT-4 or Park FCG-1 fork alignment jig. These jigs, in conjunction with a used steel screwed race for each diameter of fork column, make a more-than-adequate jig for aligning the saw blade. The mitre jigs are indispensable for threadless forks. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is in **bold** it means that different tools are required for different configurations of parts.

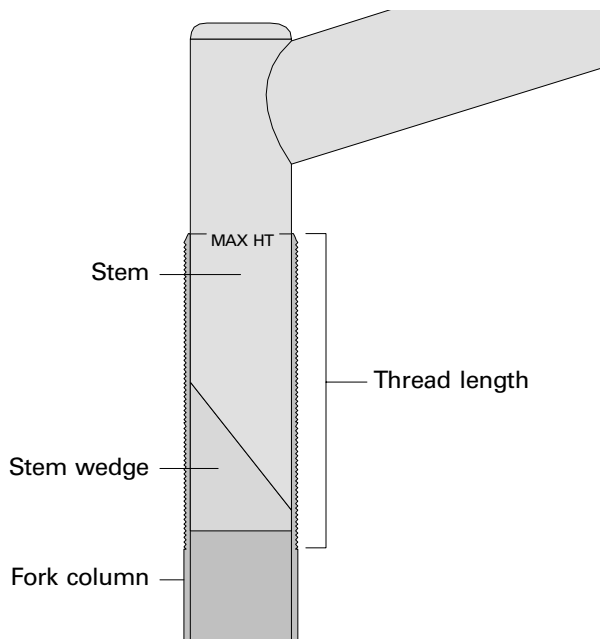
TIME AND DIFFICULTY

On a bare fork, sizing the fork column is a 5–7 minute procedure of little difficulty.

COMPLICATIONS

Too much thread left

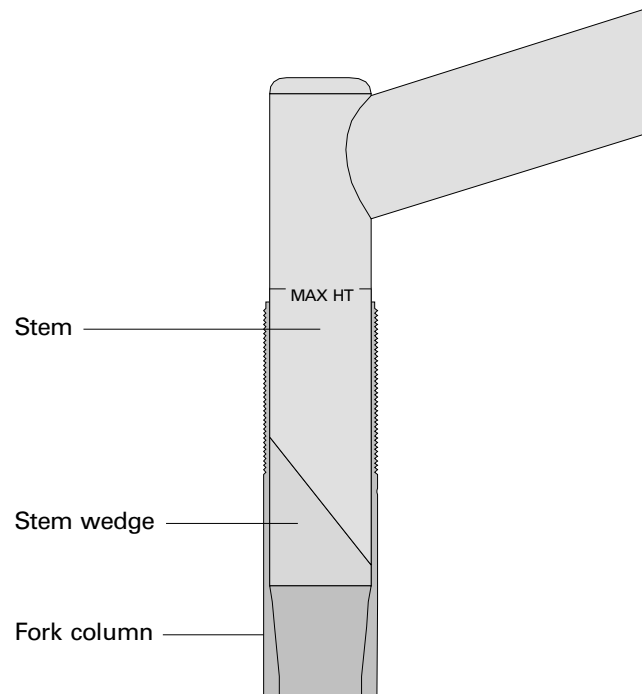
It is possible to have too much thread on the fork column after sizing it. For safety, it is important that the stem wedge end up below the threaded portion of the fork column, so that the fulcrum and stress is not in the weak threaded portion of the fork column. The only way to prevent this is to start with a fork that is not threaded too far down. In borderline situations it may be necessary to insert the stem so that the minimum insertion or maximum height mark is below the top of the fork. If this positions the bars too low, then a stem with more height should be installed.



6.1 The fork-column thread is too long if the bottom of the stem/wedge is above the bottom of the thread.

Stem will not go in far enough

With some short frames, the fork column can end up short enough that the stem will not install far enough. Near the base of the fork column the I.D. is usually reduced to take advantage of the strength that a thicker wall provides. On most forks, the diameter reduction is well below the deepest point the stem inserts to. On short fork columns, the diameter reduction interferes with stem insertion. Different forks start this diameter reduction at different heights. The best way to check for this problem before cutting the fork is to insert a seat post of the same diameter as the stem into the fork column, and see how far it will install. Some BMX seat posts are the same diameter as the common 22.2mm stem. A 25.4mm seat post is close enough to the size of stem that goes in a 1-1/8" fork column. A 28.6mm seat post is a decent fit inside a 1-1/4" fork column.



6.2 The fork is unacceptable because the stem will not install far enough because of the change of diameter inside the fork column.

Cut too short

If the fork column has been cut too short and the headset locknut will not engage properly, try the following procedures.

Try dispensing with any simple flat washers in the headset. They are used to adjust stack height and improve locknut security. Locknut security can be improved with Loctite 242 instead.

If there are any brackets for reflectors, consider an alternate location. If there is a brake cable hanger, consider one built into the stem. It may also be possible to find thinner brackets. Consider a new headset with a shorter overall stack height.

Use a head tube reamer/facer to shorten the head tube. It is best to remove material from the top as much as possible before removing any from the bottom. Shortening the head tube is a drastic solution that should only be considered when all other alternatives have been exhausted.

Cut too long

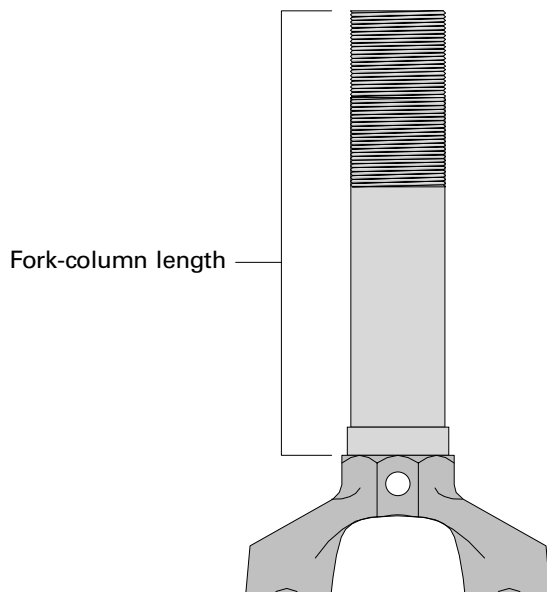
If for some reason, the fork column has been cut too long, and the headset locknut will not tighten against the headset washers and screwed race, add more washers to the headset. This correction will work for error less than or equal to 5mm. For error greater than 5mm, cut the fork column to the appropriate length.

THREADED-FORK-COLUMN SIZING PROCEDURE

1. [] Use appropriate procedure/worksheet to remove headset and fork.

Determine the correct fork-column length by one of two methods.

If replacing an existing fork and re-using an existing headset, then determine the correct fork-column length simply by measuring the fork that is being replaced. Measure from the top of the fork column down to the crown-race seat (top of the fork crown).

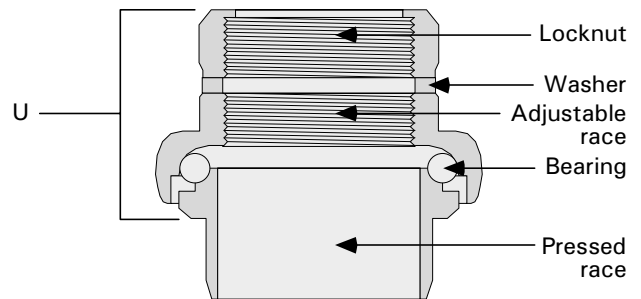


6.3 Measure fork-column length here.

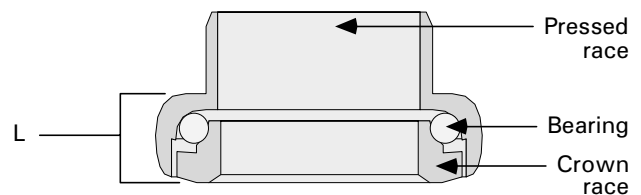
If there is no original fork to measure, or if you do not know whether the original fork column was a suitable length, or if the headset is being changed, then the correct fork-column length must be calculated by adding the headset stack height to the head tube length.

The headset consists of two *stacks*. The lower stack consists of: the fork crown race, lower ball bearings, and lower race (which is pressed into the head tube). Assemble these parts and measure all but the portion of the lower head tube race that is inserted inside the head tube. This combined measurement is the lower stack height.

The upper stack consists of: the upper race (which is pressed into the head tube), the upper ball bearings, the race that screws onto the fork column, any washers that will be used, any brackets (reflector or brake cable hanger) that will be used, and the locknut(s). Assemble and measure the upper stack except for the portion of the upper head tube race that will be inserted in the head tube, then subtract 2mm to determine the upper stack height.



$U - 2 =$ upper stack height



$L =$ lower stack height

6.4 Measure U , then subtract 2mm to determine the upper stack height of the headset. Measure L to determine the lower stack height of the headset.

The correct fork-column length is the sum of the lower stack height, the upper stack height, and the head tube length.

2. Determine correct fork-column length by one of these two methods:

[] If using same headset, measure existing fork column and record length here: _____ mm.

[] If installing new headset or there is no original fork to match:

Measure head tube length: _____ mm

Measure headset lower stack: + _____ mm

Measure headset upper stack: + _____ mm

Total is correct column length: = _____ mm

6 – SIZING AND THREADING FORK COLUMNS

When sizing the new fork, it is easier to set the mitre to the correct position to remove the *excess* length than it is to set the mitre to leave the *correct* length. For this reason, the calculated-correct length is subtracted from the new fork's actual length to determine the amount of excess to remove (in the next step).

3. [] **Measure new fork-column length and record here:** _____ mm.

4. [] **Determine excess column to remove:**

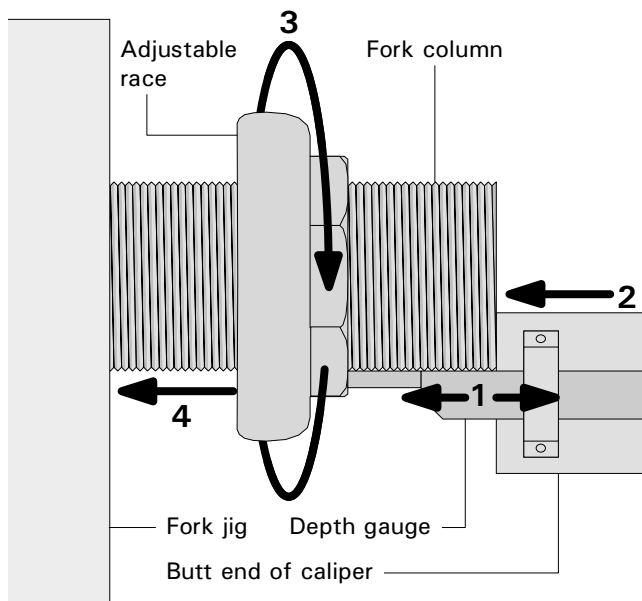
Step 3 length: _____ mm

Subtract step 2 length: - _____ mm

Excess to remove: = _____ mm

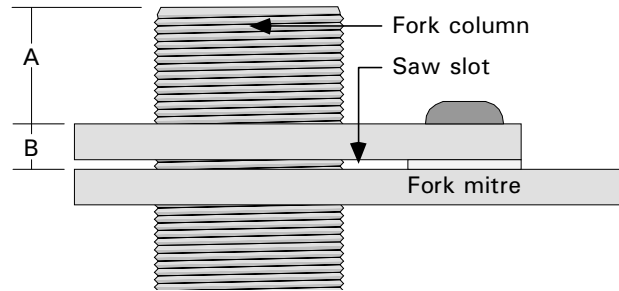
Setting the fork in the correct position to cut just the right amount of excess off is a different procedure depending on what system is being used to guide the hacksaw blade. Either a fork alignment jig and old steel screwed race can be used, or a threaded-fork mitre jig.

To set up the fork-alignment-jig system, insert the fork in a Park FT-4 or Park FCG-1, but do not secure it; later, when the length to be cut off has been set, the fork will be secured in the jig. Bicycle Research frame tube blocks (in the appropriate size) provide an inexpensive way to hold the fork column in a vise. Thread on an appropriately-sized steel headset race. Set the depth indicator of a caliper to the dimension of the excess length to be removed and use the caliper to position the screwed race so that only the excess length is exposed past the screwed race. Slide the fork in the alignment jig so that the screwed race butts against the jig, then clamp the fork column securely in the jig.



6.5 To set the proper amount of fork column to be removed; 1. set the depth gauge of the caliper to the desired amount, 2. butt the end of the caliper against the end of the fork column, 3. rotate the adjustable race up the fork column until it butts against the depth gauge, 4. slide the fork-column assembly until the race butts against the fork jig.

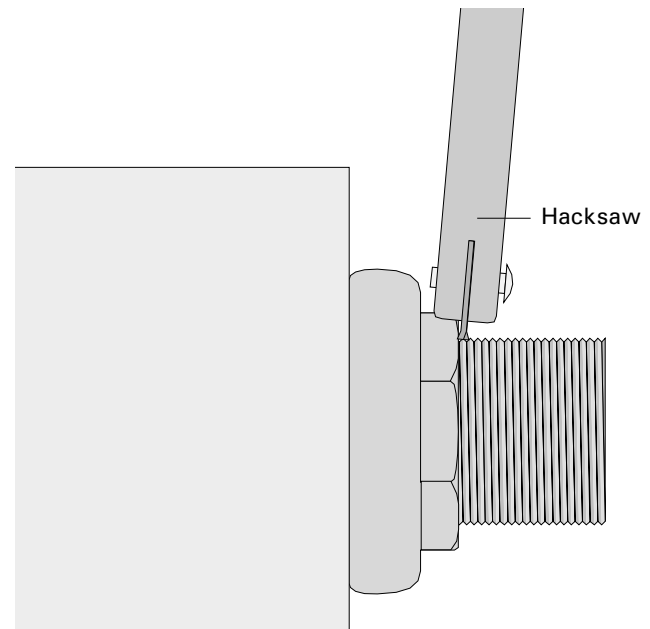
If using a threaded mitre jig, then the distance from the bottom edge of the saw blade slot to the top face of the mitre must be measured. This dimension must be subtracted from the excess column length to be removed. Adjust the fork in the mitre until the amount of exposed fork column is equal to the amount of this calculation.



6.6 A plus B equals excess fork-column length.

5. [] **Insert fork in mitre or saw guide system and adjust so blade will remove no more column length than step 4.**

When cutting the column using an old steel screwed race as a guide, angle the hacksaw slightly towards the screwed race to get as flush a cut as possible. The screwed race will be of a hard enough steel that the saw blade will not cut it. Use a bastard file to file the cut flush to the face of the screwed race if the hacksaw does not cut flush.



6.7 Angle the hacksaw blade towards the screwed race.

If using a threaded mitre, make sure that the fork column does not rotate in the mitre during the cut.

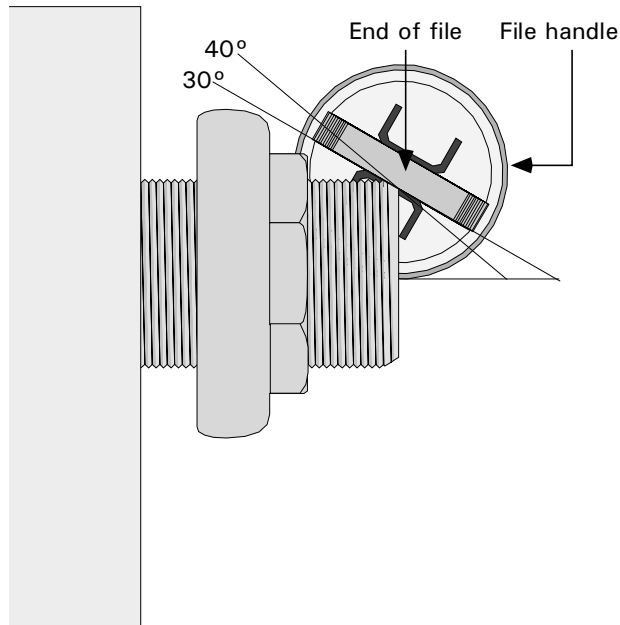
6. [] **Cut off excess column length.**

The saw will leave a burr inside the fork column that will interfere with stem installation. Use a deburring tool (United Bicycle Tool GN-BHE) or a small round file to remove this burr.

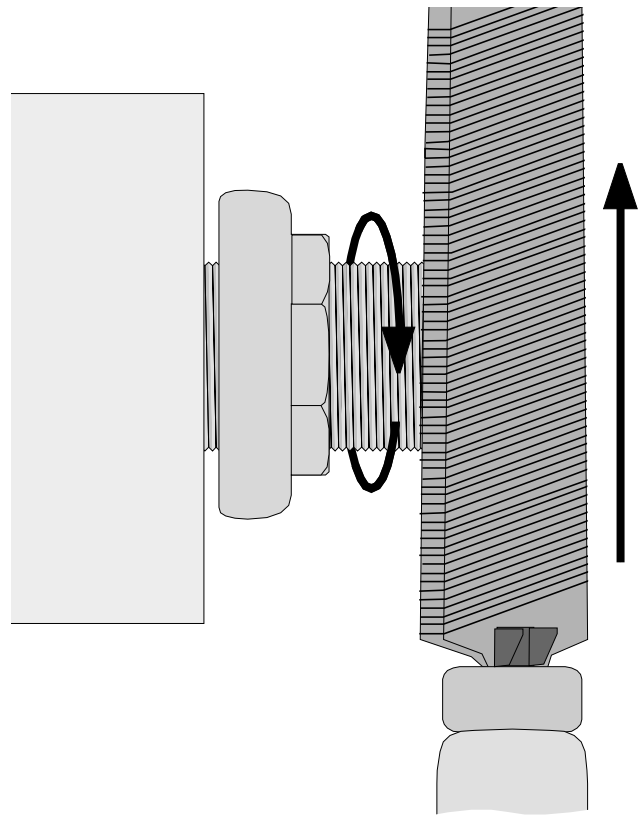
7. [] Remove burr inside fork column.

The saw cut leaves the first thread on the fork column in a condition that will make it difficult to start a screwed race when assembling the headset. The technique to improve the first thread differs depending on which system was used to guide the saw.

If the system used was the fork alignment jig and the used steel race, loosen the alignment jig clamp, push the fork through, and thread down the screwed race so that it is about 10mm from the end of the fork column. Leave the clamp loose enough so that the fork can easily be rotated. Put a flat mill bastard file on the cut end of the fork column at an angle that is closer to parallel to the axis of the column than it is perpendicular to the axis of the column (between 30° and 40°). Push the file forward while rotating the fork against the direction of the file stroke. Continue rotating and filing around the column several revolutions until there is a taper all the way around with a length of one to two threads.



6.8 *Filing a taper on the end of the fork. The file should be used at an angle of 30–40° from the axis of the fork column.*



6.9 *Filing a taper on the fork threads.*

If using a threaded-fork mitre, remove the mitre from the vise but not the fork and thread it down the fork column so about 10mm of thread is exposed. Holding the fork in your hand, use a mill bastard file to file a steep taper all the way around the end of the fork column that is one to two threads long.

8. [] Taper outside thread.

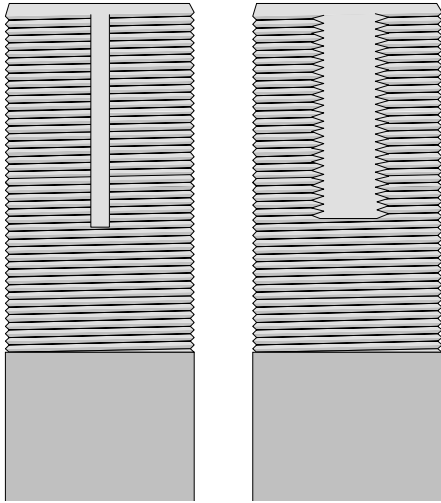
To chase the threads, simply unthread the mitre or screwed race that was used to guide the saw.

9. [] Chase threads.

Most forks come with a slot in the threads that accommodates a key on a headset washer. Sometimes when a fork column is shortened there is not enough slot length left. It is difficult and unnecessary to lengthen the slot. The easiest solution is to remove the key from the washer or brackets. The key is a convenience item, but not required; in fact, the washer or bracket with the key often rotates, and when the key rotates out of its slot, it mangles threads.

6 – SIZING AND THREADING FORK COLUMNS

If it is desired to keep the key and slot system, extend the slot with the edge of a small (6") flat file, or with the edge of a grinding disk on a rotary tool. Another alternative is to file the threads flat. This will allow the key to rotate some, but not all the way around the fork column.



6.10 On the left are fork threads with a slot in them; on the right are fork threads that have been filed flat.

10. [] **Modify or replace headset washers if slot in fork-column threads is no longer long enough to accommodate key in any keyed washers.**
11. [] **Use appropriate procedure/worksheet to install fork, headset, and stem.**

THREADLESS-FORK COLUMN SIZING PROCEDURE

1. [] **Use appropriate procedure/worksheet to remove headset and fork.**

Determine the correct fork-column length by one of two methods.

If replacing an existing fork and re-using an existing headset, then determine the correct fork-column length simply by measuring the fork that is being replaced. Measure from the top of the fork column down to the crown-race seat (top of the fork crown).

If there is no original fork to measure, or if you do not know whether the original fork column was a good length, or if the headset is being changed, then the correct fork-column length must be calculated.

To calculate the correct fork-column length, assemble the headset into the head tube and place the fork into the headset. Put all washers and brackets in place that will be between the top of the headset and the stem. Slide the stem onto the fork column, but do not secure it. Measure the amount of fork column ex-

tending above the stem. Add 3mm to the amount of fork column exposed to determine the amount of excess length. When assembled, the top of the fork column is supposed to be 3mm below the top of the stem.

2. **Determine correct fork-column length by one of these two methods:**

[] **If using same headset, measure existing fork column and record length here: _____ mm.**

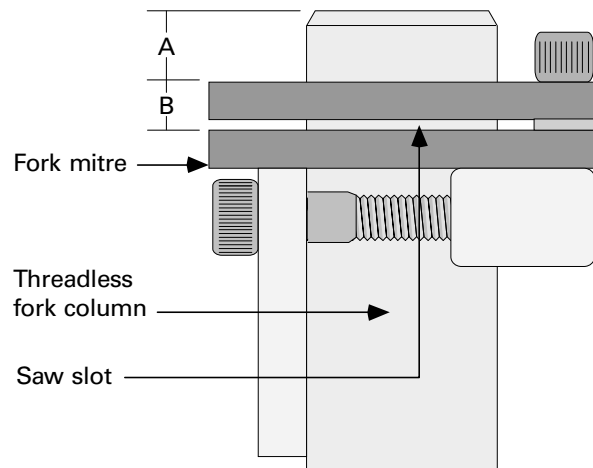
[] **If installing new headset, or there is no original fork to match, assemble fork and headset into frame and install stem:**

Measure protruding column: _____ mm

Add 3mm: _____ + 3 mm

Total is excess column length: = _____ mm

Setting the fork in the correct position to cut exactly the right amount of excess off is simply of a matter of putting the jig on the fork column and measuring from the top of the jig to the end of the fork. This dimension should be the excess length minus the distance from the bottom of the saw slot to the top face of the jig.



6.11 A plus B equals excess fork-column length.

3. [] **Remove fork from headset.**
4. [] **Insert fork in mitre, so blade will remove no more column length than step 2.**
5. [] **Cut off excess column length.**
6. [] **Remove cutting jig from fork column.**

The saw will leave a burr on the inside of the fork column that will interfere with star-nut or expansion plug installation. Use a deburring tool or a small round file to remove this burr.

7. [] **Remove burr inside fork column.**

The saw cut will leave a burr on the outside of the fork column that will make it difficult to slide the stem on. Use a mill bastard file to lightly dress the outside edge of the cut.

8. [] **File off burr on outside of column.**

9. [] **Use appropriate procedure/worksheet to install fork, headset, and stem.**

FORK-COLUMN- THREAD CHASING AND EXTENDING

TERMINOLOGY

Thread die: Sometimes referred to as just “die,” is a tool for cutting or improving external threads. It is the opposite of a tap.

Thread chasing: Sometimes referred to as just “chasing,” it is to use a die to improve the condition of existing threads.

PREREQUISITES

Stem and headset removal and installation

Chasing threads, or extending threads, on a fork column is done when a fork is out of the bike. In order to chase or extend threads, the headset and fork must be removed. The stem and headset must come out to do this if they are in place when the job is begun. At the completion of the job, the stem and headset will need to be replaced. If unfamiliar with stem removal and installation, see the **HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS** chapter (page 28-5). If unfamiliar with headset removal and installation, see the **HEADSET** chapter (page 11-9). In some cases the brake cable or front brake may need to be detached or removed in order to remove the stem.

INDICATIONS

Symptoms indicating need for thread chasing

Thread chasing on a fork column is needed whenever parts are difficult to thread on or off of the fork. The cause may be cross-threading a part on, threads damaged from impact while exposed, rust on the threads, or damage from a key on a washer or bracket that has been rotated out of its slot and into the threads.

Symptoms indicating need for thread extending

The threads need to be extended whenever the fork that must be used does not have enough thread for the screwed race to thread all the way down to compress the bearings between the stationary and rotating upper races of the headset. The usual cause for this problem is that an inappropriate fork has been selected as a replacement. *Always pursue to the limit the option of finding a fork with more threads before cutting a fork that will need its threads extended.* On rare occasions there is no fork available that has threads far enough down the fork column.

TOOL CHOICES

Tool choices are determined in part by the diameter and thread description of a particular fork column that will be chased or have threads extended. The following list (table 6-2) covers all tools required for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is in **bold** it means that different tools are required for different configurations of parts.

FORK-THREAD-DIE TOOLS (table 6-2)

Tool	Fits and considerations
Campagnolo 714	Complete handle and die for BSC 1" × 24tpi (not useable for extending threads)
Campagnolo 714/F	25mm × 1mm French die for Campagnolo 714
Campagnolo 714/I	25.4mm × 24tpi Italian die for Campagnolo 714
Campagnolo 714/80S	Complete handle and die for 1-1/8" × 26tpi threads
Hozan C421	Complete handle and die for BSC 1" × 24tpi threads
Hozan C421/8	Complete handle and dies for BSC 1" × 24tpi and 1-1/8" × 26tpi threads
Hozan C432	Complete handle and dies for 1-1/8" × 26tpi and 1-1/4" × 26tpi threads
Park FTS-1	Complete handle, dies, and pilots for BSC 1" × 24tpi, 1-1/8" × 26tpi, and 1-1/4" × 26tpi threads
VAR 40S	Complete handle and die for BSC 1" × 24tpi threads
VAR 40S18	Complete handle and die for 1-1/8" × 26tpi threads
VAR 40S14	Complete handle and die for 1-1/4" × 26tpi threads

TIME AND DIFFICULTY

This moderately difficult job takes a highly variable amount of time depending on the amount of thread length that needs to be added; furthermore, frequent long pauses are required to allow the material to cool. The actual working time could easily vary from 5 to 30 minutes.

COMPLICATIONS

Threads too stripped to fix with chasing

Threads can strip to the point that chasing them with a die will not restore their usability. If this is suspected, chase them anyway and try torquing the screwed race and locknut together on the fork column with all the washers and brackets that will be used between them. If the threads hold up to this torque test then the fork is useable. If not, a new fork is needed.

Chrome-moly steel making fork unsuitable for thread extension

The tools used for extending threads are not actually designed for that purpose. With softer metals it usually can be done, but even with the best of tools and techniques the result on high quality chrome-moly tubing may be disastrous, resulting in a trashed fork and a dull die.

Titanium

Titanium has completely different metallurgical characteristics than steel or aluminum. It is necessary for the die to be designed in a dramatically different way to be suitable for threading titanium. Once designed to be suitable for titanium it will no longer be suitable for other materials. Special dies for titanium are not yet available, but whether enough titanium forks will be encountered that need thread repair or extension is a significant question.

Aluminum

Aluminum is a perfectly suitable material for threading, but presents some special concerns to the mechanic. *The type of cutting oil used is critical.* There are cutting oils made specifically for use on aluminum. Any cutting oil that is suitable will specify for use on aluminum on the container. Do not interpret words such as “all-purpose” and “multi-purpose” to mean: includes aluminum.

For good quality results it is also critical that the die be very sharp.

Chrome plating

Chrome-plated fork columns can be threaded, but it wears the tool much faster.

CARE OF FORK-COLUMN-THREADING TOOLS

Fork-column-threading tools are very expensive and easily damaged. Proper cutting technique is important to get good life from them, but that is not all. When storing fork-column-threading tools make sure they are clean and coated with oil. The cutting edges are easily chipped by light impact with other metal objects, so handle them and store them in a way that this will not happen. On hooks on a pegboard is a good way to store fork-column-threading tools.

When cleaning fork-column-threading tools use a brush and solvent. Blowing them clean with compressed air is not damaging to the cutting edges but is dangerous because of flying metal debris. Coat the cutter with a light oil after cleaning and drying.

THREAD DESCRIPTIONS

Table 6-3 shows the pitch and diameter measurements for all fork-thread types. Diameters can vary slightly within a range but still be the same standard.

FORK-THREAD TYPES (table 6-3)

Pitch	Measured O.D.	Thread name and nominal description
24tpi	25.1–25.3mm	BSC 1" × 24tpi
24tpi	25.1–25.3mm	Italian 25.4mm × 24tpi*
1mm	24.7–24.9mm	French 25mm × 1mm
26tpi	28.3–28.5mm	Oversize 1–1/8" × 26tpi
26tpi	31.5–31.7mm	Oversize 1–1/4" × 26tpi

* Italian is interchangeable with BSC. After chasing an Italian thread with a BSC die, the head-set should still fit.

FORK-THREAD-CHASING PROCEDURE

1. [] Measure thread pitch and record here (circle correct units): _____ mm/tpi.
2. [] Measure fork thread outside diameter and record here: _____ mm.
3. [] Find in FORK-THREAD TYPES (table 6-3) matching pitch and diameter and record corresponding nominal description here: _____.

4. [] Verify die of correct thread type is in handle.

VAR and Hozan dies have adjustable diameters. In the next step, the die diameter needs to be enlarged. A set screw or bolt, 90° from the split in the die, needs to be loosened to allow expansion. A set screw or bolt at the split is tightened to expand the die. Once the diameter is set, the set screw or bolt 90° from the split is tightened to secure the die in the handle.

5. [] If die diameter is adjustable, adjust to largest diameter.
6. [] Apply cutting oil to threads and die.

When cutting threads, always use a technique called “cut-and-clear.” Once resistance is encountered by the die, advance it no more than 1/4 turn. This is the “cut” segment. After the cut has been done, back the die off about 1/2 turn. This is the “clear” segment, named so because this action clears the fresh cut fragments away from the cutting edges. Advance the die until resistance is encountered again, and repeat the cut-and-clear technique.

7. [] Thread die onto fork, using cut-and-clear technique when resistance is encountered (adding cutting oil repeatedly).

If an adjustable die was used for the first pass, it probably did the bulk of the thread clean-up, but another pass is needed to finish. In the next step the die is adjusted again, preferably while on a portion of the threads where there is no damage. When making the adjustment, the die should jiggle imperceptibly, or if there is no jiggle it should be clear that no cutting is occurring when the die is rotated in the undamaged portion of the threads.

8. [] If die diameter is adjustable, adjust die diameter to as snug as possible without cutting, on portion of thread where no damage was evident.
9. [] Run die over full length of damaged threads, using cut-and-clear technique when resistance is encountered (adding cutting oil repeatedly).
10. [] Remove die and clean fork and tool.

FORK-THREAD-EXTENDING PROCEDURE

1. [] Determine length of additional thread needed and note here: _____ mm.
2. [] Measure thread pitch and record here (circle correct units): _____ mm/tpi.
3. [] Measure fork thread outside diameter and record here: _____ mm.
4. [] Find in FORK-THREAD TYPES (table 6-3) matching pitch and diameter and record corresponding nominal description here: _____.

5. [] Verify die of correct thread type is in handle.

VAR and Hozan dies have adjustable diameters, by virtue of a split in the die. Brands of dies that have no split cannot be used for extending threads. In the next step, the die diameter needs to be enlarged. A set screw or bolt, 90° from the split in the die, needs to be loosened to allow expansion. A set screw or bolt at the split is tightened to expand the die. Once the diameter is set, the set screw or bolt 90° from the split is tightened to secure the die in the handle.

6. [] Adjust die to largest diameter (handle should jiggle up and down obviously).

7. [] Apply cutting oil to threads and die.

In the next step, thread the die down as far as it easily goes. Once resistance is met, the die is all the way down the existing threads and the cutting of new threads is about to begin. Use a caliper to measure how far the die is from the top of the fork column so that the progress of extending the threads can be monitored.

8. [] Thread die onto fork until die reaches end of existing threads.

9. [] Use depth gauge to measure exposed thread from top of fork column to top of die and record here: _____ mm.

10. [] Add step 1 to step 9 to determine amount of exposed threads that will be above die when extending threading is complete. Note result of calculation here: _____ mm.

Extending the threading on a fork is a misuse of a fork die. What is likely to suffer, however, is the fork. If extreme care is not taken to avoid heat buildup, then the fork column will expand in the die, resulting in galled threads and undersized thread diameter. Four techniques can be used in combination to avoid heat buildup.

Use an expandable die so that the threads can be cut to partial depth on the first pass, and then be cut progressively deeper on the second pass and the last pass.

6 – SIZING AND THREADING FORK COLUMNS

Use a very conservative cut-and-clear technique.

Advance the die no more than 1/8 turn into the resistance (cut), then back off 1/4 turn (clear) before starting again.

After completing one complete revolution of the die, take a break for long enough to be sure all heat has dissipated. Fifteen minutes should generally be enough. Compressed air could be used to speed the cooling, but there is a risk of blowing sharp metal fragments about in a dangerous fashion.

Flood the threads with ample quantities of fresh cutting oil to absorb the heat while it is being created. For this to work, the oil should be applied about once per full die revolution in a quantity that will wash away the last application of oil.

When using a nice sharp die on a carbon-steel fork, this combination of techniques should result in a good quality job, although a very time-consuming one. If a dull die is used, or if the fork is high-quality chrome-moly steel, there is no guarantee that the result will be acceptable.

11. [] Use cut-and-clear technique to advance die down fork column, stopping to let metal cool after every full revolution and adding cutting oil each time before re-starting.

12. [] Stop cutting when top of die is below end of fork by amount in step 10.

Now that one pass has been completed, a second one must be done at a slightly smaller diameter. This will not be the final pass, so adjust the die diameter so that it has noticeably less jiggle on the original threads than the first setting, but it still jiggles. This pass will cut substantially less metal than the first, so it is not necessary to take a long rest in between every revolution. Bigger turns for the cut-and-clear technique can be used, as well (1/4 turn for the cut and 1/2 turn for the clear).

13. [] Turn die up until it is fully on original threads and adjust diameter tighter, but leaving somewhat loose (jiggling).

14. [] Repeat steps 11 and 12.

For the final pass the die should be returned to the original threads and adjusted as tight as it will go without cutting when turned on the original threads. There should be little or no apparent jiggle between the die and the threads.

15. [] Turn die up until it is fully on original threads and adjust diameter tighter until jiggling is gone or near gone, but cutting does not occur when die is rotated.

16. [] Repeat steps 11 and 12.

17. [] Remove die from fork.

18. [] Clean fork and tools with brush and solvent then coat die with oil.

7 – SEAT-TUBE MILLING

ABOUT THIS CHAPTER

This chapter is about two procedures that might be done separately, or together, to improve the fit of a seat post in the frame. One procedure is honing, which removes corrosion and minor irregularities from the inside of the seat tube. The other procedure is reaming, which restores roundness and removes large irregularities from the inside of the seat tube.

GENERAL INFORMATION

TERMINOLOGY

Seat tube: The portion of the frame that the seat post inserts into.

Seat post: The post that connects the seat to the frame (seat tube).

Seat lug: The joint in the frame where the seat tube and top tube join; usually the seat stays join at this point as well.

Compression slot: The slot that allows the top of the seat tube to close down around the seat post when the seat post binder mechanism is tightened.

Hone: The name of a tool (and the process of using it) that polishes the inside of a cylinder, such as a seat tube.

Ream: Cutting material from the inside of a tube. The tool used to do this is a reamer.

Expansion reamer: A reamer that has an adjustable diameter.

PREREQUISITES

The only prerequisites for seat-tube honing or reaming are the ability to remove and install a seat post and the ability to determine whether a seat post is the correct size for the seat tube.

INDICATIONS

Symptoms indicating need of honing

Rust or corrosion on the seat post definitely indicates the need for honing.

Difficult removal or installation of the seat post is a definite indicator that the seat tube needs honing, and perhaps reaming as well. If not caused by rust or corrosion, this symptom is caused by imperfections inside the seat tube. Although the tube probably started out smooth and round inside, the process of welding or brazing tubes together can deform a seat tube by making it out-of-round, or by introducing bulges of material inside the tube on the backside of each weld; these bulges are called weld penetrations.

Symptoms indicating need of reaming

If after honing a seat tube it is still difficult to install the correct size of seat post, then it needs reaming.

TOOL CHOICES

The size of the stem or seat tube to be honed or reamed determines the size of hone or reamer required. All sizes are common, and all tools in the below list are recommended.

SEAT-TUBE HONE AND REAMER TOOLS (table 7-1)

Tool	Fits and considerations
Flex Hone BC20	13/16"–7/8" (BMX), fits common fork columns also
Flex Hone BC22	7/8"–15/16" (BMX), fits larger fork columns also
Flex Hone BC25.4	25.0–27.4mm seat tubes
Flex Hone AL25.4	25.0–27.4mm aluminum seat tubes
Flex Hone BC27	26.4mm–28.0mm seat tubes
Flex Hone BC29	Oversize seat tubes up to 31.6mm
Chadwick & Trefethen 26	20.64–22.23mm seat-tube reamer
Chadwick & Trefethen 28	25.4–28.5mm seat-tube reamer
Chadwick & Trefethen 29	28.5–31.7mm seat-tube reamer

7 – SEAT TUBE MILLING

TIME AND DIFFICULTY

Honing a seat tube is a 2–3 minute job of little difficulty. Reaming a seat tube is a moderately difficult job that can take 5–20 minutes, depending on the amount of material that needs to be removed.

COMPLICATIONS

Aluminum

There are no problems with reaming aluminum seat tubes, but there is with the honing process. The grit material for honing aluminum is completely different than the material used for steel. The Flex Hone AL25.4 is available for aluminum seat tubes of conventional size, but there is currently no hone available for under- or over-size seat tubes.

Titanium

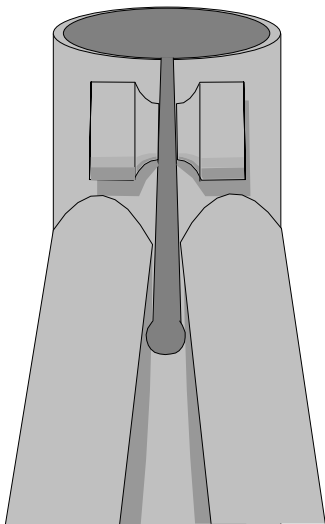
Hones or reamers suitable for use on titanium seat tubes currently do not exist.

Carbon fiber/composites

Carbon fiber or composite seat tubes are unsuited to being honed or reamed. If there is an aluminum insert in the seat tube, then it may be honed.

Deformed seat-lug/seat-tube top

If an under-sized seat post has been installed in the frame then the top of the seat tube may be deformed. This is easy to check and correct. The compression-slot width should be uniform. If it is more narrow at the top than the bottom, then insert a broad slotted screwdriver in the compression slot and lever it open, before beginning honing or reaming.



7.1 If the seat-tube compression slot is narrower at the top like the one in this drawing, the slot should be expanded before attempting honing or reaming.

Wrong size seat post

Reaming is not used to enlarge a seat tube to fit a seat post larger than the one designed for that particular frame. On the other hand, just because a seat post is difficult to install does not necessarily mean that the seat post is too large. Obstructions in the seat tube will make a correctly sized seat post seem as though it is too large.

If reaming were used to fit a seat post that is too large, the job would take an unbelievably long time to complete, and there would be a stress riser in the seat tube at the lowest edge of where the reaming was done.

SEAT-TUBE HONING AND REAMING PROCEDURE

1. [] **Measure seat post to determine correct size of hone to use.**

To keep messy cutting oil and metal fragments from collecting in the bottom bracket or at the bottom of the seat tube, position the frame so that it is uphill to the bottom bracket from the top of the seat tube.

2. [] **Position frame so top end of seat tube is lower than bottom end of seat tube.**
3. [] **Install hone in drill and coat hone with cutting oil or honing oil.**

In the next step the hone is inserted in the frame fully before starting the drill. Oil will be slung everywhere if the drill is started while the hone is outside the seat tube.

4. [] **Insert hone fully into seat tube, then start drill (moderate speed).**

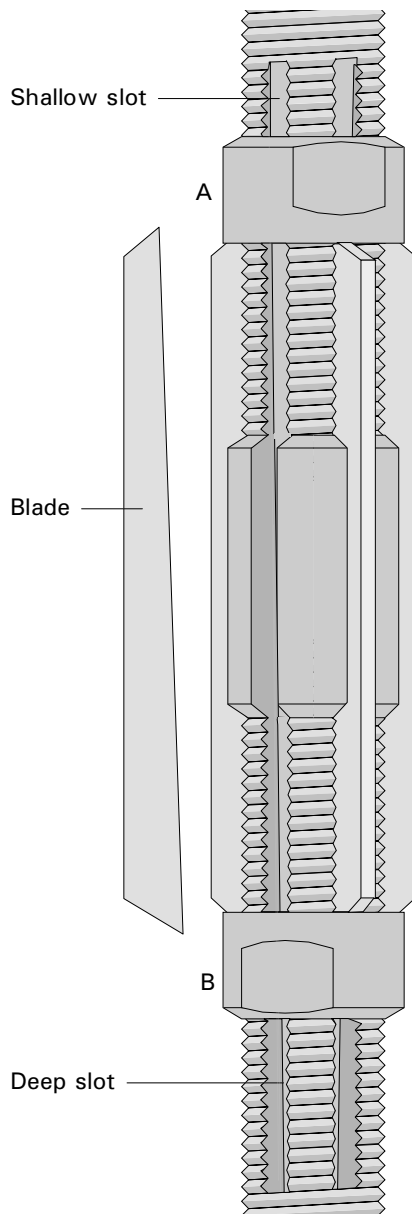
A hone will polish away roughness, but will not cut away lumps of excess metal or restore a non-round seat tube to round. What polishing it can do can always be accomplished in 20–30 seconds. Any more time spent honing is a waste of time. Most of the help needed is in the top two to three inches of seat tube, so spend the time there and just make a quick pass to the full depth of the hone.

5. [] **Hone for 20–30 seconds in seat lug and joint of top-tube and seat-tube area.**
6. [] **Insert spinning hone to its limit and pull back up to top of seat tube.**
7. [] **Stop drill and remove hone from seat tube.**

In the next step progress is checked by inserting the seat post. Corrosion should be cleaned out first.

8. [] **Insert seat post to check for resistance to insertion.**
9. [] **If excessive resistance remains after honing, select appropriately sized expansion reamer.**

10. [] Adjust expansion-reamer blades up or down until reamer inserts easily but does not jiggle inside seat tube.



7.2 An expansion reamer with a blade removed to show the sloped slot that is shallower at the top end of the tool. Adjust A up, then B up to enlarge the reamer.

11. [] Squirt cutting oil into seat tube.
12. [] Rotate expansion reamer clockwise until it is effortless to turn.
13. [] Test fit seat post.

Expansion reamers can only cut a very small amount of material at a time. If the expansion adjustment is too much (more than a 1/4 turn of the collars) the tool will not fit in the seat tube or will jam when rotated. It is likely that many small adjustments will be needed to get the job finished.

14. [] If seat post was too difficult to install, adjust upper expansion-reamer collar 1/4 turn up, then lower expansion-reamer collar 1/4 turn up.
15. [] Coat blades with cutting oil and insert expansion reamer into seat tube.
16. [] Rotate expansion reamer clockwise until it is effortless to turn.
17. [] Remove expansion reamer.
18. [] Repeat steps 13–17 as many times as necessary until seat post is a satisfactory fit.
19. [] Repeat steps 4–7.
20. [] Stuff a rag or a wind-instrument swab inside seat tube to clean out oil and cuttings.

8 – FRAME AND FORK

ALIGNMENT AND DAMAGE

ABOUT THIS CHAPTER

This chapter has four sections.

The first section is **REAR-TRIANGLE ALIGNMENT**, which is designed to be used when there are problems with rear wheel fit, bicycle tracking, or alignment of the front and rear gears.

The second section is **FORK-BLADE ALIGNMENT**, which is designed to be used when there are problems with front wheel fit or bicycle tracking.

The third section is **DROPOUT ALIGNMENT**, which is designed to be used in conjunction with either the sections on rear-triangle alignment or fork alignment, or can be used by itself when there are problems with bent axles in hubs.

The fourth section is **FRAME AND FORK DAMAGE**, which should be used whenever a bike has been in a collision or accident, or as a guide to routine inspection of bicycles for damage as a service to the customer.

GENERAL INFORMATION

TERMINOLOGY

Frame: The structural piece, usually a number of tubes joined together, to which all of the components are attached (the fork is a component).

Rear triangle: The portion of the frame that encloses the rear wheel, consisting primarily of the seat stays, chain stays, and rear dropouts.

Head tube: The near vertical tube that is the forward-most part of the frame.

Seat tube: The near vertical tube that is at the middle of a conventional (non-suspension) frame.

Top tube: The upper tube of the frame that extends back towards the seat from the head tube.

Down tube: The lower tube of the frame that extends from the bottom of the head tube to the bottom of the frame (usually connecting with the bottom-bracket shell).

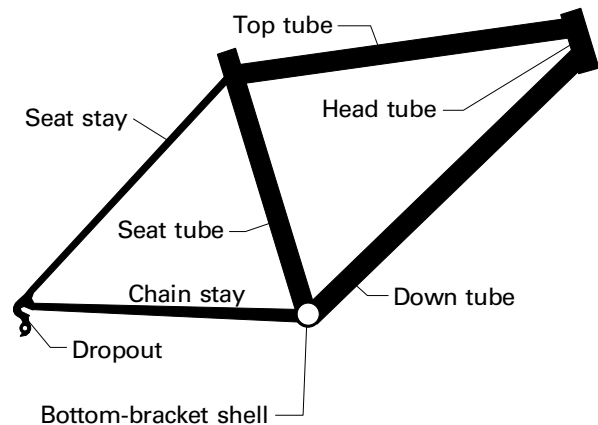
Bottom-bracket shell: The portion of the frame that contains the crankset bearings, called the bottom bracket.

Seat stay: The two tubes of the frame that go from below the seat to the center of the rear wheel.

Chain stay: The two tubes of the frame that go from the lower end of the seat tube to the center of the rear wheel.

Brake bridge: The short piece of tubing joining the two seat stays together just above the rear wheel.

Chain-stay brace: The piece of tubing or flat metal that joins the chain stays together between the bottom-bracket shell and the rear wheel.



8.1 Parts of the frame.

Dropout: The fittings at the juncture of the seat stays and the chain stays, or at the bottom of the fork, that the wheel attaches to.

Axle slot: The slot in the dropout that the hub axle inserts into when mounting the wheel to the frame.

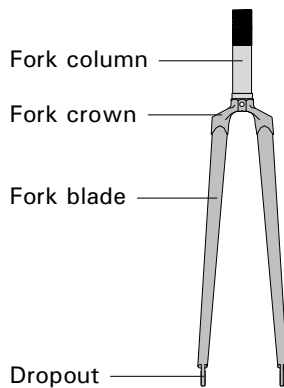
Fork: The structural piece that connects the front wheel to the frame.

Fork column: The tube at the top of the fork that inserts into the head tube of the frame (also called steerer tube, or steering tube).

Fork blades: The two tubes that go on either side of the front wheel.

8 – FRAME AND FORK ALIGNMENT AND DAMAGE

Fork crown: The joint, or connecting piece, between the fork blades and the fork column.



8.2 Parts of the fork.

Hub-over-locknut width: A dimension of the hub measured from the outer face of one locknut on the axle to the outer face of the other locknut. The locknuts are the parts of the axle set that butt up against the inside face of the dropouts when the wheel is installed.

Inside-dropout width: The distance between the inside face of one dropout to the inside face of the other dropout.

PREREQUISITES

Wheel removal and installation

Wheel removal and installation are required to align either the fork or the rear triangle.

Rear wheel cog removal

The rear cogs must be removed so that the rear hub can be measured. This measurement is used to align the rear triangle. Depending on the type of hub, either the freewheel will need to be removed or the cogs removed from a freehub.

Crank-arm and bottom-bracket removal and installation

The empty bottom-bracket shell must be held in a jig, or vise, when applying leverage to the rear stays (to align them). The crank arms must be removed to remove the bottom bracket, and must be installed when the bottom bracket is reinstalled.

Headset removal and installation

To align the fork, it is necessary to remove the headset. This will also require stem removal and perhaps some brake work.

INDICATIONS

Symptoms indicating need for centering the rear triangle or fork blades

There are two types of symptoms that indicate that the rear triangle may need centering, and one of these indicates that the fork blades need centering.

The first type of symptom that indicates either the rear triangle and/or the fork blades need centering is a problem getting the bike to go in a straight line without undue correction at the handlebars and/or with the rider's body position. This tracking problem can be caused by many other things, as well, and most of these should be checked before considering or attempting rear-triangle or fork-blade centering. Other causes of tracking problems include:

- Twisted front triangle
- Mis-dished wheel(s)
- Mis-mounted wheel(s)
- Mis-aligned fork
- Out-of-center rear triangle
- Damaged or over-tight headset
- Out-of-true wheels
- Extremely loose hub bearings

The other set of symptoms that could indicate that the rear triangle needs centering is: a problem with chain noise, or a problem shifting with the front derailleur. Chainline is affected by rear-triangle alignment, and there are numerous symptoms of chainline error. See the **CHAINLINE** chapter (page 27-3 and 27-5) for more details about chainline-error symptoms.

The rear triangle or fork blades do not need centering just because there is a measurable centering error. If the error does not create a symptom, then it is a mistake to do an alignment.

Symptoms indicating need for adjusting rear-triangle or fork-blade width

There are two types of symptoms indicating that the rear-triangle or fork-blade width needs to be adjusted: difficult wheel removal, and difficult wheel installation.

Wheels may be difficult to remove because the axle nuts, or quick release, need to be loosened excessively before the wheel will remove easily, or even after adequately loosening the retention device, force is required to get the wheel out of the dropouts. The symptom of excessive loosening of the retention devices to make it easy to remove the wheel indicates

8 – FRAME AND FORK ALIGNMENT AND DAMAGE

the width between the dropouts is too great. The symptom of difficult wheel removal, even when the retention devices are loose, indicates the width between the dropouts is too narrow.

Wheels may be difficult to install for several reasons. The wheel may be difficult to install because the retention device (quick release or axle nuts) needs to be loosened more than was necessary for removal before the wheel will install easily. The wheel may be difficult to install because the wheel requires excessive force to install, even with the retention devices adequately loosened. The wheel may be difficult to install because the dropouts require spreading before the wheel will go in easily. When the retention devices need to be loosened more to install the wheel than they needed to be loosened to remove the wheel, it indicates the dropout-inside width is too wide. When the wheel is difficult to install even when the retention devices are adequately loose, it indicates that the dropout-inside width is too narrow.

Dropout-inside width should not be adjusted just because a measurable error exists. There should be a symptom of difficult wheel removal or installation before any fork or rear-triangle alignment is done.

Symptoms indicating need for dropout alignment

The most likely symptom that indicates that the dropouts need alignment is a bent or broken axle in a hub. A bent axle will cause excess bearing wear.

In extreme cases, mis-aligned dropouts may interfere with installation of the wheel.

TOOL CHOICES

Which of the following alignment tools will be needed for a given job is determined by which procedure(s) will be done. The preferred tool choices in the following list (table 8-1) are in **bold** type. The preference is based on a combination of considerations including usability and versatility, economy, and tool quality.

REAR-TRIANGLE, FORK, AND DROPOUT-ALIGNMENT TOOLS (table 8-1)

Tool	Fits and considerations
Park FRS-1	Rigid and functional device for holding the frame at the bottom-bracket shell, comes with inaccurate alignment gauge (needs Park FAG-2 to be more complete)
Park FRS/RS	FRS-1 combined with a regular bike stand
Used steel bottom-bracket cups in assorted thread types	In conjunction with a high quality vise and heavy duty bench, a good way to hold the frame by the bottom bracket
Park FAG-2	Accurately compares relative positions of left and right stays for centering purposes
Park FFS-1	Leverage tool used for bending rear stays and fork blades
Park SS-1	Used to straighten stays that have been bowed from impact
Stein FCG	Fork alignment jig fits all sizes fork of fork columns. Should be used with Stein dropout alignment tools (available separately, or as part of set).
VAR 478	Fork-alignment jig fits all sizes fork columns, not as easy to use as Park FCG-1
Stein FG	Fork-alignment gauge used to check whether fork needs alignment before removing it from bike
Campagnolo H	Dropout-alignment tools that are adjusted for width by changing washer locations for a range of 100–135mm in limited steps
Park FFG-1	Dropout-alignment tools that are adjustable infinitely in 82–150mm range
Stein J	Dropout-alignment tools that are adjustable infinitely, clamps very securely by means of QR levers. Calibrated so width can be checked simultaneously.
Park HTS-1	Tool used for pushing head tubes forward that have been pushed back from frontal impact. <i>This procedure is not recommended!</i>

COMPLICATIONS

Aluminum, titanium, and composite tubing

Aluminum stays or fork blades should not be bent unless specifically authorized by the frame manufacturer. Titanium is simply too difficult to bend and should not be attempted. Composites, such as carbon fiber, break before they will bend.

If fit to the wheel is a problem, increase or decrease hub width. Wheel fit problems are defined in the preceding **INDICATIONS** section, under the heading ***Symptoms indicating need for adjusting rear-triangle or fork-blade width.***

If centering is a problem, create a wheel-dish error in the opposite direction.

If chainline is a problem, first attempt to correct the problem at the chainrings (if possible). If this does not work, try shifting spacers from one side of the hub to the other (requiring wheel-dishing corrections).

Aluminum and titanium dropouts

It is generally permissible to align aluminum dropouts. Titanium dropouts are an unknown at this time.

Excessive misalignment

Whenever the degree of alignment error is high, concerns arise about whether the metal will be fatigued by the amount of bending required. There is no way to quantify this. The greater concern is the number of times the tubing gets bent, rather than the amount that it has or will be bent. Most factory misalignments are not severe enough to be a concern. Modifying rear triangles to accept a hub of 5mm greater width should not be a problem; however, larger corrections, or corrections necessitated by collision damage, are a concern.

Damage

Damage may be present before alignment is attempted, or damage may result from excessive attempts to align the stays or fork blades. Inspect before and after every alignment job for cracks, wrinkles, or deformations in the shape of the tubing.

Unbendable steel tubing

Some steel tubing is so strong that it is virtually unbendable. Oversize fork blades are the most likely candidate for this problem. In this case, there is a dangerous risk of bending the fork column while attempting to bend a fork blade. Excessive effort should be avoided.

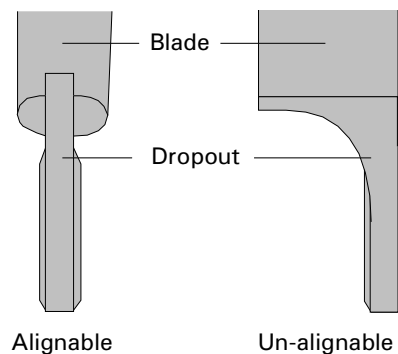
Suspension forks

Suspension forks cannot be aligned by bending. See the **SUSPENSION FORKS** chapter (page 38-???) for techniques for alignment of dropouts.

Unbendable dropouts

The design of some dropouts makes them virtually impossible to align. A conventional dropout is basically two-dimensional and “necks-down” (gets narrower) between the main body of the dropout and the stays or blade it attaches to. This type can always be aligned.

Some dropouts are not flat two-dimensional plates, but incorporate additional structural material perpendicular to the plane of the dropout face. Often this type fits like a plug into a large-diameter end to a fork blade. This type (found on some mountain bikes with rigid forks) cannot be aligned.



8.3 *The right dropout/fork-blade style makes dropout alignment impossible because the dropout is not a narrow plate where it attaches to the fork blade.*

Dropouts or stays/blades first

If stays or blades are aligned first, and then dropouts, some accuracy to the stay or blade alignment will be lost. If dropouts are aligned first, and then stays or blades, then when the stays or blades are aligned some accuracy of the dropout alignment will be lost.

The normal range of dropout misalignment is not significant enough to have an unacceptable influence on stay or blade alignment, if the dropouts are aligned after the stays or blades. If, doing the alignments in this order, it is found that the dropouts were severely misaligned, then it is necessary to check and correct the stay or blade alignment again, and then the dropouts again.

REAR-TRIANGLE-ALIGNMENT PROCEDURE

Even when symptoms indicate that there is a need to correct width error only or centering error only, a procedure should be used that corrects both. The reason for this is that if only one type of error exists it is possible and likely that the other error will be created while correcting the original error.

The following procedure is designed to diminish any existing width error while starting out with a centering-error correction. The procedure is based on the assumption that any width error of more than 1mm would create a symptom. If, after correcting a centering error, the remaining width error creates no symptom (check by installing and removing wheel), then there would be no point in correcting any remaining width error.

PREPARATION

1. [] Use appropriate procedures/worksheets to remove rear wheel, gears from rear wheel, crankset and bottom bracket.

There are two good ways to clamp the frame by the bottom bracket while performing a rear-triangle alignment.

If a Park FRS or FRS/RS is available, mount the frame to the clamp. This gives a very stable mounting with an unlimited range of adjustments, enabling a comfortable and effective working position.

The alternative is to thread some used steel cups into the bottom-bracket shell (as deeply as possible without recessing the face of the cups in the ends of the shell) and clamp the cup faces into a bench vise. This is adequate and more economical, if your shop is not already equipped with the FRS. A sturdy bench and top quality vise are necessary. The range of adjustment to put the frame in a good working position is more limited with this frame-holding technique.

2. [] Clamp frame securely by faces of bottom-bracket shell.

INITIAL CONDITIONS

Before making any corrections, it is necessary to know all the existing problems with width error and centering error. Width error is checked by measuring the hub-over-locknut width and comparing it to the dropout-inside width. Centering error is checked with a tool called the Park FAG-2.

The Park FAG-2 is used by putting the adjustable end at the dropout, the end of the flat section (near the curve of the FAG-2) against the seat tube, and the non-adjustable end at the head tube. The adjustable end is then adjusted so that contact is achieved at all three points. When positioning and setting the Park FAG-2, four things should be kept in mind.

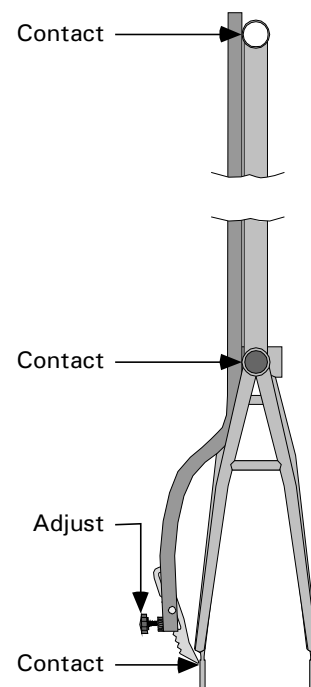
The end of the tool at the head tube needs to rest on a flat portion of the tube.

The adjustable end of the tool at the dropout should be positioned so that the tip is on the surface that the axle nut or quick release nut clamps against, preferably at a point close to the juncture of the stays.

The curve of the tool should not be against the seat tube. Extend the indicator further out if the curve of the bar touches the seat tube.

Pressure against the long flat portion of the tool between the seat stay and head tube easily distorts the tool. Hold the tool close to the seat tube to avoid this.

The fact that the procedure starts with setting the FAG-2 on the left side is absolutely arbitrary. A side has to be specified so the words “right” and “left” can be used instead of more awkward alternatives like “the side you started on” and “the side opposite the side you started on.”

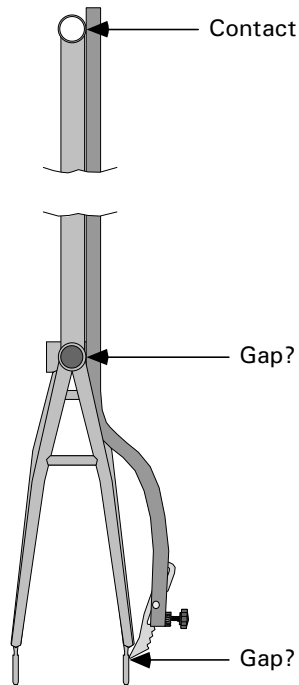


8.4 Position the flat portion of the FAG-2 against the head tube and the seat tube, and the adjustable tip of the tool against the forward portion of the surface that the axle nut/quick release nut clamps against.

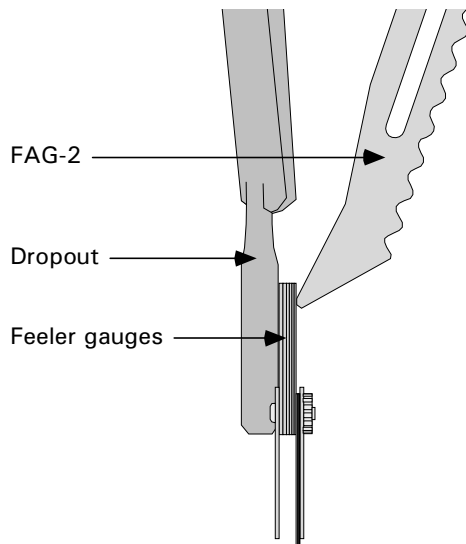
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3. [] Set FAG-2 to 3-point contact on left side.

When the FAG-2 is transferred to the second side there may be no gap at the seat tube or right dropout (centering is perfect); a gap might be detected at the dropout that is insignificant; a gap might be detected that is significant; or a gap might be detected at the seat tube (indicating that the procedure should be started over from the other side).



8.5 Transfer the FAG-2 to the right side, then check if there is a gap between the tool and the frame at the seat tube or dropout.



8.6 To measure the gap between the tip of the FAG-2 and the dropout, use a feeler gauge or stack of feeler gauges.

4. Transfer FAG-2 to right side and *check one of following choices*:

- [] no gap seen at seat tube or dropout, *skip to step 8.*
- [] gap is at right dropout and is < 1mm, *skip to step 8.*
- [] gap is ≥ 1 mm at right dropout, gap measures _____ mm, *skip to step 8.*
- [] gap is at right side of seat tube (do not measure), *proceed to steps 5–7.*

If a gap is detected on the right side of the seat tube, then the procedure should be started over on the right side.

NOTE: Skip to step 8 if any of first 3 lines were checked in step 4.

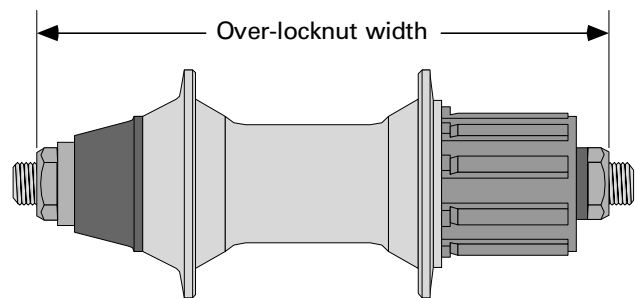
5. [] Only if step 4 resulted in gap on right side of seat tube set FAG-2 to three point contact on right side.

6. [] Transfer FAG-2 to left side.

7. Measure gap at left dropout and check one of following choices:

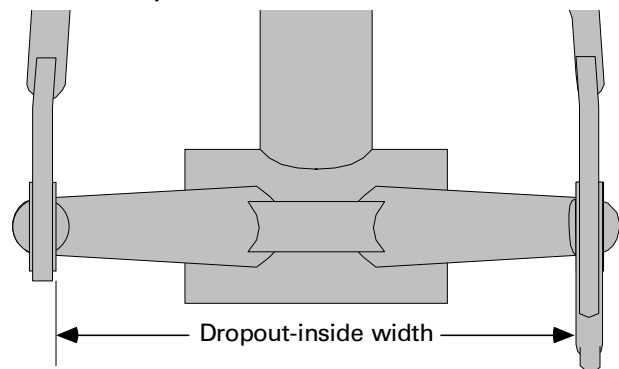
- [] gap is < 1mm.
- [] gap is _____ mm (measure if not < 1mm).

8. [] Hub-over-locknut width is _____ mm.



8.7 Measure hub-over-locknut width with calipers.

In the next step, when measuring dropout-inside width, to reduce the error created by mis-aligned dropouts, measure on the surfaces where the hub locknuts touch as close as possible to the juncture of the dropout to the stays.



8.8 Measure dropout-inside width with calipers.

9. [] Dropout-inside width is _____ mm.

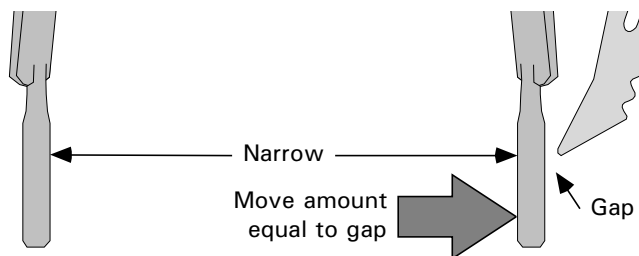
Compare the hub-over-locknut width to the drop-out-inside width to conclude whether the existing drop-out-inside width is wider or narrower than the hub-over-locknut width.

10. [] Dropouts are: **wide** or **narrow** (circle one).

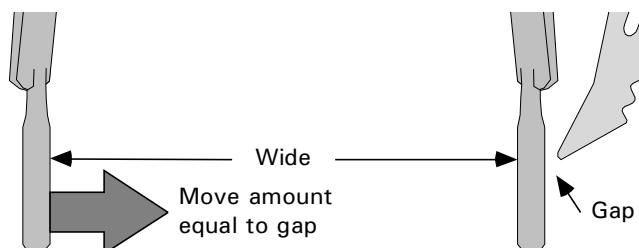
CENTERING CORRECTIONS

In the next step, whether to bend a stay in or out to correct the centering error is decided. Which stay is best to bend also needs to be decided. If the dropout width is too narrow, then obviously it makes sense to bend a stay out. If the dropout width is too wide, then a stay should be bent in. If bending a stay in, then it should be on the side where the FAG-2 contacted the dropout. If bending a stay out, then it should be on the side where the FAG-2 showed a gap at the dropout. These choices ensure that width error will not be worsened while correcting the centering error, and will generally be improved. If there is no width error initially, then skip to step #23.

NOTE: Always attempt to bend stays with just hands and start with very low effort on the assumption that they will be easy to bend. If they do not respond, then gradually increase effort. If they are too difficult to bend by hand, then use the Park FFS-1 leverage tool on the chain stay to provide greater leverage.



8.9 This diagram shows centering correction if the dropouts are too narrow and the FAG-2 shows a gap on the right side.



8.10 This diagram shows centering correction if the dropouts are too wide and the FAG-2 shows a gap on the right side.

11. [] Bend stays:
out? **in?** (circle one)
on right side? **left side?** (circle one)
 by approx. _____ mm (equals FAG-2 gap).

Each time a side is bent, it is possible and likely that the other side will move some in the same direction, as well. This is due to the connection between the sides made by the brake bridge and chain-stay brace. When this happens, the point of reference for the FAG-2 is lost, so it is necessary to reset the FAG-2 each time to check the progress the bend has made. Always reset the FAG-2 on the side where there was no gap initially. This will be the non-bending side if bending a stay out, or the bending side if bending a stay in.

12. [] Reset FAG-2 after each bend, as necessary, and check opposite-side gap. (Reset to non-bending side if bending **out**, reset to bending side if bending **in**.)

It is unlikely that a final correction will be achieved in one step. Step #13 suggests that steps #11 and #12 be repeated as many times as necessary to achieve the desired tolerance of error, suggested as being a gap at the dropout of less than 1mm.

One possibility is that during one of the bending attempts an over-correction is made, resulting in a gap between seat tube and the FAG-2, after resetting the FAG-2, and transferring it to the second side. If this happens, avoid the confusion that will be created by turning this side into a new reference side. Instead, simply bend the side back that was bent too far and continue using the original side as the reference side for the FAG-2.

13. [] Repeat steps 9–12 as many times as necessary until final gap is < 1mm.

WIDTH CORRECTIONS

To calculate the width error, the *current* dropout-inside width needs to be subtracted from the hub's over-locknut width. If the result is positive, then the dropouts are too wide and the corrections will be accomplished by moving the sides in. If the result is negative, then the dropouts are too narrow and the corrections will be accomplished by moving the sides out.

In the following step, the width error is divided by two to determine the needed correction per side. The correction of the width error has to be split between both sides in order to maintain the centering alignment.

14. Calculate needed correction per side:

over-locknut width	_____ mm
dropout-inside width	– _____ mm
width error	= _____ mm
divide	÷ 2
correction per side	= _____ mm

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The width correction, therefore, is done in two phases:

- First, either side is bent to achieve the *intermediate width*, the distance halfway between the current width and the hub-over-locknut width.
- Second, the other side is bent the same amount in the opposite direction to achieve the final width, which is the hub-over-locknut width plus or minus a suggested tolerance of 1mm.

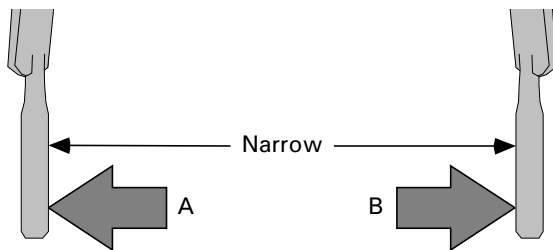
15. Calculate needed intermediate width:

dropout-inside width		_____ mm
correction per side	+	_____ mm
intermediate width	=	_____ mm

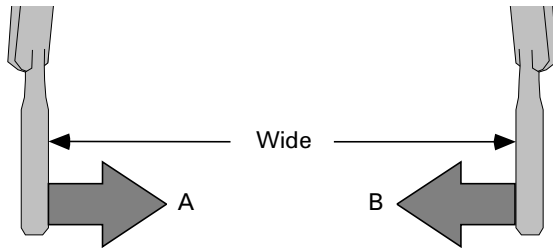
16. [] Bend one stay in or out as appropriate to achieve *intermediate width* $\pm .5\text{mm}$.

17. [] Record actual intermediate width achieved here: _____ mm.

18. [] Bend other stay in or out as appropriate to achieve final width (*final width is over-locknut width $\pm 1\text{mm}$*).



8.11 This diagram shows width correction if the dropouts are too narrow. Move A to achieve the calculated intermediate width and B to achieve the final width. Use the calipers to track progress.



8.12 This diagram shows width correction if the dropouts are too wide. Move A to achieve the calculated intermediate width and B to achieve the final width. Use the calipers to track progress.

19. [] Record actual final width achieved here: _____ mm.

Despite all efforts to the contrary, it is not unlikely that the tolerance previously achieved for centering will have worsened to an unacceptable point while correcting the width. Check to see whether this is the case.

20. [] Recheck centering error and record here: _____ mm gap (tolerance is $\leq 1\text{mm}$).

If the acceptable tolerance for centering error has been lost, then there are two approaches to fixing it.

The easiest way, if it will get the job done, is to work with one stay until the width error is *just* in tolerance. If the final width is currently narrower than the hub-over-locknut width, then bend the side *out* that improves the centering error as far as possible without exceeding the maximum acceptable dropout-inside width. If the final width is wider than the hub-over-locknut width, then bend the side *in* that improves the centering error as far as possible without exceeding the minimum acceptable dropout-inside width. Then check the centering error, which will be better, but perhaps not within the acceptable tolerance.

21. [] If centering is out of tolerance *and final width is narrower than hub-over-locknut width*, bend "gap-side" stays out until width of *up to* over-locknut width + 1mm is achieved.

22. [] If centering is out of tolerance *and final width is wider than hub-over-locknut width*, bend "non-gap side" stay in until width of *down to* over-locknut width - 1mm is achieved.

23. [] Use FAG-2 to check whether centering error is $\leq 1\text{mm}$.

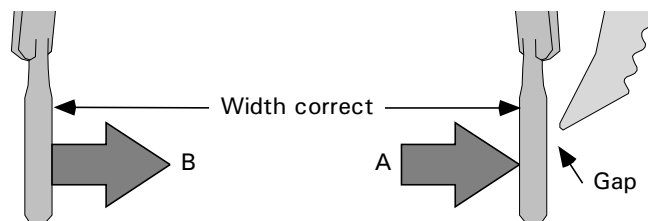
If this approach does not get both within tolerance at once, then use step #24 through step #26 to correct the centering error while maintaining the correct width.

Maintaining correct width while re-correcting centering error

NOTE: Skip to step 27 if gap in step 23 is $\leq 1\text{mm}$.

24. [] Bend gap-side stays out until width is increased by approximately 1/4 of gap amount.

25. [] Bend other side stays in until desired width is restored.



8.13 To correct centering error when width is correct, move A until width is increased by approximately 1/4 of gap amount, and then B until width is restored. Repeat as necessary.

26. [] Repeat steps 24–25 as many times as necessary to achieve width error of $\leq 1\text{mm}$ and FAG-2 gap of $\leq 1\text{mm}$.

Finish

27. [] Use appropriate procedure/worksheet to align dropouts if desired.

28. [] Use appropriate procedures/worksheets to re-assemble bike.

FORK-BLADE-ALIGNMENT PROCEDURE

Even when symptoms indicate that there is need to correct only width error or only centering error, a procedure should be used that corrects both. The reason for this is that if only one type of error exists it is likely that the other error will be created while correcting the original error.

The following procedure is designed to correct both types of error simultaneously. The procedure is based on the assumption that any width or centering error of more than 1mm would create a tracking problems or wheel-fit problem. If, after correcting a centering error, the remaining width error creates no additional symptom(s) (check by installing and removing wheel), then there would be no point in correcting any remaining width error.

In addition to centering error and width error, fork blades can have a fore-and-aft error. This type of error exists if one dropout is further forward compared to the fork crown than the other dropout.

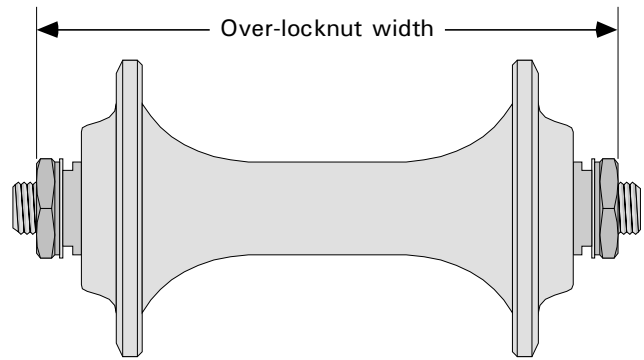
Although there would be no negative symptoms if a fore-and-aft error existed without centering or width errors, the existence of a fore-and-aft error can make the wheel appear misaligned to the rider when it is not. It is also inconsistent with good mechanical technique to have the fork out and in the jig to align the width and centering errors, but ignore the fore-and-aft error.

Finally, looking for fore-and-aft error can help identify a fork that has been damaged in a crash or shipping. It is normal to see a fore-and-aft error of up to about 2mm. If significantly more error than this is seen, then it is likely that the fork is damaged. The fork should be inspected thoroughly before proceeding further.

PREPARATIONS

1. [] Use appropriate procedures/worksheets to remove fork from bike.

In the next step, front-hub-over-locknut width is measured with calipers and recorded. It is not necessary, but would be handy if the calipers were locked at this setting until step #16 is completed.



8.14 Measure front-hub-over-locknut width with calipers.

2. [] Measure front-hub-over-locknut width (front-hub locknut width: _____ mm).

Align and secure fork in jig

The Park FCG-1 has three interchangeable clamping blocks for 1", 1-1/8", and 1-1/4" fork columns. The older Park FT-4 fits 1" only, and the VAR 478 fits all sizes without changing blocks.

NOTE: Skip step 3 unless using a Park FCG-1.

3. [] Secure correct block inside Park FCG-1 (skip if using Park FT-4).

Depending on the brand and model of fork jig used in the next step, it is possible to insert the fork column too far into the jig. This is not possible with the Park FCG-1, but with the other models make sure that the clamp of the jig does not go on the fat portion at the base of the fork column, or on the fork-crown race.

Do not secure the clamp at this time. It will be secured in step #8.

4. [] Slip fork column into jig until crown race or fork-column base is against, but not inside, jig clamp. **Do not secure clamp now!**

In the next two steps, the sliding gauge is set so that it can be used to align the fork in the jig before securing the jig clamp. The sliding gauge is positioned above the fork blades just below the point they join the fork crown (or where the blades begin curving inward, if the fork is a unicrown style). The sliding gauge *must be secured on the main bar* before bringing it down against the fork blades in step #7.

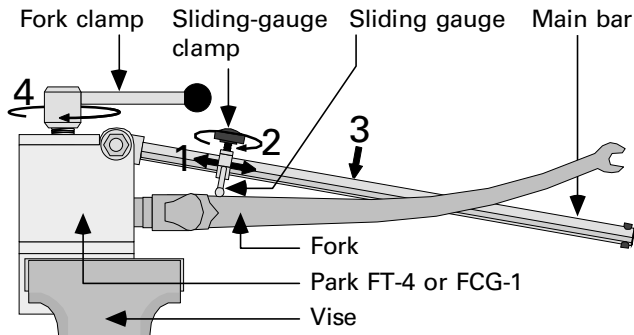
5. [] Move sliding gauge to position that will contact fork blades just below fork crown.
6. [] Secure sliding gauge.
7. [] Swing main bar down until sliding gauge is firmly against both fork blades.

With the sliding gauge positioned and secure, and the fork still loose in the clamp, applying pressure down on the main bar will automatically bring the

8 – FRAME AND FORK ALIGNMENT AND DAMAGE

fork into proper rotational alignment. Maintain the downward pressure while securing the fork clamp in the next step.

It is easy for the fork to slip in the clamp while bending the blades, so get the clamp as tight as possible. The design of the clamp mechanism insures that the fork column will not be crushed.

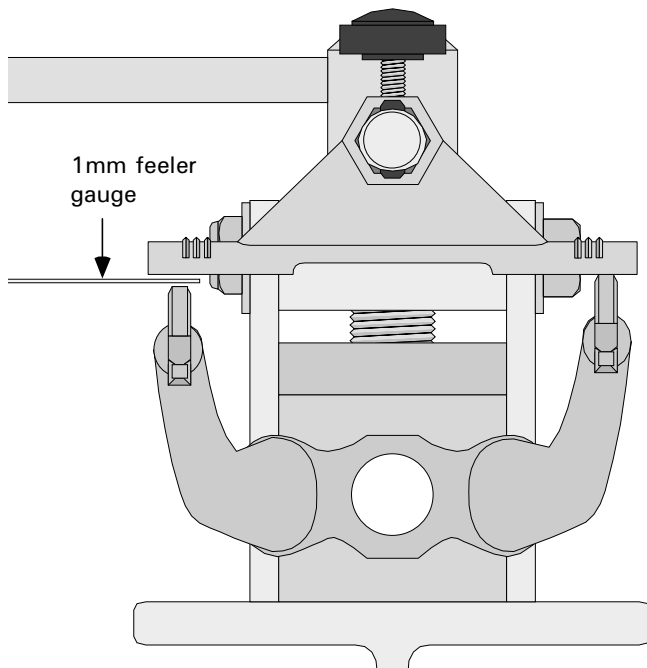


8.15 Perform in order: 1. Position sliding gauge. 2. Secure sliding-gauge clamp. 3. Press downward on main bar. 4. While maintaining pressure on main bar, secure fork clamp.

8. [] While holding main bar firmly down, secure fork clamp.

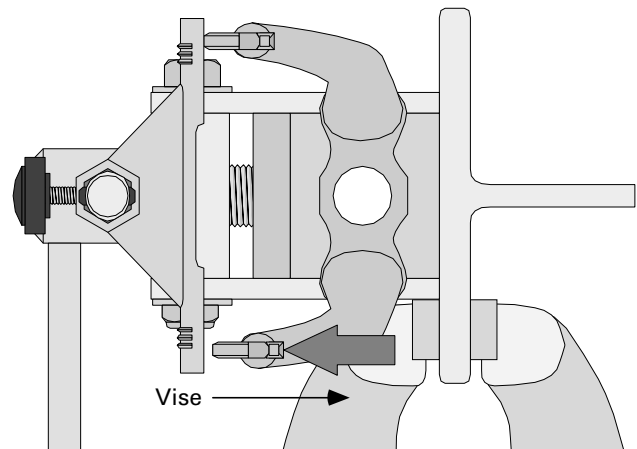
FORE-AND-AFT ALIGNMENT

9. [] Move sliding gauge into axle slots, if possible, or over leading edge of dropout if not. Secure to main bar.
10. [] Move main bar until bottom surface of one end of sliding gauge contacts a dropout.



8.16 Use feeler gauge to check gap between dropout and sliding gauge to check if gap (if any) exceeds 1mm.

11. [] Check with feeler gauge(s) to see if gap at other end of sliding gauge exceeds 1mm.
12. [] If gap exceeds 1mm, turn jig in vise so that one side-mounting plate is in vise.



8.17 Turn the jig on its side to bend fork blades fore-and-aft.

NOTE: Always attempt to bend blades with just hands and start with very low effort on the assumption that they will be easy to bend. If they do not respond, then gradually increase effort. If they are too difficult to bend by hand, then use the Park FFS-1 leverage tool with a conservative effort initially.

13. [] Using the FFS-1 *only if necessary*, bend one blade until difference at each end of sliding gauge is < 1mm.
14. [] Move sliding gauge back to just below fork crown, secure, and check that there is still two-point contact when the sliding gauge is swung down to contact the blades. Reset fork in jig as necessary to re-establish two-point contact.

WIDTH AND CENTER CORRECTION

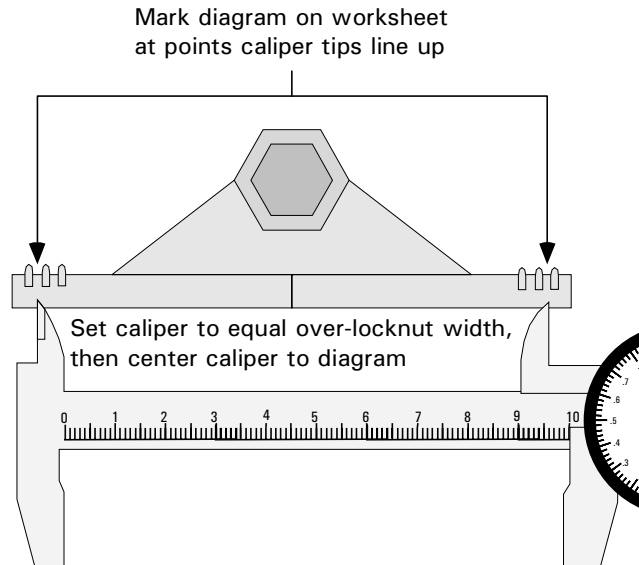
Determine correct end location for each dropout inner face

In the next step, the caliper is set to the hub's over-locknut width and then held up against the sliding gauge and centered to the sliding gauge (see figure 8.18).

15. [] Transfer hub-over-locknut width to sliding gauge by holding calipers up to sliding gauge, and moving calipers side-to-side until they are centered relative to marks on each end of sliding gauge.

In the next step, do not mark the diagram on this page. Instead, mark the diagram on your photocopy of page WORKSHEETS – 10.

16. [] **Mark on below diagram of sliding gauge points where caliper tips end up when centered:**



8.18 In this example, the caliper is set to the over-locknut width and centered to the sliding gauge lines up between the middle and outer ridges on each end of the sliding gauges, so sliding-gauge diagram on your photocopy of page WORKSHEET – 10 should be marked to reflect this.

Align blades to correct width and center

17. [] **Align each blade so that inner face of each dropout ends up directly in line with points on sliding gauge marked on sliding-gauge diagram.**
18. [] **Measure dropout-inside width: _____ mm.**
19. [] **Difference between over-locknut width and dropout-inside width is: _____ mm.**
20. [] **If difference is ≤ 1 mm, alignment is done.**
21. [] **If difference is > 1 mm, move both blades in or out equally until difference is ≤ 1 mm.**

The force of aligning the blades can cause the fork column to twist in the clamp. In the next step, whether this has happened is checked, and if two-point contact with the sliding gauge is not still occurring at the top of the fork blades, then the fork needs repositioning and the alignment should be redone.

22. [] **Make sure fork is still aligned in jig correctly when all blade alignments are done. If not, reset fork in jig and repeat steps 17–22.**
23. [] **Use appropriate procedure/worksheet to align dropouts if desired.**
24. [] **Use appropriate procedure/worksheet to install fork and stem.**

DROPOUT-ALIGNMENT PROCEDURE

If performing dropout alignment before fork-blade or rear-triangle alignment, then dropout alignment may need to be redone. This is certainly the case if fork blades have been aligned in the fore-and-aft respect.

If performing dropout alignment after fork-blade or rear-triangle alignment, then fork-blade or rear-triangle alignment may need to be redone after the dropout alignment. This is only likely if the dropouts were found to be severely misaligned.

All brands of dropout-alignment tools have a fat spacer washer 10–13mm thick that goes outside the dropouts on front dropouts and inside the dropouts on rear dropouts. When securing the dropout-alignment tools to the dropouts, make sure that they are fully inserted and do not squirm out of position while being secured. They do not need to be secured very tightly.

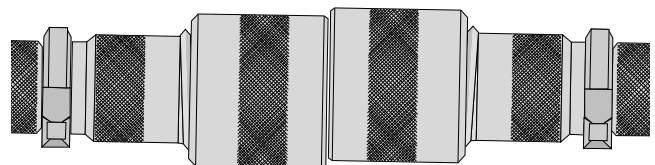
1. [] **Insert tools in dropouts and secure.**

The alignment cylinders should be as close to each other as possible without touching. With Park FFG-1 tools, simply rotate the alignment cylinders so that they thread closer or further apart as needed. With Campagnolo H tools, shift washers from one face of the dropout to the other to adjust spacing. For fine-tuning the Campagnolo H tools, 1mm rear hub axle spacers can be added to the tool on either of both sides.

2. [] **Adjust so that alignment cylinders are close but not touching.**

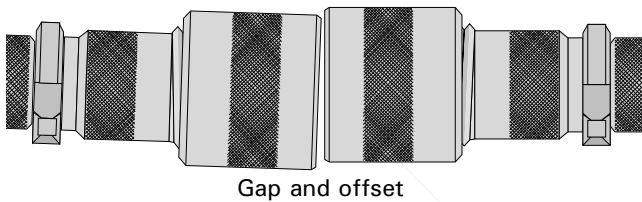
There are two types of misalignments that will be seen at the ends of the alignment cylinders. These will be called offset and gap spread. Both of these misalignments need to be checked from two perspectives: viewed from in front and from above.

Offset is when one cylinder edge is offset to the closest edge of the other cylinder. The following illustrations show simple offset error (figure 8.19) and combined offset and gap-spread error (figure 8.20).



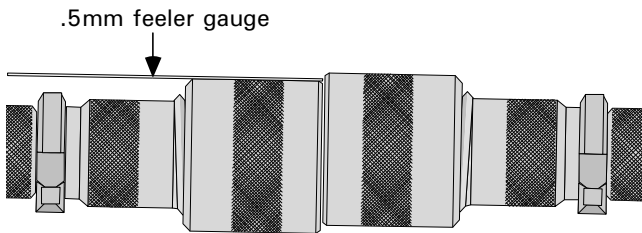
8.19 Simple offset error.

8 – FRAME AND FORK ALIGNMENT AND DAMAGE



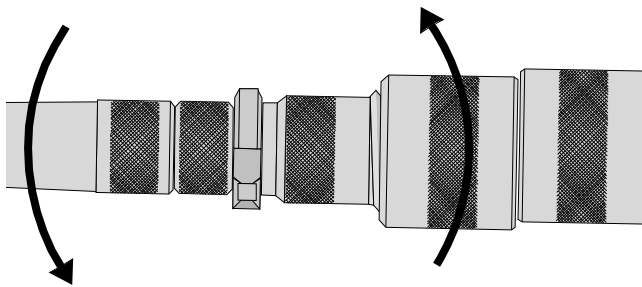
8.20 Offset error and gap-spread error combined.

When offset error is slight, check whether it is tolerable by placing a .5mm feeler gauge on the lower cylinder. If the top of the feeler gauge is even with the other cylinder or above the other cylinder, offset error is in tolerance.



8.21 Use a feeler gauge to check whether the offset error is in tolerance. This example shows unacceptable offset error because the offset is more than .5mm.

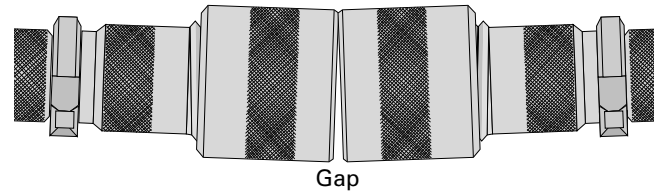
Correct offset by applying leverage to one tool handle only, until offset is reduced to acceptable. If there is also a gap-spread error, it is possible to correct offset in a direction that also reduces gap-spread error. If there is no gap-spread error initially, correcting offset error will introduce gap-spread error unavoidably.



8.22 Correct offset error by applying leverage to one tool only until error is reduced to acceptable.

3. [] If offset between cylinders viewed from in front exists, bend one side to reduce offset to .5mm or less.

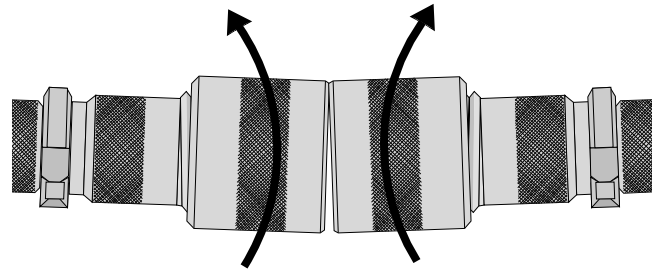
Gap spread should only be corrected when there is no offset error. The below illustration shows a simple gap-spread error.



8.23 Simple gap-spread error.

To measure a gap-spread error, adjust the alignment cylinders until they are just touching (Park FFG-1) and use a feeler gauge to measure the gap at the widest point. Less than or equal to .5mm is good. With Campagnolo tools, the alignment cylinders cannot be set to contact, so use a feeler gauge at the closest and widest points and calculate the difference.

The easiest way to fix a gap-spread error is to grab both tool handles simultaneously and bend them the same direction the same amount at the same time. If they don't bend equally, then a slight offset error will be created, which can be corrected after the fact.



8.24 Fix a gap error by applying leverage to both tools at once, in the same direction.

4. [] If gap spread (viewed from in front) is not in tolerance from top to bottom, bend both sides equally in same direction until gap-spread difference is .5mm or less.

After eliminating offset and gap-spread errors evident when viewing the alignment cylinders from in front, the process needs to be repeated viewing the alignment cylinders from a viewpoint 90° away, such as from directly above.

5. [] If offset between cylinders viewed from above exists, bend one side to reduce offset to .5mm or less.
6. [] If gap spread (viewed from above) is not in tolerance from front to back, bend both sides equally in same direction until gap-spread difference is .5mm or less.

It's quite possible that the alignment tools have shifted in the dropouts during all the bending. In the next step, they are loosened and re-installed to check if the adjustments are still good.

7. [] Loosen and resecure both tools.

It is easy to mess up the original alignments while doing the second set. Steps #8 and #9 have you recheck everything.

8. [] Check and repeat steps 3 & 4 if necessary.

9. [] Check and repeat steps 5 & 6 if necessary.

10. [] Recheck rear-triangle or fork-blade alignment if dropout misalignment was severe.

FRAME AND FORK DAMAGE

TWISTED FRONT TRIANGLE

When a front triangle of a frame is twisted, the head tube is not in the plane of the seat tube. Since the front wheel is in the same plane as the head tube and the rear wheel is in the same plane as the seat tube, the two wheels are in different planes. When the wheels are in different planes, the bike will have a tendency to pull to one side.

Identifying a twisted front triangle

The key to identifying a twisted front triangle is knowing when to look for it, since it is not usually obvious during casual observation. Lateral impact to the front end is what does the damage. This impact is not directly to the head tube but through the wheel and fork, or through the handlebars. When fork blades are bent dramatically to the side or handlebars are crushed from the side, it is time to inspect for a twisted front triangle.

To inspect, put the bike in a bike stand so that the seat tube is vertical, rather than laid back. Put a magnetic base angle finder on the side of the head tube and the side of the seat tube. Ideally, these two should be identical. If the angles are different by less than one degree it should be no problem. More than one degree of difference probably indicates damage, and two or more degrees is a certain indicator of damage.

Repair of twisted front triangles

There are two approaches to repair a twisted front triangle, neither of which would be considered standard shop operating procedure.

Using a frame builder's frame table, it is possible to insert a leverage bar into the head tube and twist it back. This is not recommended because the original damage

meant that either the down tube or top tube became twisted over its length. Twisting the head tube will not untwist the damaged tube; it will simply twist another tube in an offsetting direction. The result is a frame that ends up stressed and unstable.

A frame builder can repair the damage by replacing the top tube or down tube, as necessary. This is rarely financially feasible, and is certainly a job for a professional frame builder and not a bicycle repair shop.

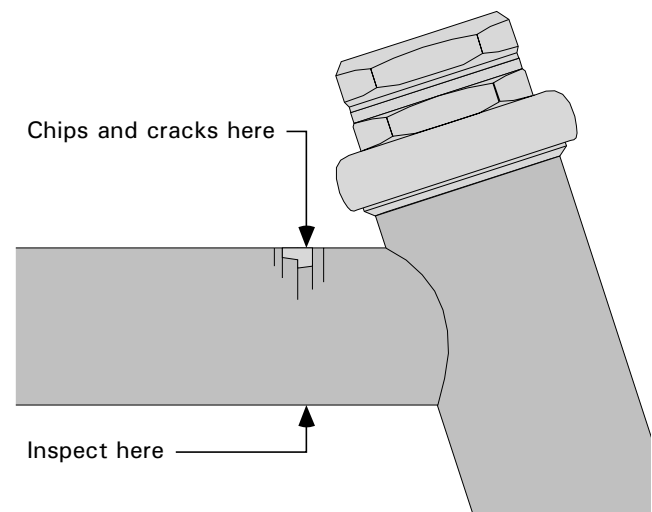
BUCKLED DOWN TUBE AND TOP TUBE

Frontal impact can easily buckle the top tube and/or the down tube. This type of damage is not obvious through casual observation, but is easily spotted if the correct warning signs are known.

Identifying buckled down tubes and top tubes

Down tubes and top tubes become buckled during any type of frontal impact. This impact usually damages the fork in some way, either bending the blades back or the fork column back. Anytime either of these conditions are detected, the down and top tubes should be inspected for buckling.

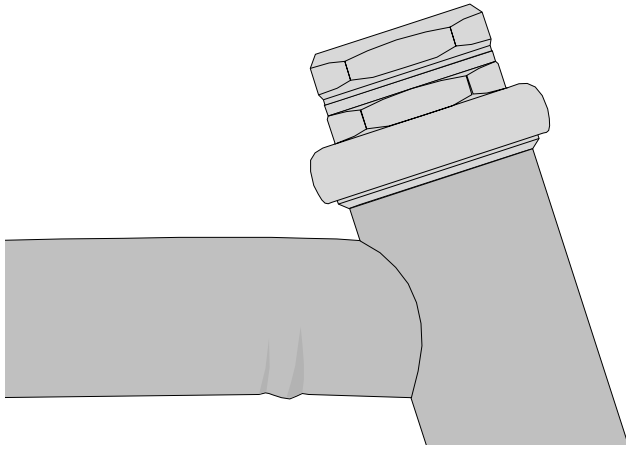
Even when there is no apparent fork damage, there are some good warning signs to look for. When tubes are buckled, it usually damages the paint on the tube directly opposite the buckle. Any cracks or chips in the paint on the top of the down tube or top tube directly behind the head tube are signs that the tubes have been flexed severely and probably have buckled.



8.25 Paint cracks indicate the top tube may be buckled. Inspect opposite the cracks for any bulge or deformity.

8 – FRAME AND FORK ALIGNMENT AND DAMAGE

On the *underside* of these tubes, directly behind the head tube, is where the buckling would be found. Any bulge or deformity in this area means the tube is buckled.



8.26 *The bulge on the bottom side of this tube indicates it is damaged from frontal impact.*

Repair of buckled down tubes and top tubes

The obvious consequence of this type of damage is that the head-tube angle is steeper and the front wheel has moved further back, often so much so that the rider's feet or the pedals or crank interfere with the front wheel when it is turned to the side. The Park HTS-1 is designed to push the head-tube angle back, *but it does not repair the damage.*

The real problem with these buckled tubes is *not* the change of head-tube angle, but the buckling itself, which causes a stress riser in the tubing. A stress riser is an irregularity in a structural piece that causes stress to localize in the area of the irregularity, rather than distribute more evenly over the entire piece. This concentration of stress leads to premature metal fatigue and ultimately leads to failure.

The only legitimate repair, consequently, is to have the damaged tubes replaced by a framebuilder. This option is rarely financially sensible.

When buckled tubes are detected, always advise the customer the bike is unrideable and unrepairable.

FRAME AND FORK FATIGUE CRACKS

Fatigue cracks can occur at any time, anywhere in a metal structure. They are most likely to occur in the areas of highest stress, but poor design or construction technique can lead to cracks in relatively unstressed areas.

The optimum time to inspect for fatigue cracks is any time the frame is being cleaned.

What is most consistent about fatigue cracks is that they almost always occur near joints. The inspection should focus on all the joint areas of the frame and fork:

- anywhere the design of the frame creates a stress riser
- anywhere damage to the frame or fork creates a stress riser
- on or near the dropouts
- anywhere on the head tube
- both ends of the down tube
- bottom of the seat tube
- front end of the chain stays
- all around the seat lug
- top end of the fork blades
- where the fork column enters the fork crown

Fatigue cracks often just appear as paint cracks; however, not all paint cracks indicate metal fatigue. Chip away cracked paint to inspect for cracks in the metal below, particularly if the cracked paint is in one of the areas listed above.

DENTED TUBES

The location and severity of a dent in a tube determines the extent of the problem. A dent near a joint is more of a concern than somewhere near the middle of a tube. A dent with a crease is far worse than a dent without a crease. Dents with creases or near a frame joint are likely locations for fatigue cracks.

There is no reason to repair a non-significant dent except cosmetics. The technique for removing the dent will damage the paint and also require the use of a filling compound to completely eliminate the dent. Unless prepared to go as far as a paint job, there is no point in trying to reduce or eliminate dents in tubes.

Critical dents cannot be repaired except by tube replacement by a framebuilder, which is rarely financially sensible.

BOWED STAYS

Bowed stays are an uncommon form of damage, which can look quite severe, but are actually very repairable. Typically it is the seat stays that are bowed, but occasionally the chain stays.

A bowed stay is displaced from its normal path in a gradual curve. Sharp bends or wrinkled tubing fall under the category of severely dented tubing and are not repairable.

A Park SS-1 is a tool specifically made for pulling the bow out of a stay. Its use is simple and self explanatory.

After using the SS-1 to correct the bow, full rear-triangle alignment will be required.

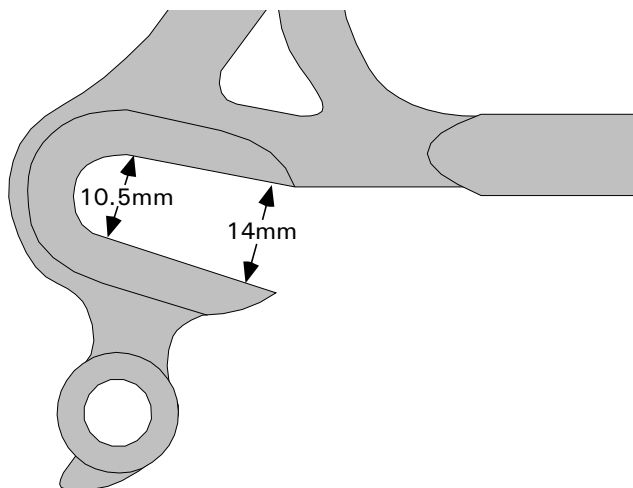
DAMAGED AXLE SLOT IN REAR DROPOUT

When a rear derailleur is shifted past the innermost gear and caught by the rear wheel, it can damage the axle slot in the right-rear dropout by spreading it open.

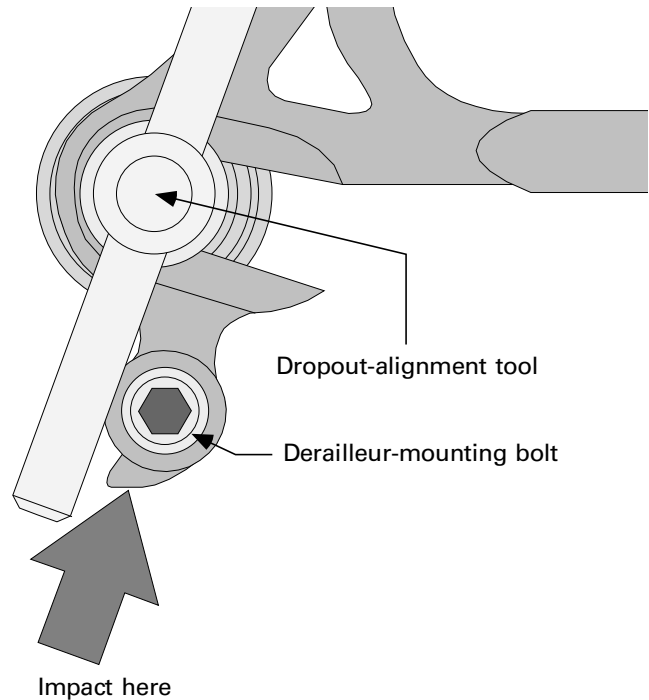
This damage can look very severe and still be repairable. Even if cracks are evident before or after, repair reliability is not an issue, because the stressed and cracked area does not normally experience any significant load during riding.

The rule of thumb when dealing with this problem is to tell the customer that the frame should be considered a loss, but there is a simple repair that can be attempted that is quite effective as long as the dropout does not break in two during the repair.

There are two tricks to the repair. First, the dropout must be sandwiched firmly between two surfaces so that it does not collapse sideways while being pushed back. A dropout-alignment tool supplies the necessary support. Second, the hole for the derailleur mounting bolt must be filled to prevent it from collapsing while force is applied to the dropout through the derailleur hanger.



8.27 This is a damaged axle slot resulting from the derailleur getting caught in the wheel.



8.28 This is the setup for repairing a damaged axle slot.

The repair is done when the width of the slots in both dropouts are equal. Normal dropout alignment and derailleur-hanger alignment should be done afterwards.

RUSTED FRAME OR FORK

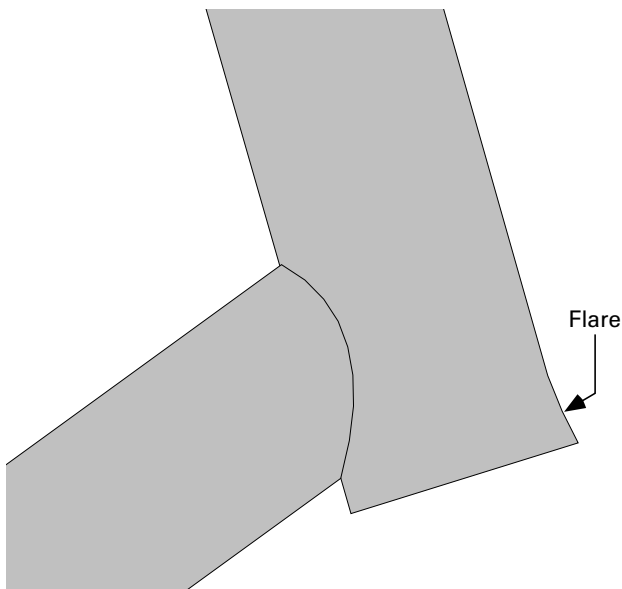
Rust is not much of a problem as long as it is limited to rust at a few points where the paint is chipped. Rust that is a problem cannot usually be seen. It is hidden inside every tube of the bicycle.

When a rust condition exists, there is nothing that can be done to eliminate it. Prevention has more to do with the customer than the mechanic, but if a customer wants to know what can be done the mechanic can advise them of the following tips to prevent rust:

- Spray the inside of any accessible tubes with lubricant when the bike is new.
- Avoid submersion in water.
- Avoid washing the bike with a hose.
- Put a drain hole in the bottom of the bottom-bracket shell.
- Put a drain hole in the top of the bottom-bracket shell and into the bottom of the seat tube, if the seat tube is not open to the bottom-bracket shell.
- Avoid leaving the seat post out of the frame without covering the top of the seat tube.

ENLARGED HEAD TUBE

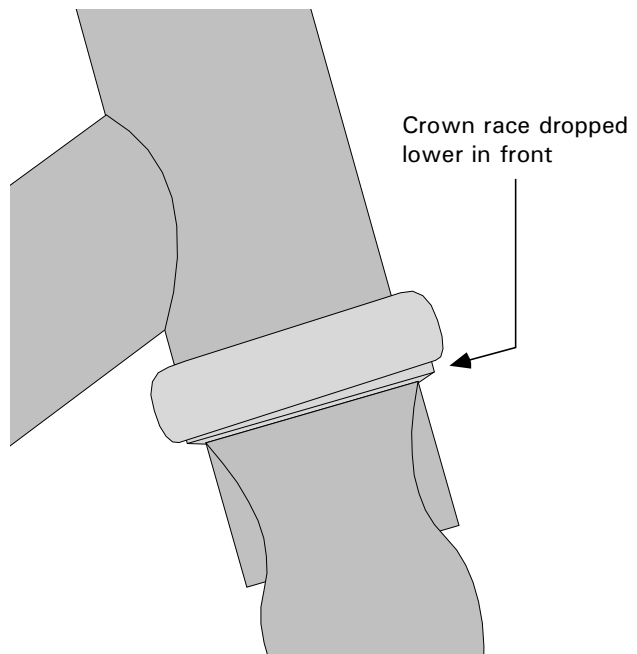
Enlarged head tubes can occur when excessive loads are experienced from landing hard after the front wheel leaves the ground or from frontal impact. Usually there will be some sort of visible flare in the bottom of the head tube at the front or back, but the most noticeable symptom is that the cup pressed into the bottom of the head tube has become loose. The stretched metal cannot be shrunk, so the only feasible repairs are to install a larger cups (unlikely), or to fill the space between the head tube and cup somehow. Depending on the extent of enlargement it might be possible to use Loctite RC680 or 660 (Quick Metal) to fill the gap between the head tube and cup. If these do not work, there is no other effective repair technique.



8.29 This head tube is enlarged. Note the flare at the bottom on the front of the head tube.

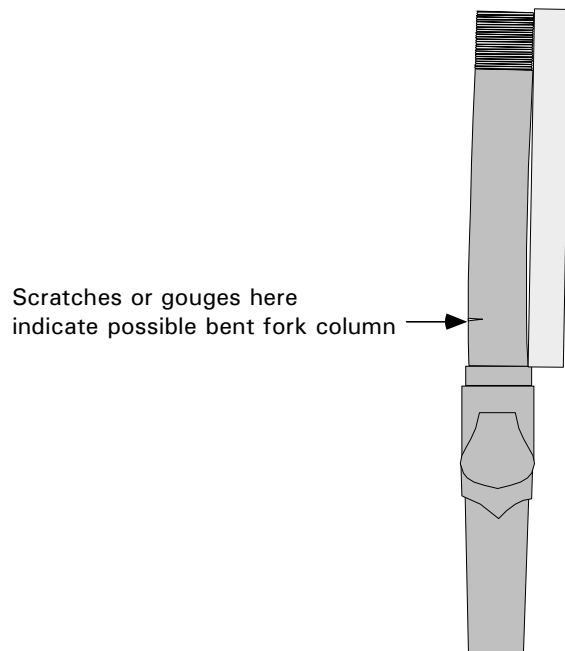
BENT FORK COLUMN

Fork columns get bent back at the bottom from frontal impact; they get bent forward from harsh landings. It is likely, but not necessary, that the blades are also bent. Bent blades are only one clue that the fork column might be bent. Another clue is that the head-set rotates with a tight/loose pattern (tight through part of its rotation and loose through another part). Yet another clue is that the fork-crown race appears dropped out of the lower cup, more in the front than in the back, or vice versa.



8.30 Crown race dropped lower in front, indicating fork column may be bent back from frontal impact.

All of these symptoms have other causes. Their value is only that they lead to further inspection of the fork column by taking the fork out of the bike and holding a straight edge to the front and back of the column.



8.31 The gap between the straight edge and fork column indicates that the fork has been bent back from frontal impact.

The mere fact that the fork column is bent is cause for replacement of the fork. In many cases the situation is critical. When a fork column bends it often

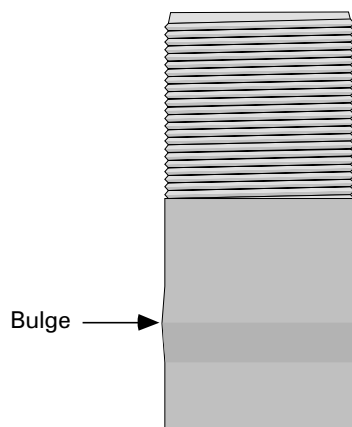
ends up rubbing against the top edge of the lower headset cup. This creates a groove in the fork column which becomes a dangerous stress riser.

BENT, CRACKED, OR BROKEN FORK-COLUMN THREADS

There are two reasons that a fork column will fail in the threaded area: either the stem was installed too high, or the fork column had too long a threaded area. In both cases, the stem expander ended up inside the threaded portion of the fork column. If the stem was too high, a taller stem should be installed. After the fork has been replaced, a taller stem allows the rider to maintain his or her original handlebar position. If the problem was too much thread length on the fork column, be sure to install a fork that has no more than 1.5" of thread after being cut to size, or use an extra-tall stem that can be inserted deeper into the original fork column.

EXPANDED FORK COLUMN

An easily overlooked, but dangerous, condition is a fork column that has been expanded by a too-tight stem expander. To secure the stem in the fork, a mechanism on the stem “enlarges” the stem. If the stem-binder bolt is tightened too much, the expander can permanently deform the fork column. The thinned fork-column wall is weakened. This weakening happens exactly where loads on the stem cause the fork column to flex.



8.32 *Bulge indicating fork column has been destroyed by a too-tight stem-binder bolt.*

If an expanded fork column is suspected but not clearly evident, set a caliper to the fork-column diameter and slide the caliper up or down the column. If it

hangs up where the bottom of the stem was inserted into the fork column, then the column is damaged and the fork should be replaced.

DAMAGED FORK BLADES

Fork blades should be considered damaged any time there is a wrinkle, dimple, or bulge in the tubing. These deformities create stress risers in a most critical area. If unsure, attempt alignment of the fork blades and check closely for any type of deformity. If another mechanic is unable to determine the fork had been bent, then assume that there are no critical deformities.

STEIN FORK ALIGNMENT JIG PROCEDURE

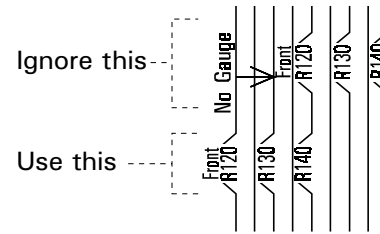
The Stein FCG fork clamp and gauge, used in conjunction with the Stein J-style dropout alignment tools, employs the easiest method to precisely align forks. Since Park has discontinued its tool, the Stein is now the method of choice.

INSTALLING THE FORK

1. [] Fully loosen both bolts on triangular crown aligner.
2. [] Securely clamp main bar in vise just below black clamping plates.
3. [] Position crown aligner on main bar so that triangle points down and so aligner is located under where fork crown will be.
4. [] Liberally loosen 19mm bolt on top of clamp, and install fork (face up) into clamp.
5. [] Secure 19mm bolt until fork will just twist in clamp, but no play (slop) can be felt.
6. [] Slide crown aligner along main bar until it is just below top end of fork blades.
7. [] Secure bottom bolt of crown aligner.
8. [] Tighten top bolt of crown aligner to bring aligner up to contact both fork blades, which aligns fork to jig.
9. [] Secure 19mm bolt on top of clamp so that fork will not move in jig.

ALIGNING THE FORK BLADES AND DROPOUTS

10. [] Position knurled cylinders on J-tools (dropout alignment tools) so that inward ends of knurled cylinders align with “Front/R120” calibration lines. Do not use the “No Gauge” set of calibrations. (If front hub is not standard width, compensate knurled cylinder positions on each J-tool by half of difference between actual hub width and 100mm.)



8.33 *This is the scale that appears on the J-tool cylinders. There are two scales, one to use when using just the J-tools by themselves (marked “No Gauge”), and the other to use when using the J-tools with the Stein fork alignment gauge.*

11. [] Install J-tools fully and securely into dropouts (10mm fat spacers go outward of dropouts).
12. [] Adjust gauge on main bar so that 19mm-long target cylinder is positioned between faces of J-tools (bend fork blade outward to allow knurled cylinder to clear target cylinder, if necessary).
13. [] Apply leverage to J-tools until faces of knurled cylinders are parallel to faces of target cylinder.
14. [] If either knurled cylinder ends up higher or lower than target cylinder, bend fork blade up or down until alignment is achieved.
15. [] Bend each blade in or out as necessary until 1mm clearance exists between inside face of each knurled cylinder and faces of target cylinder. When 1mm clearance exists on each side, dropouts are correct width, and dropouts are centered to fork axis.
16. [] Move knurled cylinders close to target cylinder, then apply leverage to J-tool handles to fine-tune parallel of knurled cylinder faces to target cylinder faces, as necessary.

9 – ADJUSTABLE-CUP BOTTOM BRACKETS

ABOUT THIS CHAPTER

This chapter is about adjustable-cup bottom brackets. Adjustable-cup bottom brackets have a spindle, loose balls or balls in a retainer, and cups that thread into the bottom-bracket shell. There are also sealed cartridge-bearing bottom brackets, which may press into, or thread into, the bottom-bracket shell. These are generally less serviceable, and are covered in a chapter called **CARTRIDGE-BEARING BOTTOM BRACKETS** (page 10-1).

GENERAL INFORMATION

TERMINOLOGY

Bottom bracket: The bearing assembly that allows the crankset to rotate in the bottom-bracket shell.

Bottom-bracket shell: The 1.5" diameter 3" long horizontal frame tube at the bottom of the frame that contains the bottom bracket.

Cone: A surface that bearings roll on that is positioned inside the circle of balls. Two cones are built into the bottom-bracket spindle.

Cup: A cup is a surface that bearings roll on that is positioned outside the circle of balls. The cups thread into the bottom-bracket shell.

Race: The cone or cup surface on which a ball bearing rolls. A misuse of this term is to use it to describe a set of ball bearings held together in a holder, which is more properly called a *retainer*.

Retainer: A clip that holds a group of ball bearings that go between a cup and a cone. A retainer is sometimes mistakenly called a *race*.

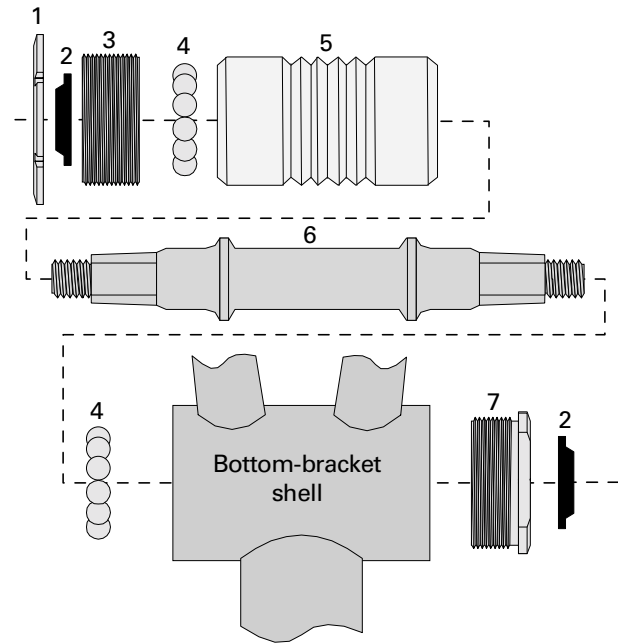
Adjustable cup: A bearing cup that threads into the left side of the bottom-bracket shell, which is positioned further in or out to loosen or tighten the bearing adjustment.

Fixed cup: A bearing cup that threads into the right side of the bottom-bracket shell that is seated fully and left in one fixed position. The fixed cup has a built in flange that stops against the right end of the bottom-bracket shell.

Spindle: The axle that rotates inside the bottom-bracket shell. The word *axle* is sometimes used in the vernacular in regards to the bottom-bracket spindle.

Lockring: A ring with notches on its outer perimeter that threads onto the adjustable cup and against the left end of the bottom-bracket shell, and fixes the position of the adjustable cup relative to the bottom-bracket shell. Lockrings are round and have notches that are engaged by a special tool called a lockring spanner.

Seal mechanism: A rubber insert that fills the gap where the spindle goes through the holes in the adjustable cup and fixed cup.



9.1 Parts of the bottom bracket: 1. Lockring, 2. Seal mechanisms, 3. Adjustable cup (left side), 4. Ball bearings, 5. Plastic sleeve protector, 6. Spindle, 7. Fixed cup (right side).

PREREQUISITES

Chainline error

Before removing crank arms the chainline should be checked. The reason for this is that one way to fix a chainline error is to change the bottom-bracket spindle, something that may be done when overhauling the bottom bracket. See the **CHAINLINE** chapter (page 27-1) before removing the crank arms.

Crank-arm removal

In order to overhaul the bottom bracket, it is necessary to remove the crank arms. To just adjust the bottom bracket, it is recommended, and often required, to remove the crank arms. See the **TAPERED-FIT CRANK ARMS** (page 20-6) or **COTTERED CRANK ARMS** (page 21-3) chapter before starting the bottom-bracket overhaul or adjustment.

INDICATIONS

There are several reasons the bottom bracket may need an overhaul, and several reasons it may need adjustment. A bottom-bracket overhaul should be done as part of a regular maintenance cycle, the duration of which will change depending on the type of riding, the amount of riding, and the type of equipment. Adjustments should be done on the basis of need.

Maintenance cycles

If you start out with a bottom bracket known to be in good condition with good quality grease, it should be able to be ridden thousands of miles without needing an overhaul. If the equipment sees little wet-weather riding, then an appropriate maintenance cycle would be 2000–3000 miles in most cases. If a lot of wet-condition riding is done, then the maintenance cycle might need to be as often as every 750–1000 miles. Parts rust whether being ridden or not, so another factor is how long the bike may be sitting before it will be used again. For example, if ridden 200 miles in the rain in the fall, then the bike is put away for four months for the winter, it would probably be a good idea to overhaul the bottom bracket *before* the bike is put away for the winter.

Some other factors affecting the maintenance cycle are whether the bottom bracket is equipped for grease injection and whether the bottom bracket has seal mechanisms. *Grease-injection systems do not eliminate the need for overhauling.* They only increase the acceptable time between overhauls; furthermore, grease-injection systems are only as good as the customer is consistent and thorough about pumping in new grease.

Seal mechanisms (adjustable-cup bottom brackets with rubber seals between the spindle and cups) *are not effective water-tight seals.* Their effectiveness varies with the brand and model. At best, they can lengthen the acceptable time between overhauls.

Symptoms indicating need of overhaul

One of the most common symptoms that leads the customer to believe that his or her bottom bracket needs overhaul is noise coming from the general area of the bottom bracket. Most noises that seem to come from the bottom bracket are crankset and pedal noises. When bottom brackets do make noise, it is almost always from a loose cup or lockring and can be fixed without an overhaul. A bottom bracket with enough internal damage or wear to make a noise that is audible while riding, would be an extremely damaged piece of equipment.

So what symptom would indicate that the bottom bracket should be overhauled? The only one is that when performing an adjustment, the looseness (free play) in the bearings cannot be eliminated without the bearing becoming excessively tight (does not turn smoothly). The lack of smoothness could be caused by dry grease, contaminated grease, or worn parts.

Symptoms indicating need of adjustment

The primary symptom that will be experienced indicating that the bottom bracket needs an adjustment is looseness in the bearings. This can be detected by grasping the end of the crank arms and jerking them in and out while feeling for a knocking sensation. Another possible symptom indicating that the bottom bracket needs adjustment is a clicking sound that cannot be solved by tightening the crank arms, chainrings, pedals, or pedal parts. A loose fixed cup or loose lockring can be the source of this sound. Whenever the lockring or fixed cup is loose, it is not adequate to simply secure the loose part, as the bottom-bracket adjustment may have been lost while the part was loose.

One other case in which it is recommended to adjust the bottom bracket is on any new bike assembly. Most bikes come in the box from the factory with an installed bottom bracket. It is common that the factory is not very reliable, and bottom brackets sometimes are completely worn out after as little as 1000 miles of use due to poor factory setup.

TOOL CHOICES

The design or brand of bottom bracket will determine the tools needed. The following list covers tools for adjustable-cup bottom brackets only. This list covers all the tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among:

ease of use, quality, versatility, and economy. When more than one tool for one function is **bold**, it means that several tools are required for different configurations of parts.

ADJUSTABLE-CUP BOTTOM-BRACKET TOOLS (table 9-1)

Tool	Fits and considerations
FIXED-CUP TIGHTENING (cup already installed)	
Stein FCC2	Attaches to nut-type and bolt-type spindles to retain spanners to cup.
Campagnolo 713	36mm fixed cup (also 15mm pedal flats)
Cobra	36mm fixed cup (also 15mm pedal flats)
Cyclo 1329	36mm fixed cup (also 15mm pedal flats)
Diamond C79	Old-fashioned monkey wrench odd-size fixed cups not fit by fixed cup spanners (special order from Ace hardware stores)
Park HCW-2	35mm fixed cup (also with hinged single peg lockring spanner)
Park HCW-3	Slotted 36mm spanner fits with right crank still mounted, if inner ring does not overlap fixed cup (also fits 25mm one-piece bottom-bracket cones and nuts)
Park HCW-4	36mm fixed cup (also fits pin-hole adjustable cups w/ 29mm dia. hole pattern)
Park HCW-11	16mm flats found on old English and some Taiwan fixed cups (also fits adjustable cups with slots or square holes)
Shimano TL-FC30 (set)	Set includes 36mm fixed-cup wrench
Sugino 201 (set)	Set includes 36mm fixed-cup wrench
FIXED-CUP INSTALLATION AND REMOVAL	
Campagnolo 793/A	36mm fixed cups
Hozan C358	35.7mm and 36mm
Kingsbridge 301	Universal (works by friction, may slip on most difficult removals)
United Bicycle Tool BBCR	Universal (works by friction, may slip on most difficult removals)
VAR 30 with 30/2 & 30/3	35mm, 35.4mm, 36mm, 36.7mm, 37.7mm and 38mm fixed cups
LOCKRING TOOLS (Single-hook design fits all lockrings, but is best used when plier will not fit because number of notches is odd. Pliers are superior grip, but don't fit three-notch lockrings. Multiple-hook design tools fit specific brand of lockring only).	
Campagnolo 712	Multiple-hook design fits Campagnolo lockrings (also fits 32mm headset races)
Cyclo 1333	Multiple-hook design fits Campagnolo lockrings (also fits 32mm headset races)
Eldi 2712	Single-hook hinged design (fits headset lockrings also)
Hozan C205	Single-hook design (other end fits headset lockrings)
Hozan C203	Pliers have excellent fit to all lockrings with even number of notches (also fits headset lockrings with even number of notches)
Park HCW-2	Hinged single-hook design (fits headset lockrings also, and 35mm fixed cups)
Park HCW-5	Single hook design on one end fits all lockrings, multiple-hook design on other end fits some 3 and 6 notch lockrings
Park HCW-12	Single-hook design (also fits 32mm headset races)
Shimano TL-FC30 (set)	Set includes multiple-hook design fits Shimano lockrings only
Stein LW	Vise grip plier has secure grip for stuck lockrings w/even number of notches
Sugino 201 (set)	Set includes single-hook design lockring tool
VAR 16	Plier (bulky and awkward compared to Hozan C203)

9 – ADJUSTABLE-CUP BOTTOM BRACKETS

ADJUSTABLE-CUP BOTTOM-BRACKET TOOLS (table 9-1 cont.)

Tool	Fits and considerations
ADJUSTABLE-CUP PIN SPANNERS (Adjustable spanners can be adjusted to fit various cups. They may be light duty or heavy duty. Fixed spanners fit certain cups only and are all heavy duty).	
Cyclo 1330	Fixed pin spanner fits Campagnolo cups
Park SPA-1 (green)	Light duty adjustable with 3.0mm pins
Park SPA-2 (red)	Light duty adjustable with 2.4mm pins
Park SPA-6	Heavy duty adjustable with 2.4mm pins (not as stout as VAR 13)
Park HCW-4	Fixed pin spanner (fits many, but not all, pin-hole cups)
Shimano TL-FC30 (set)	Set includes fixed pin spanner that fits Shimano cups
Sugino 201 (set)	Set includes fixed pin spanner that fits Sugino cups
VAR 13	Heavy duty adjustable with 2.4mm pins
SLOTTED ADJUSTABLE-CUP SPANNERS (for adjustable cup with square holes or slots in its face)	
Park SPA-4 (yellow)	Light duty, limited fit
Park HCW-11	Heavy duty (fits cups with 16mm flats also)
VAR 311	Heavy duty, but awkward compared to Park HCW-11
16MM FLATS ADJUSTABLE-CUP SPANNERS (for adjustable cup with 16mm wrench flats)	
Park HCW-11	Good tool, only one made for the job (works on similar fixed cups also)
HEX-FACED ADJUSTABLE-CUP SPANNERS (for adjustable cup with hex fittings on its face)	
Diamond C79	Old-fashioned monkey wrench fits all size hex faces with crank arm removed (special order from Ace hardware stores)
Park HCW-3	25mm (36mm fixed-cup spanner on other end)
VAR 19/1	22mm & 24mm
VAR 19/2	26mm & 28mm
VAR 19/3	22mm & 24.9mm

TIME AND DIFFICULTY RATING

Overhauling the bottom bracket (including crank-arm removal and bottom-bracket adjustment) is a 30–40 minute job of moderate difficulty. Adjusting the bottom bracket alone (including crank-arm removal) is a 10–15 minute job of moderate difficulty.

COMPLICATIONS

Difficult cup removal

Difficulty may be experienced removing the adjustable cup or fixed cup. Using a self-retaining fixed-cup tool such as the VAR 30 and a cheater bar, will generally solve the problem for the fixed cup. When the adjustable cup is difficult to turn, retain the adjustable-cup spanner with something like a Stein Fixed Cup Spanner Clamp (FCC-2).

Difficulty may be experienced threading the cups out even after they have broken loose, or difficulty may be experienced threading them in. In this case, it is recommended to tap the bottom-bracket threads. See the **TAPPING THE BOTTOM-BRACKET SHELL** chapter (page 2-3).

Difficult adjustment

One other difficulty that might be experienced is that it may not be possible to get a good adjustment even with good quality new parts. If the symptom experienced is that the spindle feels smooth through part of its rotation, then gets difficult to turn, and finally easy again, then the bottom-bracket shell may need facing. See the **FACING THE BOTTOM BRACKET** chapter (page 3-4).

THREADS

Bottom brackets thread into the frame. There are several different thread standards listed in the following table. It is necessary to identify what thread standard is used on a particular bike in order to determine which way to turn the fixed cup, or to determine compatible replacement parts. To identify the threads a thread-pitch gauge and a caliper are needed.

See the following page for a table of bottom-bracket-thread information.

9 – ADJUSTABLE-CUP BOTTOM BRACKETS

BOTTOM-BRACKET THREADS (table 9-2)

ADJUSTABLE CUPS: Always found on the left side of the bike and always are right-hand thread.

FIXED CUPS: Always found on the right side of the bike, see **Right-side thread direction** row below for thread direction.

Thread type	"BSC" ¹	"ISO" ¹	"Italian"	"Swiss"	"French"	"Whitworth"
Typical occurrences	All Asian and most American bicycles, as well as many others. <i>All unmarked Taiwan and Japan cups are BSC or ISO thread.</i>		Most Italian, some Mexican and American bicycles	French bikes from the late-seventies to mid-eighties	French bikes from the mid-eighties or earlier	English inexpensive three-speed and ten-speed bikes
Pitch	24tpi		24tpi	1mm	1mm	26tpi
Cup O.D.	34.6–34.9mm		35.6–35.9mm	34.6–34.9mm	34.6–34.9mm	34.6–34.9mm
Right-side thread direction	left-hand thread		right-hand thread	left-hand thread	right-hand thread	left-hand thread
Left-side thread direction	right-hand thread		right-hand thread	right-hand thread	right-hand thread	right-hand thread
Nominal thread description²	1.370" × 24tpi ¹ (Shimano ⁴)	1.375" × 24tpi ¹	36mm × 24tpi	35mm × 1mm (left ³)	35mm × 1mm (right ³)	1–3/8" × 26tpi
Shell I.D.	33.6–33.9mm		34.6–34.9mm	33.6–33.9mm	33.6–33.9mm	33.6–33.9mm

¹ BSC (British Standard Cycle) and ISO (International Standards Organization) sizes are fully interchangeable. The .005" diameter difference shown in the **Nominal thread description** row is a difference on "paper" only.

² **Nominal thread description** is the name of the thread type. The diameter value is not a measurement, but a value rounded-up from the actual measurement.

³ French and Swiss threads are identical except that the thread direction of the fixed cup (right side) is left-hand for the Swiss and right-hand for the French. The notations (left) and (right) rarely show up in the nominal thread descriptions, although sometimes the letter "G" (stands for left in French and Italian) might be part of the name (example: 35 × 1G) if it is a Swiss thread.

⁴ Shimano marks BSC cups "BC 1.37 × 24".

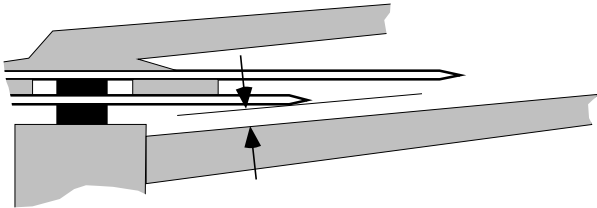
9 – ADJUSTABLE-CUP BOTTOM BRACKETS

OVERHAUL AND ADJUSTMENT PROCEDURE

NOTE: If just adjusting bottom bracket and not overhauling it, do step 3, turn locking counterclockwise to loosen it, then skip to step 46.

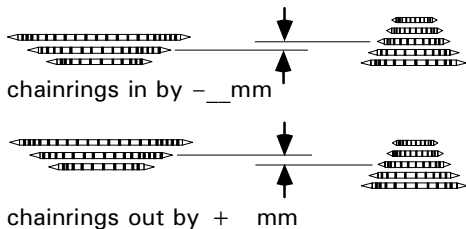
CRANK-ARM REMOVAL

1. [] Measure chainring-to-chainstay clearance with stack of feeler gauges: _____ mm.



9.2 Check clearance here before removing crank arm.

2. [] Measure chainline error (see CHAINLINE chapter, page 27-5). Chainrings are *out* or *in* (circle one) _____ mm.

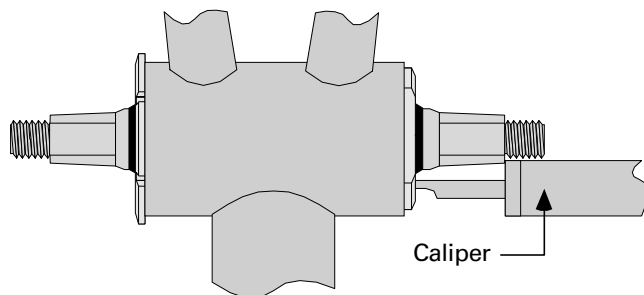


9.3 Determine the chainline error. Write the measurement as a negative number if the chainrings are in.

3. [] Remove crank arms.

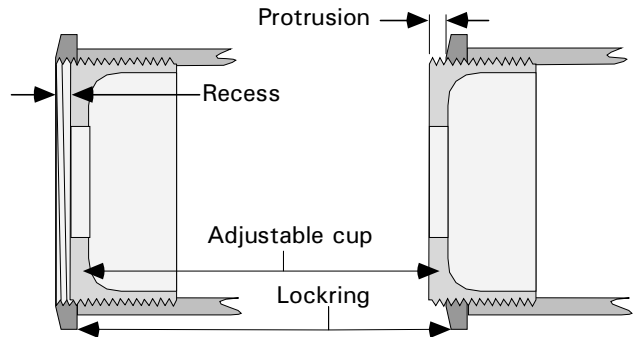
BOTTOM-BRACKET REMOVAL

4. [] Measure bottom-bracket-axle right-side protrusion from cup face: _____ mm.



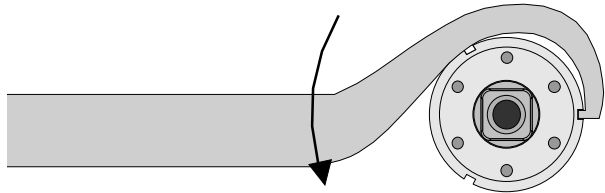
9.4 Measuring right-side axle protrusion.

5. [] Measure adjustable-cup protrusion (or recess) from locking face: _____ mm (write recess as a negative number).



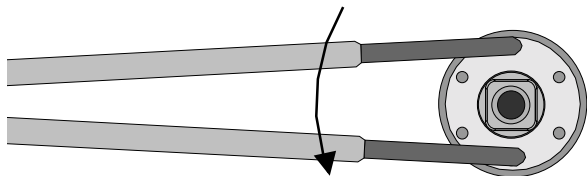
9.5 The adjustable cup should not recess into the locking at all, but may protrude up to 2mm.

6. [] Turn locking counterclockwise with locking tool to remove it.



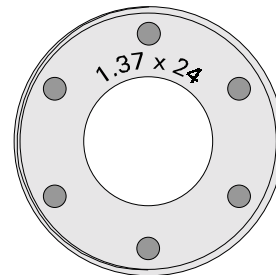
9.6 Remove the locking.

7. [] Turn adjustable cup counterclockwise with adjustable-cup tool to remove it.



9.7 Remove the adjustable cup.

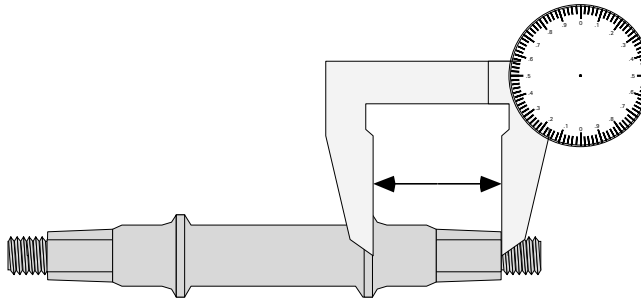
8. [] Inspect cup faces for thread identification. Record markings here: _____



9.8 Inspect cup and locking face for thread identification (1.37x24 in this case).

9 – ADJUSTABLE-CUP BOTTOM BRACKETS

9. [] *Only if adjustable-cup markings are inadequate*, measure cup diameter and pitch and record here: _____
10. [] Look thread type up in **BOTTOM-BRACKET THREADS** (table 9-2) from cup marks or from measurements that were taken.
11. [] From table information, choose whether fixed cup is *right-* or *left-* (circle one) hand thread.
12. [] Remove ball bearings from inside adjustable cup or from left end of spindle.
13. [] If replacing bearings (*strongly recommended*), pop one out of the retainer and measure it with the Park SBC-1 bearing ruler. Record ball bearing size here: _____
14. [] Remove spindle (keeping careful track of which end was on the right and which was on the left), measure spindle ends, and note whether *right long?* or *left long?* or *symmetrical* (circle one).

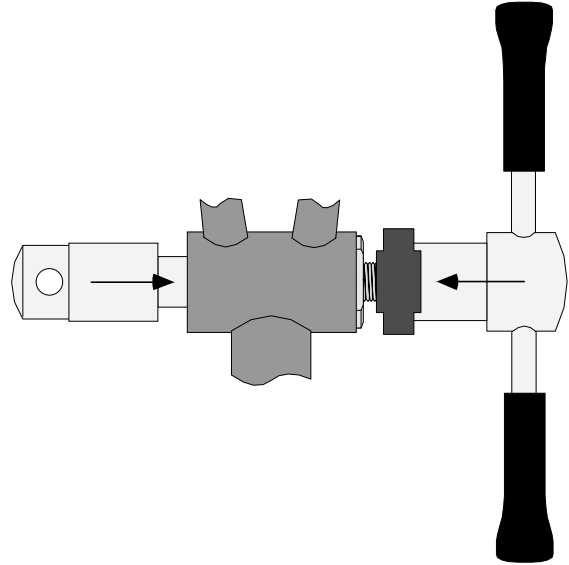


9.9 Correct way to measure the spindle end.

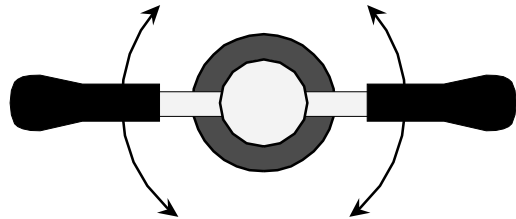
If the spindle needs to be replaced because it is worn out or a bad fit (due to poor chainline, poor chainring clearance, or poor adjustable-cup position), a suitable replacement needs to be found. Spindles have code numbers on them that can be used to determine the appropriate solution. There is a section later in this chapter on spindle interchangeability.

15. [] **Note spindle markings here:** _____
16. [] **Remove plastic sleeve if there is one.**
17. [] **Remove other set of bearings from right end of spindle or from inside fixed cup.**

18. [] Remove fixed cup with fixed-cup tool (check thread direction noted in step 11).



9.10 Assemble fixed-cup tool into bottom-bracket shell.



9.11 Turn the fixed-cup tool in the correct direction noted previously in step #11.

Both cups have now been removed. Was either or both difficult to thread out? If so, it would be a good idea to tap the threads. It can make a big difference in whether the cups might cross-thread when re-installing them, and it will also make adjustment easier. It could be that all the threads need is cleaning, so after cleaning them test install the cups to decide whether to tap the threads.

Many bottom-bracket cups have rubber seals in the hole where the spindle goes through the cup. It is optional to remove these seals, but it helps cleaning if done. The seals are generally soft rubber and pull out easily with fingers. The seals are often asymmetrical, with some sort of lip protruding from one face with no comparable lip on the other face. If put in backwards the seals may not do their job and may interfere with the rotation of the spindle.

19. [] **Remove seals from cups (if any) and write down orientations here:** _____

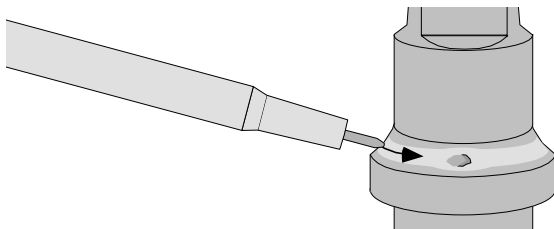
9 – ADJUSTABLE-CUP BOTTOM BRACKETS

CLEANING THE PARTS

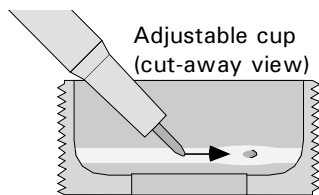
- 20. [] Clean spindle, inside cups, and inside crevasses where any seals were mounted.
- 21. [] Clean inside of bottom-bracket shell.
- 22. [] Clean cup threads and shell threads with toothbrush and solvent.
- 23. [] Clean balls bearings only if re-using them (re-using bearings *not* recommended).

PARTS INSPECTION

When bearings wear out, the surfaces on which the balls roll develop pits (rough craters in the metal) called galling. Once this occurs a proper adjustment cannot be made, and the wear will continue at a high rate. The design of the bottom bracket is such that the spindle tends to wear out first, the fixed cup next, and the adjustable cup last. This order is not cast in stone, especially if all three parts have not been in service an equal amount of time. Although it is sometimes possible to get individual replacement parts, more often than not only complete bottom brackets are available. In any case, if any parts are heavily worn, it is a good idea to replace them all. The ultimate test to determine whether there are pits is to trace the wear path the bearings have left on the cup or the spindle with the tip of a ball point pen. If the tip of the pen catches anywhere, you have found a pit.



9.12 Trace the ball path with a ball point pen to check for pits in the cone race.

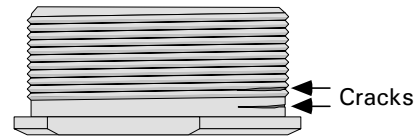


9.13 Check for galling (pits) on the ball path in the cup by tracing the ball path with a ball point pen.

Inspecting the ball bearings for wear is not recommended. Significant wear on bearings is not necessarily detectable with the naked eye or by feel. Always replace the bearings if going to the trouble to overhaul the bottom bracket.

- 24. [] Inspect cone race on spindle for pits.
- 25. [] Inspect inside cups for pits in ball wear line.

- 26. [] Inspect inside cups for cracks in vicinity of ball wear line.
- 27. [] Inspect in fixed-cup threads for any cracks between threads, particularly at end near cup flange.



9.14 Cracks can be seen at the points indicated by arrows.

PARTS REPLACEMENT AND INSTALLATION OF NEW PARTS

Verification of thread compatibility

When replacing parts and old parts are at hand, measure cup-thread diameter and pitch. Observe fixed-cup-thread direction. Verify that replacement parts match in all respects.

When installing new parts with no original parts on hand, measure pitch and inside diameter of the bottom-bracket shell. See **BOTTOM-BRACKET THREADS** (table 9-2), and use the **Pitch** row and the **Shell I.D.** row to determine the thread type.

Spindle compatibility

Spindle interchangeability is a challenging problem. First you must decide if you:

- Want the new spindle to match as closely as possible in all respects.
- Want the new spindle to move the adjustable cup in or out by how many millimeters.
- Want the new spindle to move the chainrings in or out by how many millimeters.

For example, if the adjustable cup is recessed 1mm in the face of the lockring with the original spindle, it would seem that you would want a spindle with 1mm additional width between the cone races. What complicates matters is that cone diameters on the spindle vary from brand-to-brand. A replacement spindle might have the extra millimeter of width between the cone races, but due to a smaller cone diameter no effect will be seen on the adjustable-cup position at all. In regards to chainring position, it would seem that all that matters is the length of the spindle from the cone race to its end. For example, if you want the chainrings to move in 2mm, get a spindle with a right-end length that is 2mm shorter; unfortunately, the thickness of the taper that fits into the crank arm varies brand-to-brand. If the replacement spindle was

2mm shorter on the end, but the taper was thicker, then it could end up that the chainrings would not move in at all. As long as the replacement spindle is a brand match, a simple comparison of width between cone races and length from cone race to end of spindle should be sufficient.

Fortunately most bikes with adjustable-cup bottom brackets use Taiwanese or Japanese parts, which all adhere to the JIS standard. There is a section later in this chapter about spindle interchangeability in regard to these JIS spindles, with a table of dimensions and worksheets for determining appropriate replacement spindles.

28. [] If original spindle caused problems with chainline, chainring-to-frame clearance, or adjustable-cup protrusion from lockring, go to *SPINDLE INTERCHANGEABILITY* (page 9-13) to determine appropriate replacement(s).

29. [] Replace any worn out spindle, or spindle that is causing problems with chainring position or adjustable-cup position.

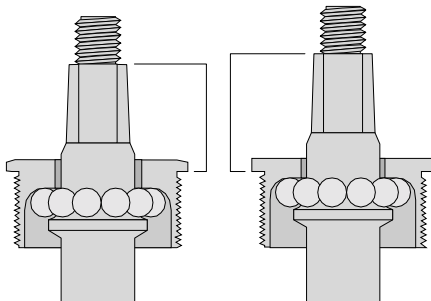
Cup compatibility

Many cups, particularly Asian ones, are compatible fit across brands. Use the following test to determine compatibility between old and new parts.

Check the diameter of the hole in the cup. This will be the minimum for any cup to be considered for replacement.

With the spindle held vertically, place a ball retainer and the worn cup on the top end of the spindle. If it is an adjustable cup, measure the distance from the end of the spindle to the face of the cup. If it is a flanged fixed cup, measure the distance from the end of the spindle to the inside face of the flange.

Install any candidate replacement cup on the spindle in the same fashion, and take the same measurement. If the difference is less than .5mm, the replacement is acceptable. A cup with a difference greater than .5mm may work, but at this point test-assembly of the bottom bracket would be best.



9.15 The fixed cup on the right has a lower stack height and would position the spindle further out from the end of the bottom-bracket shell. Measure from the back side of the fixed-cup flange to the end of the spindle (as shown) to compare fixed-cup stack height.

If test-assembling to determine replacement suitability, the lockring must engage three full threads of the adjustable cup, no more than two threads of the adjustable cup should protrude past the face of the lockring, and the chainwheels should clear the frame by at least 2mm.

30. [] Replace any worn out or damaged cups.

Replacing ball bearings

The original ball bearings are usually in a retainer (a clip that holds the balls together in a set). There are no mechanical advantages to using retainers, but there can be several disadvantages. Installing loose balls is always recommended, but the following information is provided about retainers in case they come with a new bottom bracket you are installing. If installing loose balls, try to find the highest quality balls available. Good balls are described as *grade 25*. Decent ball bearings might be described in the range of *grade 100* to *grade 200*. Any higher number than these is a mediocre bearing.

Balls in a retainer are more expensive to buy in a high grade, and grade information is rarely available for balls in a retainer. Retainers often have fewer than the maximum number of balls that will fit, leading to an increased rate of wear. Any retainer with 1/4" balls can be replaced by 11 loose 1/4" balls. Any time the original balls were 1/4" (loose or retained), the correct quantity of loose balls to use is 11. If the retainers include a size of ball bearing other than 1/4" (usually 3/16" or occasionally 7/32"), the quantity of loose balls that will fit is less certain. Fill the cups with balls without forcing any in. Retainers can be put in backwards, which can destroy the bottom bracket or drive you nuts when you are trying to adjust the bottom bracket.

Important information if installing ball retainers

Forget any rules of thumb about which way ball retainers face in relation to the cups and spindle. There is only one way to get ball retainers in correctly and that is to test mate them both ways to the spindle and both ways to the cup. In one of the four combinations, the clip that holds the balls together will be obviously contacting the ball race on the spindle or the cup instead of the balls themselves contacting the race. Install the retainers opposite this. If good measurements of the right-side spindle protrusion were taken, and the original retainers were in correctly, and the original (or an identical) spindle has been put in, putting a retainer in backwards will reduce the spindle

9 – ADJUSTABLE-CUP BOTTOM BRACKETS

protrusion by more than a millimeter. If good measurements of the adjustable-cup protrusion from the lockring face were taken, and the original retainers were in correctly, and the original (or an identical) spindle and adjustable cup has been put in, putting a retainer in backwards will increase the cup protrusion by more than a millimeter.

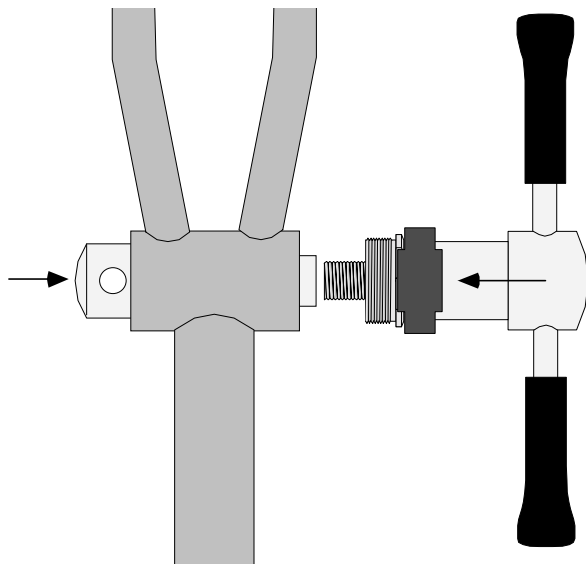
31. [] Replace ball bearings.

ASSEMBLY

32. [] Loctite fixed-cup threads (Loctite 242).

Cups are about to be threaded into the bottom-bracket shell. It is easy to cross thread them, which can damage the shell and require thread tapping. If fingers are used to start the cups, and no tools are used until the cups have turned in several full revolutions, there is no chance of damaging the shell. If the cups were easy to thread out they should be easy to thread in. If they were hard to thread out, it is best if the shell threads have been chased. If not, be *extremely* careful to not cross thread the cups. If there is trouble getting the threads started, try rotating the cups backwards just until a little “pop” is felt, then turn the correct direction. *Remember*, if the fixed cup was a left-hand thread it turns counterclockwise to install. To avoid the potential for cross-threading, start by installing the fixed cup on a piloted fixed-cup tool, such as the VAR 30.

33. [] Put fixed cup on fixed-cup tool and assemble tool together inside bottom-bracket shell with fixed cup. Secure to 25ft-lbs (25lbs@6", on two levers simultaneously).



9.16 Set-up for using the VAR 30 fixed-cup tool. With the fixed cup already on the handle end of the tool, assemble the tool inside the bottom-bracket shell.

34. [] **Only** if installing balls in a retainer, test mate retainers facing both possible ways in cups and on spindle to determine correct orientation.

35. [] Grease seals (if any), then install into cups.

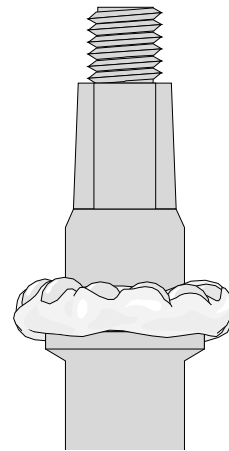
36. [] Thoroughly grease adjustable-cup threads on cup and inside left side of bottom-bracket shell.

37. [] Put an ample quantity of grease in adjustable cup.

38. [] Put bearings into adjustable cup and cover bearings with grease.

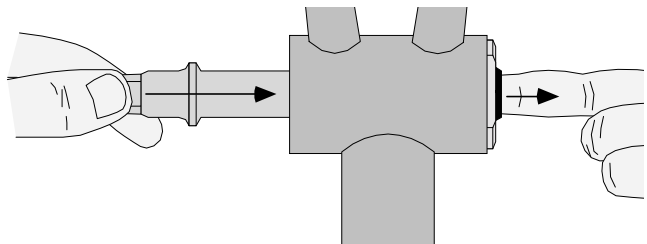
39. [] Put an ample quantity of grease onto right end of spindle.

40. [] Put bearings into grease on spindle and cover bearings with grease.



9.17 Put an ample quantity of grease on the bearing race on the right end of the spindle, then submerge the balls in the grease.

41. [] Install right end of spindle into left side of bottom-bracket shell.



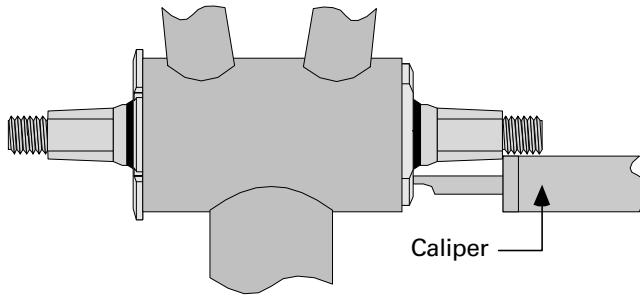
9.18 Use a finger to guide the right end of the spindle through the fixed cup.

42. [] Install plastic sleeve protector (if any).

43. [] Thread in adjustable cup until it exerts light pressure on spindle.

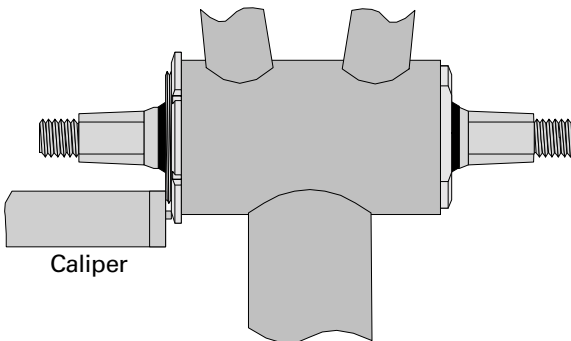
9 – ADJUSTABLE-CUP BOTTOM BRACKETS

44. [] Verify that right-side spindle protrusion matches pre-disassembly dimension (unless spindle is changed or deliberately reversed to improve chainline).



9.19 Measure right-side axle protrusion.

45. [] Hand-thread on locking and verify that cup protrusion matches pre-disassembly dimension (unless spindle was changed). If cup protrusion has increased and spindle is unchanged, disassemble bottom bracket and find if bearing retainer(s) are out of place or if a loose ball is out of place.



9.20 Verify adjustable cup still protrudes the same distance from the locking face.

ADJUSTMENT

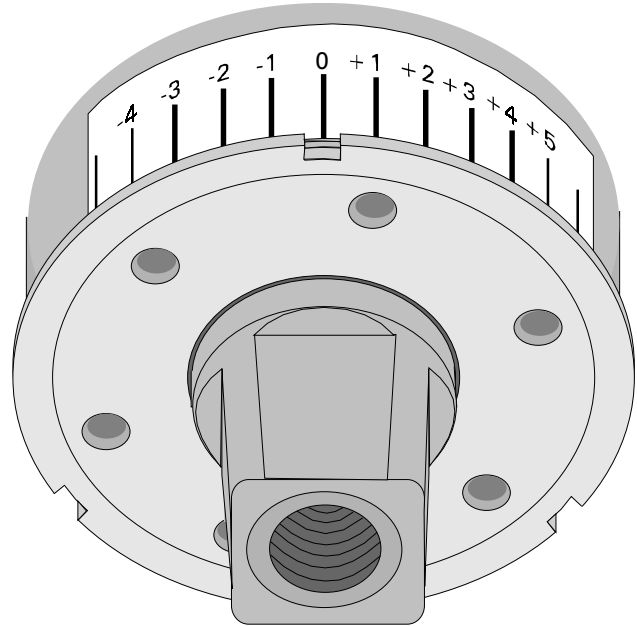
NOTE: If the bottom bracket was just installed skip to step 50.

46. [] Loosen locking and loosen adjustable cup one full turn.
 47. [] Secure fixed cup to 360in-lbs (30lbs@12").
 48. [] Loosen locking one extra turn.
 49. [] Thread in adjustable cup until it exerts light pressure on spindle.

This book comes with some complimentary bearing calibration stickers sold by Barnett Bicycle Institute. A supply of these stickers is available from BBI for \$14.99 (price subject to change). The stickers are

used in the accompanying illustrations. If preferred, draw some pen lines onto some 1/2" masking tape at 1/8" intervals to duplicate the function of the sticker.

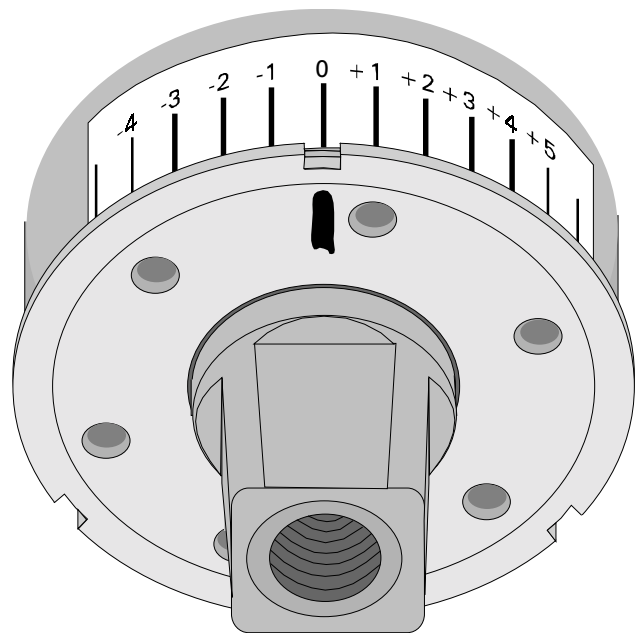
50. [] Clean adjustable-cup face with acetone or alcohol and put masking tape or BBI Bottom Bracket Tape sticker.



9.21 BBI Bottom Bracket Tape sticker in place.

51. [] Set adjustable cup to **gently** contact ball bearings.

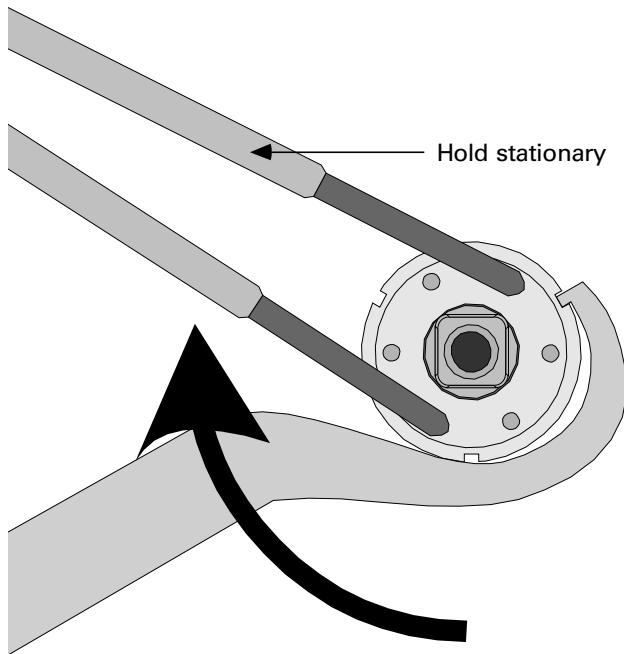
52. [] Use fine-tip permanent marker to put mark on cup face to match "0" mark on sticker.



9.22 Put a mark on the cup face in line with the "0" mark on sticker.

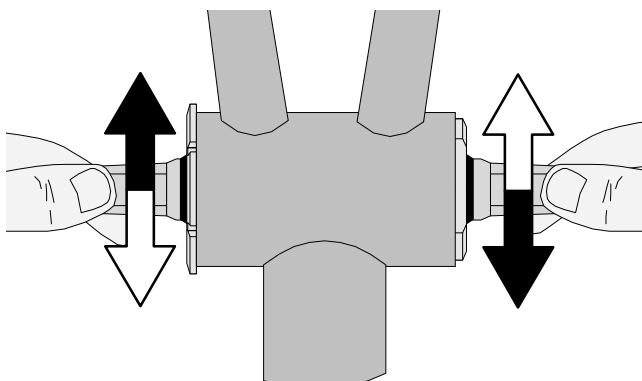
9 – ADJUSTABLE-CUP BOTTOM BRACKETS

53. [] Holding adjustable cup stationary with adjustable-cup spanner, secure locking with locking spanner to at least 300in-lbs (38lbs@8").



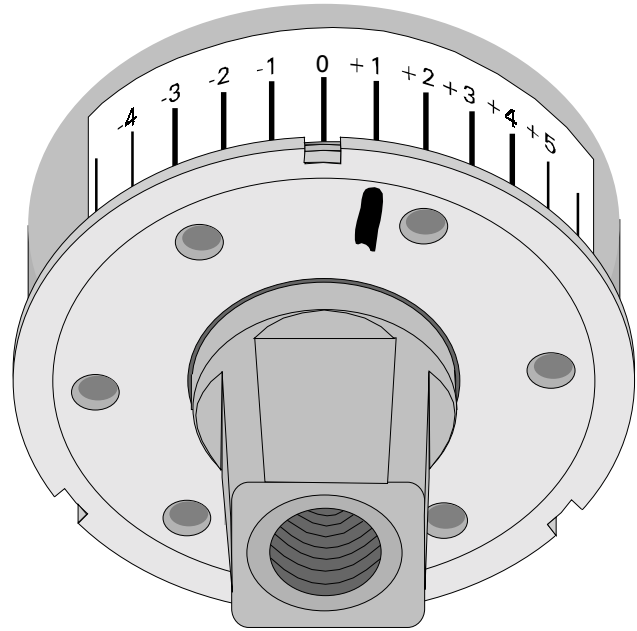
9.23 Secure the locking while holding the adjustable cup absolutely stationary.

54. [] Check that mark on cup still lines up with "0" mark. Reset if cup slipped.
 55. [] Grasp both ends of spindle firmly and jerk vigorously to check for knocking sensation that indicates adjustment is too loose. If no knocking is felt, reset cup 4 marks looser counterclockwise and check again.



9.24 Jerk spindle vigorously to check for knocking.

56. [] Loosen locking and turn adjustable-cup mark to next clockwise mark on sticker or on masking tape.



9.25 Move the cup clockwise to make the cup mark line up with the next sticker mark to eliminate the knocking.

57. [] Holding adjustable cup stationary, tighten locking to at least 300in-lbs (38lbs@8").
 58. [] Check for knocking. When knocking is difficult to feel, rotate the spindle to various positions and check further for knocking. Repeat adjustment (steps 56–58) one mark clockwise at a time as necessary until play is eliminated.

When rotating the spindle at the point the knocking seems to be eliminated, it is possible that it might feel sluggish, tight, rough, or tight and smooth simultaneously at this point. How good it feels is largely a function of the quality and condition of the parts, and whether there are rubber seal mechanisms. If the parts were high quality and in great condition, it is likely they will feel great at this point. If there are any seal mechanisms, they will make the spindle feel sluggish when rotated. If a non-overhauled bottom bracket feels sluggish or tight, the grease may be dried out. If the bottom bracket feels rough and has not just been overhauled, the parts are worn out. If the spindle feels tight through a portion of its rotation and loose through another portion, it indicates inexpensive new parts that need break-in, or if using broken-in used parts (or high quality new parts), that the bottom-bracket shell needs facing.

59. [] Rotate spindle and decide whether it feels OK

60. [] Install right crank arm (see **TAPER-FIT CRANK ARMS** chapter on page 20-10 for correct technique). If changing spindle, be sure to check chainring clearance, chainline, and front derailleur adjustment.
61. [] Rotating crank arm to various positions, jerk vigorously in and out on end of crank arm to see if any knocking remains. If additional knocking is felt, repeat adjustment.
- Decide next whether to make a break-in adjustment. A break-in adjustment is one that is left one increment tighter than necessary to eliminate play. The purpose of a break-in adjustment is to compensate for the initial high rate of wear that occurs with new and inexpensive cups and spindles. As an alternative to a break-in adjustment, anticipate needing to re-adjust the bottom bracket within the first couple hundred miles. If new parts appear especially polished where the balls roll on the spindle or cup, a break-in adjustment would be a mistake. If not sure, then skip making a break-in adjustment.
62. [] If desired, reset cup to next clockwise mark for break-in adjustment.
63. [] Remove tape or sticker and clean off marks.
64. [] Install left crank arm (see crank-arm chapters for correct technique).

SPINDLE INTERCHANGEABILITY

USING THE SPINDLE- INTERCHANGEABILITY WORKSHEETS

Purpose of the worksheets

Spindle-interchangeability worksheets serve the mechanic in three general areas: when the original spindle has been acceptable, but no identical replacement is available; when the original spindle positioned the chainrings in an unacceptable location with regards to chainline and/or chain stay clearance; selecting a replacement spindle when the original spindle put the adjustable cup in an unacceptable position.

About the example worksheets

The worksheet in this chapter (pages 9-16 through 9-18) is a filled-in example. There is a blank worksheet in the **WORKSHEETS** section of the book to photocopy and use. In the following explanation,

there are descriptions of what do, followed by notations such as, “**Example worksheet:** The adjustable-cup-protrusion measurement for the example is **3mm**.” When encountering one of these notations refer to the example worksheet (pages 9-16 through 9-18) and see how and where the information has been entered.

Preliminary measurements and observations

Measure the adjustable-cup protrusion from the lockring face. If the adjustable cup sticks out past the face of the lockring, give this number a positive value (+). If the adjustable-cup face is recessed in the lockring face, give this number a negative value (-). Record the number in **EXISTING CONDITIONS** box on the first page (9-16) of the worksheet. It goes in the first blank.

Example worksheet: The adjustable-cup-protrusion measurement for the example is **3mm**.

Measure the chainring-to-chainstay clearance. This can be measured from whatever part of the chainring set comes closest to the chain stay. This could be the inner chainring, a middle chainring of a triple, or sometimes the chainring bolt. Record this number in the **EXISTING CONDITIONS** box on the second page of the worksheet (9-17). It goes in the first blank.

Example worksheet: The chainring-to-chainstay clearance measures **1.5mm**.

Measure the chainline error. For a method of measuring chainline error, see the **CHAINLINE** chapter (page 27-5). If the chainrings need to move out, describe the error as a negative (-) number. If the chainrings need to move in, describe the error as a positive (+) number. Record this number in the **EXISTING CONDITIONS** box on the second page of the worksheet. It goes in the second blank.

Example worksheet: The chainrings are in by 3mm, this is a chainline error of **-3mm**.

Spindle information

After removing the spindle, check the spindle for brand markings and identification codes. Record these brand and code marks in both **EXISTING CONDITIONS** boxes on the first and second pages of the worksheet.

Example worksheet: The spindle is of Taiwanese or Japanese origin. Brand is not important, as all current spindles from these countries are of the **JIS** (Japanese Industrial Standard) type. The code on the spindle is **D-5A**.

9 – ADJUSTABLE-CUP BOTTOM BRACKETS

Find the spindle on the **JIS SPINDLE DIMENSION** (table 9-3, page 9-20) later in this chapter, or measure the spindle as shown in the drawing on the same pages. Record the existing spindle center width in the last blank in the **EXISTING CONDITIONS** box on the first worksheet page (9-16).

Example worksheet: From table 9-3 (page 9-20), the center width for this spindle is **55mm**.

Record the existing right-side axle-end length in the last blank in the **EXISTING CONDITIONS** box, on the second page of the worksheet (9-17).

Example worksheet: The spindle in the bike had the long side on the right. From table 9-3 (page 9-20), the long-side length for this spindle is **32.5mm**.

Completing the worksheet

To complete the worksheet, it may be necessary to add and subtract negative numbers. The following examples explain how to do this using a pocket calculator (other than a Hewlett-Packard). The key to being able to do this is to know how to use a key on the calculator that changes the value of a positive number to negative. This key is usually marked “+/-.” In the following examples, each key stroke on the calculator is shown in a set of brackets [].

To calculate $3 + 2$, enter:

[3] [+] [2] [=]

The answer is 5.

To calculate $3 + (-2)$, enter:

[3] [+] [2] [+/-] [=]

The answer is 1.

As can be seen in this example, the only difference between the first and second examples is pressing the [+/-] key after the [2] to change the 2 to a negative value.

To calculate $(-3) + 2$, enter:

[3] [+/-] [+] [2] [=]

The answer is -1.

To calculate $3 - (-2)$, enter:

[3] [-] [2] [+/-] [=]

The answer is 5.

To calculate $(-3) - (-2)$, enter:

[3] [+/-] [-] [2] [+/-] [=]

The answer is -1.

If not using a calculator, two simple rules apply to adding and subtracting negative numbers. To add a negative number, simply consider the value of the number and subtract it. To subtract a negative number, simply add the number as though it were a positive number (the two minus signs cancel each other).

On the first page of the worksheet, fill in all the blanks in the box titled **DETERMINE RANGE OF ACCEPTABLE CENTER WIDTHS**. Work down the box, one line at a time, completing each line before moving down to the next. An arrow points to each blank that needs to be filled in. To fill in the blank, follow the arrow back to its source, and copy the number found there. Be sure to indicate a negative value whenever copying a negative number.

Example worksheet: The value 3 is carried down into both the formulas under **DETERMINE RANGE OF ACCEPTABLE CENTER WIDTHS**.

Example worksheet: The result of the “upper limit” formula is -1.

Example worksheet: The result of the “lower limit” formula is -3.

At the end of this box are blanks for **Maximum center width** and **Minimum center width**. *If the calculations are correct to this point, these two numbers will always differ by 2.* Transfer the numbers that are filled into these two boxes to the **Maximum center width** and **Minimum center width** boxes on the third page of the worksheet.

Example worksheet: 55 is carried down into the first blank of the **Minimum center width** and **Maximum center width** formulas.

Example worksheet: -3 is carried down to the second blank of the **Minimum center width** formula. The result of the formula is 52.

Example worksheet: -1 is carried down to the second blank of the **Maximum center width** formula. The result of the formula is 54.

On the second page of the worksheet, fill in all the blanks in the box titled **AXLE END LENGTH TOLERANCE RANGE FOR ACCEPTABLE CHAINLINE**. Work down the box one line at a time, completing each line before moving down to the next. An arrow points to each blank that needs to be filled in. To fill in the blank, follow the arrow back to its source, and copy the number found there. Be sure to indicate a number has a negative value whenever copying one that is a negative. The result of the first two calculations, labeled **UPPER LIMIT** and **LOWER LIMIT**, *will always differ by 4 if the calculations are correct.*

Example worksheet: -3 is carried down into the first blank of the **UPPER LIMIT** and **LOWER LIMIT** formulas.

Example worksheet: The result of the **UPPER LIMIT** formula is 5.

Example worksheet: The result of the **LOWER LIMIT** formula is 1.

The last formula in this box is **RESULTING RING-TO-STAY CLEARANCE**. Sometimes, if you use the full tolerance range for the spindle, it will result in the chainrings ending up too close to the frame. If this is the case, use the left-hand **CORRECTED TOLERANCE** box to determine the acceptable tolerance range; if it is not the case, then use the right-hand **CORRECTED TOLERANCE** box.

Example worksheet: 1.5 is carried down into the first blank of the **RESULTING RING-TO-STAY CLEARANCE** formula.

Example worksheet: 1 is carried down into the second blank of the **RESULTING RING-TO-STAY CLEARANCE** formula.

Example worksheet: The result of the **RESULTING RING-TO-STAY CLEARANCE** formula is 2.5, *indicating only the right-hand box should be used in this example, when moving down the worksheet to the next step.*

Below the box just completed are a left and right box. *Only one of these boxes should be completed!* Use the left box *only* if the answer in the blank to the left of the statement “*Pick which box below now!*” is *less than 2*. Use the right box *only* if the answer in the blank to the left of the statement “*Pick which box below now!*” is *2 or more*. An arrow points to each blank that needs to be filled in. To fill in the blank, follow the arrow back to its source, and copy the number found there. Be sure to indicate a negative value whenever copying a negative number.

Example worksheet: 5 is carried down into the Upper limit blank found in the **CORRECTED TOLERANCE** box.

Example worksheet: 1 is carried down into the Lower limit blank found in the **CORRECTED TOLERANCE** box.

On the second page of the worksheet, fill in all the blanks in the box titled **ADD CORRECTED TOLERANCE TO EXISTING AXLE END LENGTH**. Work down the box, one line at a time, completing each line before moving down to the next. An arrow points to each blank that needs to be filled in. To fill in the blank, follow the arrow back to its source, and copy the number found there. Be sure to indicate a negative value whenever copying a negative number.

Example worksheet: 32.5 is carried down into the first blank of both formulas in the last box.

Example worksheet: 5 is carried down into the second blank of the **Maximum axle end length** formula.

Example worksheet: 1 is carried down into the second blank of the **Minimum axle end length** formula.

Example worksheet: The result of the **Maximum axle end length** formula is 37.5.

Example worksheet: The result of the **Minimum axle end length** formula is 33.5.

There are blanks at the end of this box for **Maximum axle end length** and **Minimum axle end length**. Transfer the numbers that are filled into these two boxes to the **Maximum axle end length** and **Minimum axle end length** boxes on the third page of the worksheet.

Example worksheet: 52 is carried from the bottom of the first worksheet page (9-16) to the **Minimum center width** box (page 9-18).

Example worksheet: 54 is carried from the bottom of the first worksheet page (9-16) to the **Maximum center width** box (page 9-18).

Example worksheet: 33.5 is carried from the bottom of the second worksheet page (9-17) to the **Minimum axle end length** box (page 9-18).

Example worksheet: 37.5 is carried from the bottom of the second worksheet page (9-17) to the **Maximum axle end length** box (page 9-18).

Search table 9-3 (page 9-20) for spindles that have center width and axle end length that fall in the ranges calculated and list them in the **CONCLUSION:...** box on the third page of the worksheet. It is preferred, but not required, to select spindles that have a long end that is within the axle-end-length range, but it is acceptable to select spindles that have a short end that is correct, as long as the spindle is installed with the short end on the right. *In the case that the worksheet calculates a minimum that is larger than the maximum, the minimum is the only length that will work!* Use the spindle that is in stock and closest in quality to the original spindle.

Example worksheet: JIS 3A is listed as a suitable substitute with center width of 52 and axle end of 33.5.

Example worksheet: JIS 3P is listed as a suitable substitute with center width of 52 and axle end of 35.

Example worksheet: JIS 3N is listed as a suitable substitute with center width of 52 and axle end of 36.

Example worksheet: JIS 3SS is listed as a suitable substitute with center width of 52 and axle end of 37.5.

NOTE: See example worksheets on next page.

9 – ADJUSTABLE-CUP BOTTOM BRACKETS

SPINDLE INTERCHANGEABILITY WORKSHEET

PURPOSE: USE THIS WORKSHEET TO

- a) specify suitable replacement spindles that
- b) improve or maintain adjustable cup protrusion and
- c) improve or maintain chainline while
- d) improving or maintaining adequate chainring clearance to the chainstay.

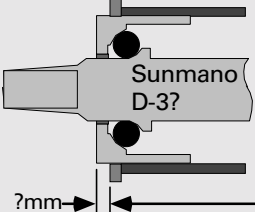
WORKSHEET INSTRUCTIONS

*** *First*, fill in all blanks on the first and second worksheet pages marked with ***.

** *Second*, fill in all blanks on the first and second worksheet pages marked with **.

Third, start at the top of the worksheet, completing each line before moving to the next line down.

Each empty parenthesis is filled in by following the arrow pointing to it back to its source.

EXISTING CONDITIONS	
	Measure cup protrusion from locking face *** <u>3</u> mm
	Observe the spindle brand *** <u>MS</u> and code *** <u>54</u>
** <u>55</u>	Measure the distance from the top of one cone profile to the top of the other.

DETERMINE RANGE OF ACCEPTABLE CENTER WIDTH	
(The cup face may end up protruding from the locking face by a range of +2 to -0mm)	
DETERMINE TOLERANCE RANGE (for new spindle)	
$2 - (\underline{3}) = \underline{-1}$	upper limit
$0 - (\underline{3}) = \underline{-3}$	lower limit

ADD TOLERANCE RANGE TO EXISTING CENTER WIDTH	
(to determine new spindle center width range)	
$(\underline{55}) + (\underline{-3}) =$	52 Minimum center width
$(\underline{55}) + (\underline{-1}) =$	54 Maximum center width

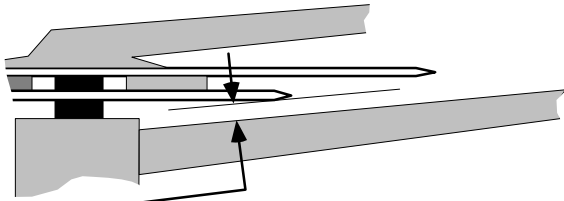
Numbers in these boxes are the range of acceptable center widths.

WORKSHEET PART #1

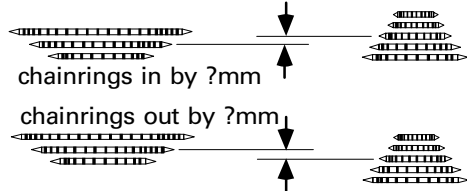
CONTINUE ON NEXT PAGE

9 – ADJUSTABLE-CUP BOTTOM BRACKETS

EXISTING CONDITIONS



Measure chainring-to-chainstay clearance:
Clearance measures *** 1.5 mm



Measure chainline error and write below.
Write as a negative number if chainrings are in.

Error is *** -3 mm

Observe spindle brand *** MS and spindle code *** 54

Measure the right end of the spindle from the top of the cone profile to the end:

** 32.5 Axle end length

AXLE END LENGTH TOLERANCE RANGE FOR ACCEPTABLE CHAINLINE

(Chainring center may be ± 2 mm off freewheel centerline)

UPPER LIMIT $2 - (\text{ } -3 \text{ }) = \text{ } 5 \text{ }$

LOWER LIMIT $(-2) - (\text{ } -3 \text{ }) = \text{ } 1 \text{ }$

RESULTING RING-TO-STAY CLEARANCE
(rings must clear stays by 2mm)

$(\text{ } 1.5 \text{ }) + (\text{ } 1 \text{ }) = \text{ } 2.5 \text{ }$ Pick which box below now!

This way only if above is less than 2

This way only if above is 2 or more

~~CORRECTED
TOLERANCE
Upper limit ()
Lower limit ()
 $2 - (\text{ } \text{ }) = \text{ } \text{ }$~~

ONE ONLY!

CORRECTED
TOLERANCE
Upper limit (5)
Lower limit (1)

ADD CORRECTED TOLERANCE TO EXISTING AXLE END LENGTH

$(\text{ } 32.5 \text{ }) + (\text{ } 5 \text{ }) = \text{ } 37.5 \text{ }$ Maximum axle end length

$(\text{ } 32.5 \text{ }) + (\text{ } 1 \text{ }) = \text{ } 33.5 \text{ }$ Minimum axle end length

Numbers in these boxes are the range for acceptable axle end lengths.

CONCLUSION: SELECTION OF ACCEPTABLE REPLACEMENT SPINDLES

FROM BOTTOM OF
WORKSHEET PART #1

52

Minimum center width

54

Maximum center width

FROM BOTTOM OF
WORKSHEET PART #2

33.5

Minimum axle end length

37.5

Maximum axle end length

Look up in table 9-3 (page 9-20), and list below the choices that have both a center width and axle end length that fall in the ranges indicated above.

BRAND	<u>MS</u>	CODE	<u>3A</u>	CENTER WIDTH	<u>52</u>	AXLE END	<u>33.5</u>
BRAND	<u>MS</u>	CODE	<u>3D</u>	CENTER WIDTH	<u>52</u>	AXLE END	<u>35</u>
BRAND	<u>MS</u>	CODE	<u>3N</u>	CENTER WIDTH	<u>52</u>	AXLE END	<u>36</u>
BRAND	<u>MS</u>	CODE	<u>3SS</u>	CENTER WIDTH	<u>52</u>	AXLE END	<u>37.5</u>
BRAND		CODE		CENTER WIDTH		AXLE END	
BRAND		CODE		CENTER WIDTH		AXLE END	

WORKSHEET PART #3

USING THE JIS SPINDLE-DIMENSIONS TABLE

Table 9-3 (page 9-20) is a list of commonly available bottom-bracket spindles that are manufactured to JIS specifications. They can, in most cases, be manufactured by any number of companies but be consistent enough in design to be interchangeable despite brand differences. The numbers provided are direct from the manufacturer, not measured by Barnett Bicycle Institute. It is our experience that manufacturers sometimes do not hold very tight tolerances, so do not be surprised if a spindle does not exactly match the given numbers. Even when the JIS standardizes something, such as that a 3S spindle should measure 37.5mm on the long end, 52mm in the center, and 32mm on the short end, manufacturers may deviate dramatically; for example, a Sugino brand 3S spindle is 35mm on the short end instead of the usual 32mm.

Even when a spindle measures exactly as it is supposed to, it does not mean that it will fit exactly like it is supposed to. Two spindles from two companies, or even from two batches by the same company, may both have the same long-end length, but the chainrings may end up several millimeters closer to the frame with one spindle than the other. This could be caused by variations in taper thickness. A fatter spindle will not insert as far into a crank arm as a thinner spindle. It could also be caused by differences in surface texture on the spindle flats. A smoother spindle will insert further into a crank arm than a coarser one when the crank arm is secured to both with the same torque.

This dimension table is useful only for common Asian spindles. Certain spindles, such as Shimano Dura-Ace, all Campagnolo, all other European brands, Specialized, and SunTour are so different in design that comparing measurements on one brand to measurements on another brand is meaningless. For example, a Specialized spindle marked 114-68 has a center width of 49mm. All of the spindles in the following table with a “3” in the code have a center width of 52mm. It is logical to assume that if removing the Specialized spindle and installing one of the “3” coded spindles in its place that the adjustable cup would stick out 3mm more. In fact, due to the smaller cone diameter on the “3” coded spindles, the adjustable-cup position remains virtually the same.

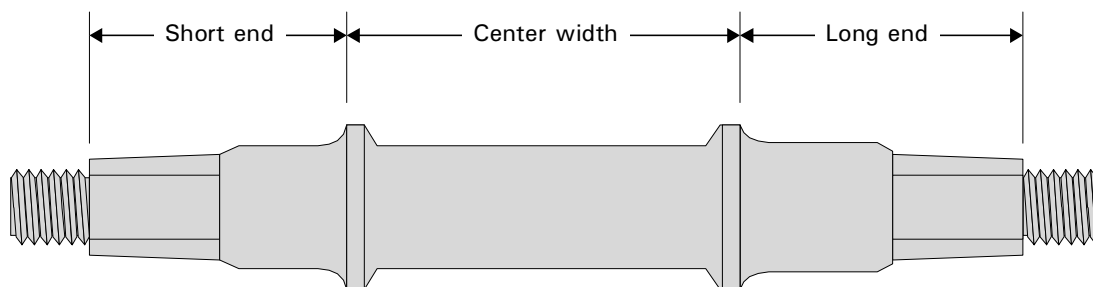
When interchanging spindles that are not on this list, stick with trial and error, or with spindle tables in *Sutherland’s fourth* and *fifth* editions. *Sutherland’s* has factored variables such as variations in and taper thick-

ness to come up with “axle end factor” values that can be compared to each other just like the long end and short end lengths. *Sutherland’s* has factored variables such as variations in cone diameter to come up with “center width factor” values, which can be compared to each other just like the center widths can be compared. The **SPINDLE-INTERCHANGEABILITY WORKSHEETS** can be used with *Sutherland’s* “factors” with the following considerations. When the worksheet suggests measuring the existing center width or axle end, use the “center width factor” and the “axle end factor” in the appropriate *Sutherland’s* tables. Do not mix these “factors” with actual spindle dimensions. The whole worksheet has to be done one way or the other.

The values on the following table can be used on the **SPINDLE-INTERCHANGEABILITY WORKSHEET**. When the worksheet suggests measuring an existing spindle, look up information on the existing spindle in the following table or take measurements directly from the spindle.

It is generally accepted that the long end is the right side and the short end is the left, but there is no reason that these cannot be reversed if it improves the chainring position.

9 – ADJUSTABLE-CUP BOTTOM BRACKETS



JIS SPINDLE DIMENSIONS (table 9-3)

Codes	Long end (mm)	Short end (mm)	Center width (mm)
Sugino MS-68, Shimano D-3K	28.0–28.5	28.0–28.5	52
3I-B	30	29	52
3H, D-3H, 3H-B	30.5–31.0	30.5–31.0	52
3J, 3J-B, 3L, D-3L, 3L-B	32	32	52
Sugino MW-68	33.5	30.5	52
3A, D-3A, 3A-B, 3K, 3K-B	33.5	32	52
3P, D-3P, 3P-B	35	32	52
3N, 3N-B	36	32	52
3NL, D-3NL	36	34.5	52
3NN, 3NN-B	36	36	52
Sugino MT-68	37.5	29.5	52
3SS, D-3SS, 3SS-B	37.0–37.5	32	52
3S, D-3S, 3S-B	37.5	32	52
Sugino & Tange 3S	37.5	35	52
3T, D-3T, 3T-B	38.5–39.0	32	52
Sugino & Tange 3T, 3T-B	38.5–39.0	35	52
3TM-B, 3TS, D-3TS	39	37.5	52
Sugino 3U-B	40.5	32	52
3U, D-3U	40.0–40.5	35	52
Tange 3U	40	39	52
D-3XA	40.5	39	52
3X	40.5	40.5	52
Sugino 3R, 3R-B	42	32	52
3R, D-3R, 3R-B	42	35	52
Sugino 3RR-B	42	35	52
3TR-B	42	39	52
3RR-B	42	42	52
3M	43.5	35	52

Codes	Long end (mm)	Short end (mm)	Center width (mm)
Sugino MS-70	28.5	27.5	53.5
Sugino MW-70	32.5	29	53.5
Sugino MT-70	37	29.5	53.5

5H, D-5H	31	31	55
5J-B	32	32	55
5L, D-5L	32	32	55
5LL	32	32	55
D-5A	32.5	31	55
5P, D-5P	33.5–34.0	31	55
5N, 5N-B	35	32	55
D-5NL	35	33.5	55
D-5SP, 5SP-B	37.5	30.5	55
5SS, 5-SSB	37.5	32	55
5S (Sakae Royal, SR)	37	32	55
Sugino 5S-B	37.5	32	55
5S	37.5	35	55
5T, D-5T	39	35	55
Sugino 5U, 5U-B	40.5	32	55
5U, D-5U, 5U-B	40.5	35	55
5R	42	35	55

7H, D-7H	30.5	30.5	57
7L	32	30.5	57
7P-B	33.5	30.5	57
7NL, D-7NL, 7NL-B	33.5	32	57
7EL, D-7EL, 7EL-B	36.0–36.5	35.0–35.5	57
D-7S	37.5	35	57
7T-B, D-7TL	39	35	57
7R-B	42	35	57

ADJUSTABLE-CUP BOTTOM-BRACKET TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>The bearing adjusts with a tight/loose pattern, i.e., with the adjustment completed, the spindle is tight through a portion of its rotation, and looser in another portion.</i>	
Bearing cups seated against misaligned shell faces.	Face bottom-bracket shell.
Low-precision parts.	Will go away with break-in if facing shell does not solve.
Bent spindle (detect by rolling on flat surface).	Replace spindle.
Cup(s) cross-threaded.	Tap shell with piloted taps.
SYMPTOM: <i>The spindle feels "sluggish" to rotate after completing a precision adjustment.</i>	
Grease is dried out.	Inspect, then overhaul.
Seal mechanism causes drag.	Lubricate seal mechanism, problem may reduce with use.
Seal mechanism is installed wrong.	Check that seal is properly mounted in groove. Try reversing orientation.
SYMPTOM: <i>Bearings feel "rough" after completing a precision adjustment.</i>	
New, low-precision parts.	Will improve with break-in.
Contamination in bearings.	Overhaul.
SYMPTOM: <i>Play cannot be eliminated without making the spindle very difficult to rotate.</i>	
Parts are worn out.	Disassemble and inspect.
Too many ball bearings.	Disassemble and inspect.
Bearing retainer reversed (evidence would be that the adjustable cup would not be inserting as far as it did originally).	Disassemble and inspect.
Seal mechanism in wrong.	Disassemble and inspect.
SYMPTOM: <i>A gritty or rough feeling that is not constant in location.</i>	
Contamination in bearings.	Overhaul.
SYMPTOM: <i>Adjustable cup will not reinstall to original depth.</i>	
Retainer in backwards.	Disassemble and inspect.
Balls out of position in cups.	Disassemble and inspect. Balls may be caught on upper lip of race.
Too many balls.	Check ball quantity and use fewer if balls are jumbled in cup.
Cup is cross threading.	Remove cup and attempt to thread straight. Disassemble and tap shell if necessary.
Ball bearings wrong size.	1/4" balls have been used where 7/32" or 3/16" are required.
SYMPTOM: <i>A clicking, knocking, popping sound or sensation is heard or felt from the bottom bracket after eliminating loose cranks, loose pedal mounting, loose pedal parts or bearings or loose chainwheel bolts as possible causes.</i>	
Loose lockring.	Tighten lockring.
Loose fixed cup.	Tighten fixed cup.
Extremely worn parts.	Disassemble and inspect.

Continued next page

ADJUSTABLE-CUP BOTTOM-BRACKET TROUBLESHOOTING (continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Fixed cup is loose.</i>	
Not properly installed (common).	Reinstall with correct Loctite and torque.
Threads have failed.	Simple and inexpensive solution is to install a cup in good condition with Loctite #RC680. This installation should be considered permanent. A more difficult and expensive solution appropriate on expensive bikes is to convert the threading to Italian if it is not already; converting threads to Italian is time-consuming, dulls the taps rapidly, and results in poor-quality threads. One other solution is to install a Mavic bottom bracket (if there is one available compatible with the crankset) because they do not use threads to install. The bottom bracket must be modified with a Mavic facing tool (see page 10-4).
SYMPTOM: <i>Premature wear of components.</i>	
Improper original lubrication or adjustment (common).	Check all factory assemblies.

10 – CARTRIDGE-BEARING BOTTOM BRACKETS

ABOUT THIS CHAPTER

Unlike many chapters in this book, this chapter deviates from the worksheet approach used in other chapters. The procedures for cartridge-bearing bottom brackets are relatively simple, and do not require most of the same structure for recording data. Instead of procedures being written in **bold** type with check-boxes, they are written just as numbered steps. There are no comparable worksheets in the **WORKSHEETS** section at the back of the book.

Sections

This chapter has sections covering: Shimano cartridge bottom brackets, Fisher cartridge bottom brackets, Mavic cartridge bottom brackets, and multiple brands of bottom brackets that have threaded cups with cartridge bearings inside the cups.

Threads

All threaded cartridge-sealed-bearing bottom brackets fit the same bottom-bracket-shell threads as adjustable-cup bottom brackets. For thread information, see the **BOTTOM-BRACKET THREADS** table (page 9-5) in the **ADJUSTABLE-CUP BOTTOM BRACKETS** chapter.

Prerequisites

For all types of bottom brackets, the only prerequisite is crank-arm removal and installation.

If changes in the effective spindle length creates changes in the chainring position, then front derailleur adjustment would also be required.

Tools

The special tools needed for each type of cartridge bottom bracket are mentioned in each section as part of the procedure for servicing that bottom bracket.

SHIMANO CARTRIDGE BOTTOM BRACKETS

ASSEMBLING NEW BIKES

The plastic and aluminum threaded rings provided with Shimano cartridge bottom brackets have proven to be very intolerant of poor thread quality in the shell, resulting in stripped threads. If the pieces do not thread in and out easily, tap the bottom-bracket shell.

When assembling new bikes, the only other concern is whether the factory installed and secured the main cartridge unit and adapter ring correctly.

In order to check this, crank-arm removal is required. Use the Park BBT-2 to secure the main cartridge unit in the frame and secure the lockring. A standard 32mm headset spanner will fit the Park BBT-2, but the Park tool can be driven with a 3/8" drive ratchet or torque wrench, as well. The torque specification is 260–350in-lbs.

The Shimano specification is that no grease should be put on the main body threads or on the adapter-ring threads. In many climates, corrosion between metal threads on the bottom bracket and metal threads inside the shell is a genuine concern. If concerned about this, remove the bottom bracket and treat the threads with Loctite #222 or #242. There have been some reports of problems with the plastic adapter ring loosening. It would be of no harm, and perhaps some benefit, to treat these threads with Loctite #222 or #242 as well. When either the bottom-bracket shell or an adapter ring is aluminum, use anti-seize compound.

The only tool needed is the Park BBT-2.

When making sure the unit is secure, follow these steps exactly:

1. Loosen the adapter ring (the side with no flange, possibly either side).
2. Use a Park BBT-2 to snug the main body into the bottom-bracket shell. The flange may be left up to 1mm from the end of the shell if desired, to improve chainring position.
3. Secure the adapter ring to 260–350in-lbs.

CARTRIDGE-INSTALLATION PROCEDURE

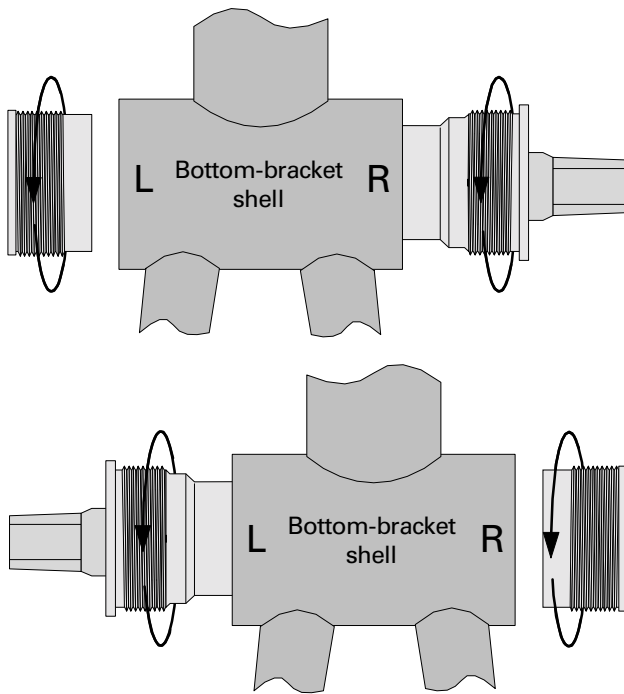
Considerations

The only tool needed is the Park BBT-2.

The plastic and aluminum threaded rings provided with the Shimano cartridge bottom brackets have proven to be very intolerant of poor thread quality in the shell, resulting in stripped threads. If the pieces do not thread in and out easily, tap the bottom-bracket shell. Thread damage on the adapter rings sometimes occurs at the factory due to over-tightening or cross-threading.

When installing a new cartridge-bottom-bracket unit, always install the main body completely before installing and securing the lockring.

On the low end models (CS, LP, etc.), the main body has a right-hand thread and installs into the left side of the bottom-bracket shell. The adapter ring (currently made of black plastic, but there is no guarantee it will remain so) has a left-hand thread and installs from the right side of the shell.



10.1 Depending on the model, the Shimano cartridge may install from the left or right.

All the other models (UN series) have a left-hand thread on the main body, which installs into the right side of the shell. The adapter ring is right-hand threaded and installs into the left side of the shell. The adapter ring currently is, depending on the model, gray plas-

tic or silver aluminum. It is important to understand these distinctions because there are no thread-direction marks, and because the plastic adapter rings will readily install if put in the wrong side of the shell, quickly destroying the adapter-ring threads.

Installation

There is no worksheet for this procedure in the **WORKSHEETS** section of this book. To install a Shimano cartridge bottom bracket in the bottom-bracket shell:

1. Treat the main-body threads with Loctite #222 or #242 (or anti-seize whenever there are any aluminum threads).
2. Install the main body fully in the correct side and snug gently.
3. Treat the adapter-ring threads with Loctite #222 or #242 (or anti-seize whenever there are any aluminum threads).
4. Install the adapter ring from the opposite side.
5. Secure the adapter ring to 260–350in-lbs.

Fixing creaking Shimano cartridges

Shimano cartridge bottom brackets often develop an annoying creak. The source of this creak could be lack of enough torque on the adapter ring, but the source is just as likely to be looseness between the inside of the adapter ring and the portion of the cartridge shell that the adapter ring engages. This can be fixed by using Loctite #242 between the adapter ring and the cartridge shell. The same problem may develop if the fixed ring that is supposed to be a permanent part of the main body works loose. It can be fixed in the same way.

MAINTENANCE

Shimano designed these bottom brackets with the intent that they be maintenance free. This does not mean that they will last forever, but that during their life, no maintenance is needed.

The inexpensive (CS and LP) series models have soft neoprene seals that can easily be pried out with a small screwdriver, or seal pick, with little risk of damaging the seals. Once the seals are removed, it is an easy matter to flush the old grease with solvent, and/or squeeze more grease in from a tube.

Once the seals are out, the wrench flats on a locknut and cone will easily be seen. Do not attempt to use the locknut and cone for further disassembly or adjustment! The only way to disassemble or adjust the cartridge is with a Park BBT-6, a tool that is not recommended due to high tool expense. Replacing these inexpensive cartridges is cheaper than servicing them.

10 – CARTRIDGE BEARING BOTTOM BRACKETS

Shimano generally warrants bottom brackets with excessively tight or loose bearings, within normal bottom-bracket life.

The UN series units have snugly fitting seals with thin metal parts that are instantly damaged when any attempt to remove the seals is made.

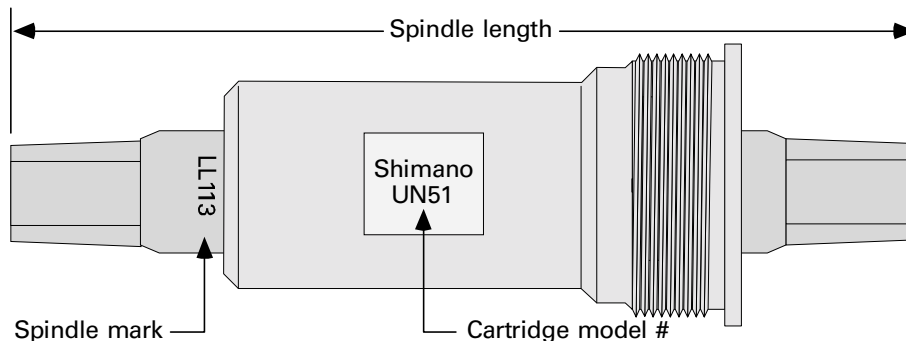
INTERCHANGEABILITY

Use the following table to replace adjustable-cup bottom brackets with Shimano cartridge bottom brackets, or one cartridge with another. If the bike is equipped with newer Shimano crank arms it is *never* appropriate to replace a Shimano cartridge bottom bracket with an adjustable-cup bottom bracket! A single variety of Shimano cartridge bottom bracket is sometimes suitable to replace several lengths of conventional spindles; this is possible because the main body of the cartridge can be fixed in a variety of positions. The CS and LP series can be moved up to 1mm to the left, shortening the effective right-side length by up to 1mm. The UN series can be moved up to 1mm to the right, lengthening the effective right-side length by up to 1mm.

Shimano makes different versions of most cartridge models that fit 68mm and 73mm bottom-bracket shells. Always use the cartridge that matches the shell size.

The spindle mark cannot always be found on the spindle, in which case measure the overall spindle length. Use the overall-spindle-length measurement in combination with the model name of the cartridge shell to identify the specific cartridge. For example, a cartridge is marked with the name CS10 and has an overall spindle length of 115mm. According to table 10-1, this cartridge would be a CS10 (D-H).

The **Relative chainline** column (table 10-1) does not show the actual chainline, but instead shows the relative amount the chainline will change if using an unmatched replacement; by determining the difference between the relative chainline values for two different cartridges, the amount the chainline will change can be determined. For example, a UN90 cartridge marked MM 107 has a relative chainline value of 1mm. Using the UN90 marked LL113 (with a relative chainline value of 2mm) will position the chainrings 1mm further out from the frame than would the UN90 marked MM 107.



SHIMANO CARTRIDGE BOTTOM BRACKET INTERCHANGEABILITY (table 10-1)

Adjustable-cup bottom bracket Spindle types	Cartridge model (not all available for both 68mm and 73mm shell)	Mark/Length	Relative chainline
For 68 shell: D-3K	UN51	MM 107	0mm
	UN51, LP 25	MM 110	
For 68 shell: 3I-B	UN52, UN71, UN72, UN90, UN91	MM 107	1mm
	UN52, UN 72	MM 110	
For 68 shell: 3H, D-3H, 3H-B For 73 shell: 7H, D-7H	UN51, UN 90	LL 113	2mm
For 68 shell: 3J, 3J-B, 3L, D-3L, 3L-B For 73 shell: 7L	UN52, UN71, UN72, UN91, LP20, LP30 CS10, CS11, CS20, CS21, UN50, UN51, UN70, UN71, UN91	LL 113 D-H 115	3mm
For 68 shell: 3A, D-3A, 3A-B, 3K, 3K-B, 3P, D-3P, 3P-B For 73 shell: 7P-B, 7NL, D-7NL, 7NL-B	UN50, UN51, UN52, UN71, LP26	XL 118	5mm
For 68 shell: 3N, 3N-B, 3NL, D-3NL, 3NN For 73 shell: 7EL, D-7EL, 7EL-B	CS10, CS11, CS21, UN50, UN51, UN70, UN71	D-NL 122.5	7mm
For 68 shell: 3SS, D-3SS, 3SS-B, 3S, D-3S, 3S-B For 73 shell: D-7S	UN52, UN72	D-NL 122.5	8mm
For 68 shell: 3T, D-3T, 3T-B, 3TM-B, 3TS, D-3TS For 73 shell: 7T-B, D-7TL	CS21	D-EL 127.5	10mm
For 68 shell: 3U, 3U-B, D-3U, 3XA, 3X	UN50, UN51, UN52, UN70, UN71, UN72	D-EL 127.5	11mm

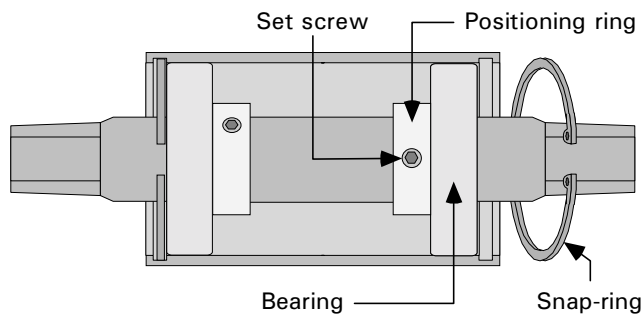
10 – CARTRIDGE BEARING BOTTOM BRACKETS

FISHER CARTRIDGE BOTTOM BRACKETS

Fisher used to have its own design of cartridge-bearing bottom brackets. Fisher no longer does this; it uses threaded bottom-bracket shells like most other manufacturers.

SNAP-RING STYLE

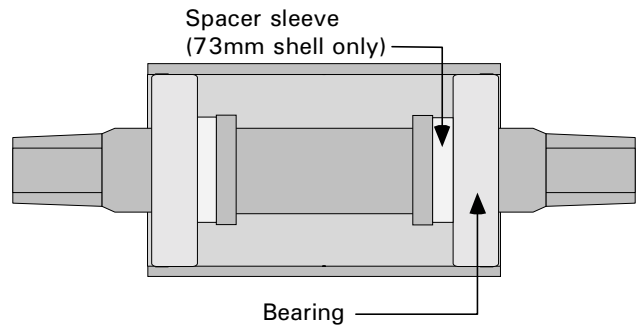
Fishers have cartridge bearings held in by a mild press fit and retained by snap rings in a groove in the bottom-bracket shell. After removing the snap ring with a snap-ring plier, use a plastic hammer to drive the spindle out of the shell. One bearing will also come out. After removing the bearing from the spindle, the spindle is reinserted to drive out the remaining bearing on the opposite side of the bottom-bracket shell. Positioning rings are held to the spindle with set screws to position the bearings on the spindle. Use Loctite RC680 between the spindle and bearings, and bearings and frame, when reassembling. Cartridge bearings can be replaced separately, or cleaned and regreased while removed.



10.3 Cross-section of an old-style Fisher bottom bracket.

NO SNAP-RING STYLE

Newer Fisher bottom brackets have the following features: the positioning rings on the spindles are fixed instead of adjustable; spacing sleeves slip onto the spindle to mount between the positioning rings and the bearings, so that the same spindle can fit in the original-width bottom-bracket shell and the newer 73mm bottom-bracket shell. Fisher's most recently made models may not have snap rings retaining the bearings in the shell, instead relying entirely on the Loctite for security.



10.4 Cross-section of a new-style Fisher bottom bracket.

MAVIC CARTRIDGE BOTTOM BRACKETS

Advantages

The Mavic bottom bracket does not use the bottom-bracket-shell threads. This makes it a viable way to salvage a frame that has stripped shell threads. Different models have spindle lengths of 112, 114, 116, 119, 123, 124, and 134 millimeters.

Installation and removal

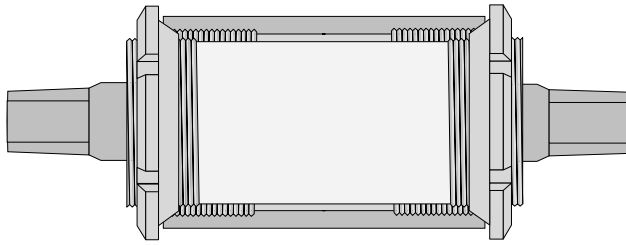
Mavic bottom brackets require no threads in the shell to install, and are a viable alternative for repair of moderate-to-expensive bikes that have damaged bottom-bracket threads. The shell must be prepared for installation of the bottom bracket by facing it with the Mavic tool 65234. This tool faces the ends of the shell to be conical, to match the conical-faced bottom-bracket mounting rings. Face the shell until the face is chamfered to a depth of 2–2.5mm (chamfering is to cut the inside edge of the bottom-bracket-shell face at an angle).

To install a Mavic bottom bracket, grease the threads on the outside of the cartridge-shell unit. Put a locking onto the end of the cartridge with the dust cap marked "Fixe." Slip a conical plastic fixing washer over the cartridge so that it is against the inside face of the locking. Older versions of the bottom bracket will not necessarily have this ring. Slide the bottom bracket into the shell from the right side of the bike. If it will not slide in effortlessly, remove obstructions inside the bottom-bracket shell. Do not force!

Slip the other conical plastic fixing washer onto the left end of the bottom bracket (older bottom brackets may not have one). Attach the other locking to

10 – CARTRIDGE BEARING BOTTOM BRACKETS

the left end of the unit. Use one lockring spanner to hold one of the lockrings, and another to tighten the other lockring. Secure to 240–300in-lbs (13–17lbs@8").

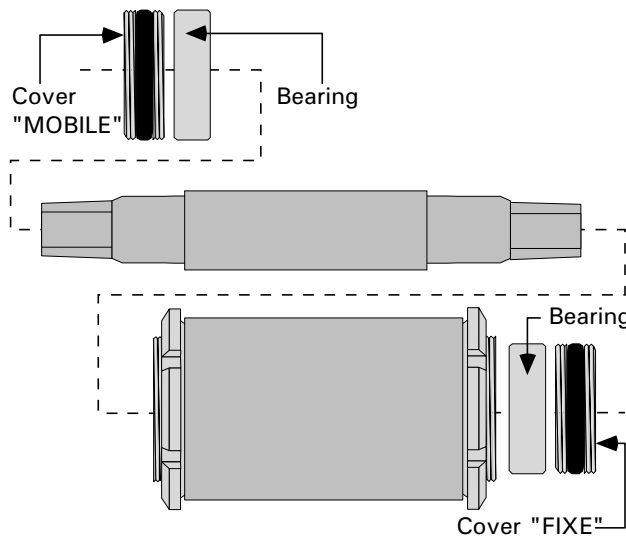


10.5 A Mavic cartridge bottom bracket in a cross-section of a bottom-bracket shell.

Install the right crank arm and check the chainline. If it needs adjustment, remove the crank arm, break loose the left lockring, adjust the right lockring in or out to move the bottom bracket, and then resecure the lockrings.

To remove the bottom bracket, remove either or both lockrings with a lockring spanner and slip the unit out of the shell.

Bearing replacement



10.6 Blow-up of a Mavic bottom bracket.

There is no worksheet for this procedure in the **WORKSHEETS** section of this book.

1. With the cartridge mounted securely in the bottom-bracket shell, use Mavic 670 to unthread the cover marked "MOBILE" and the cover marked "FIXE." A crank-arm bolt can be used to retain the 670 to the cover marked "FIXE."
2. Tap the axle out with a plastic mallet. One bearing will remain in the cartridge and one will be on the axle.
3. Use a drift punch or Mavic 670-3 to drive the bearing out of the cartridge shell.
4. Use a plastic mallet to tap the bearing off the axle.
5. Use Mavic 6702 to tap a bearing (black rubber seal facing out) into the chainring side of the cartridge shell until it is deep enough to expose most of the cover threads inside the end of the cartridge shell.
6. Install the "FIXE" cover into the right end of the shell with the Mavic 670.
7. Insert the spindle into the left side with the desired long or short end (if not symmetrical) on the right side and tap into place with a plastic mallet.
8. With black rubber seal facing out, use Mavic 6702 to tap a bearing into the left side until it is deep enough to expose most of the cover threads.
9. Use the Mavic 670 to thread the "MOBILE" cover into the shell and seat the bearing all the way.
10. Loosen the "MOBILE" cover 1/4 turn.
11. Tap gently on the right end of the spindle with a soft mallet, if it seems tight when rotated.

CARTRIDGE BEARINGS IN THREADED CUPS

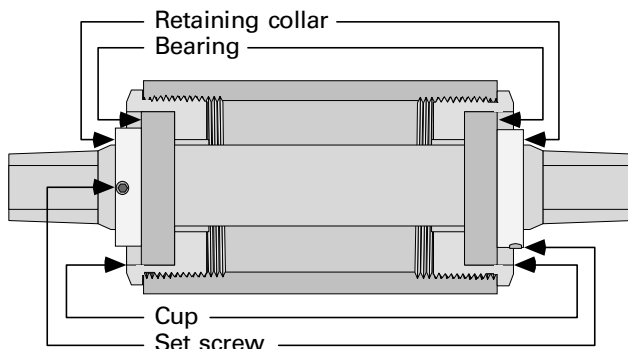
STRONGLIGHT, AMERICAN CLASSIC, AND SUGINO

These bottom brackets are similar to an adjustable-cup bottom bracket, but with cartridge bearings used instead of loose balls. Cartridges may be a slip fit or mild press fit into the cups and onto the spindle and can be replaced without the replacement of the entire assembly. Adjustments should be performed as with an adjustable-cup bottom bracket.

Cartridges can be removed from the assembly (except American Classic). A removed cartridge can have its seal removed and can be cleaned and re-greased in case of moisture contamination, or can be replaced if worn out or damaged. Sugino bottom brackets of this configuration require a special tool, Sugino 214.

COOK BROS.

Although the Cook Bros. bottom bracket has cups that thread into the shell, the bearings are inserted into the cups from the outer face instead of the inner face.



10.7 Cross-section of a Cook Bros. bottom bracket.

This bottom bracket presents two problems. The aluminum cups have very delicate wrench flats that are easily distorted by poor-fitting tools or brutish technique. Once distorted, the lip of the cup may interfere with the retaining collars on the spindle, causing the spindle to rotate roughly. Also, in some cases it may be difficult to access the 7/32" Allen set screw in the

retaining collar. If the Allen set screw is difficult to access, use the edge of a file to notch the lip of the cup 90° from a wrench flat to allow access.

To remove and/or install the bottom bracket, perform the following steps. There is no worksheet for this procedure in the **WORKSHEETS** section of this book.

Removal

1. Use a 7/32" Allen wrench to loosen the set screw in one of the retaining collars on either end of the spindle.
2. Use a Stein FCC2 to retain a Park HCW-2 (35mm) to each cup and break loose both cups without removing.
3. Use a plastic mallet to drive the spindle out the opposite side of the bike from where the set screw was loosened. The spindle and other retaining collar will go out the opposite side. The opposite-side bearing may go out with the spindle or stay in the cup.
4. Use a drift punch or bearing puller to remove the bearing(s) from the cups.
5. Use the Park HCW-2 to remove both cups.

Installation

1. Prepare the cup threads with Loctite 242.
2. Thread both cups into the shell fully and secure gently with the Park HCW-2.
3. Slide a retaining collar onto one end of the spindle and secure the set screw with a 7/32" Allen wrench.
4. Slide a bearing cartridge onto the spindle against the backside of the retaining collar.
5. Slide the spindle/bearing assembly into one side of the bottom bracket.
6. Slide the other bearing onto the other end of the spindle.
7. Tap against the end of the spindle with the retaining collar mounted so that it will drive the bearing into the cup.
8. Use a metal cylinder that clears the spindle and closely matches the outside diameter of the bearing to drive the other bearing into the cup.
9. Rotate the spindle and feel if it rotates smoothly. If it is binding, tap gently on alternating ends of the spindle to eliminate side load.
10. Slide on the remaining retaining collar and secure the set screw.

SHIMANO SPLINED-SPINDLE BOTTOM BRACKETS

TERMINOLOGY

Splines: An alternating arrangement of axially aligned lands (ridges) and flutes (grooves) around a cylinder.

Splined spindle: A bottom-bracket spindle that is splined on the ends, as opposed to the traditional squared taper.

VARIETIES

There are three basic varieties of Shimano bottom brackets that have splined spindles. Each variety requires somewhat different technique to properly install and service.

The first variety includes the Dura-Ace model BB-7700 and the XTR model BB-M950. Other than the model numbers, the distinguishing visual characteristic of these varieties is the fact that the right-side threaded cylinder has a notched flange that resembles a conventional locking for the left side of an adjustable-cup bottom bracket. At first glance, these models may appear to be simple cartridge-bearing bottom brackets. When the bottom bracket is in the package it comes in, the parts are securely fit together in a way that makes it appear as though it is a cartridge-bearing bottom bracket. In fact, this bottom bracket consists of a spindle with two cone races, two threaded cups with cup races, and a lockring just like an adjustable-cup bottom bracket. Directions for servicing this configuration appear under the heading **ADJUSTABLE SPLINED-SPINDLE BOTTOM BRACKETS** (page 10-8).

The second variety includes the Dura-Ace model BB-7710 (track), the Ultegra model BB-6500, the 105 model BB-5500, and the XTR model BB-M952. At first glance they appear very similar to the adjustable variety described in the previous paragraph, but the right-side threaded cylinder lacks the notched flange and can only be fit by the splined tool normally used to install and remove regular Shimano cartridge-bearing bottom brackets (Park BBT-2 or Shimano TL-UN74). Functionally, these bottom brackets are the same as the squared-taper models. The difference is in the spindle configuration and which crank arms will fit it. One other minor difference is that the left-side mounting ring (on the BB-M952) has a notched-flange configuration in addition to the internal spline that fits the splined tools. Additional information on this variety appears under the heading **CARTRIDGE-BEARING SPLINED-SPINDLE BOTTOM BRACKETS** (page 10-10).

The third variety includes the year 2000 Deore XT/LX model BB-ES70. This is a simple cartridge-bearing bottom bracket that is serviced just like all other squared-taper Shimano bottom brackets. This model is separate because it has different spline dimensions and does not interchange with any other models listed earlier. Additional information is under the heading **LONG-SPLINED SPINDLES** (page 10-11).

TOOL CHOICES

The design or model of the bottom bracket will determine the tools needed. The following list covers tools for all varieties of Shimano splined-spindle bottom brackets. This list covers all the tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is **bold**, it means that several tools are required for different configurations of parts.

SHIMANO SPLINED-SPINDLE BOTTOM-BRACKET TOOLS (table 10-2)

Tool	Fits and Considerations
Park BBT-2	Installs all non-adjustable models, allows use of 3/8" drive wrenches. Older versions might not fit over splined spindles.
Shimano TL-UN74-S	Installs all non-adjustable models, does not permit use of 3/8" drive wrenches.
VAR 966/PRO2	Installs all non-adjustable models, does not permit use of 3/8" drive wrenches. Includes retaining bolt to improve security for difficult bottom bracket removal.
Park BBT-8	Required to install Dura-Ace BB-7700 and XTR BB-M950 (adjustable models).
Park TWB-368	Crow foot adapter that allows use of torque wrench with BBT-8.
Shimano TL-UN96	Required to install Dura-Ace BB-7700 and XTR BB-M950 (adjustable models). Torque wrench cannot be used.
Lockring spanner	Required to secure lockring on BB-7700 and BB-M950. Assorted varieties available. See table 9-1 (page 9-3).

ADJUSTABLE SPLINED-SPINDLE BOTTOM BRACKETS

There are two versions of this design, designated Type 1 and Type 2 by Shimano, and these designations only appear in the Shimano parts catalog. The XTR model BB-M950 exists in both types, but the Dura-Ace model BB-7700 is the Type 1 configuration only. To distinguish Type 1 from Type 2 when the bottom bracket is already installed, remove the right-side crank arm, and then look inside the notched ring on the right-side “cup.” If there is a black plastic cap, the bottom bracket is Type 1. If there is a silver metal plate, then the bottom bracket is Type 2. To distinguish the type when removing it from the packaging, the same observation could be made, or you could inspect the plastic sleeve between the two “cups.” If the sleeve is obviously dumbbell-shaped, with a center diameter approximately 5mm less than the cup diameters, then the bottom bracket is Type 1. If the sleeve is a uniform diameter and just slightly smaller in diameter than the cups, then the bottom bracket is Type 2.

Regardless of the type, this bottom bracket style (Dura-Ace BB-7700 or XTR BB-M950) is fundamentally the same as a conventional adjustable-cup bottom bracket, but there are some differences. These differences include: what tools fit, the nature of the seals, the removable nature of the spindle cones, and the presence of an additional set of bearings (needle type) in addition to the cup-and-cone ball bearing set.

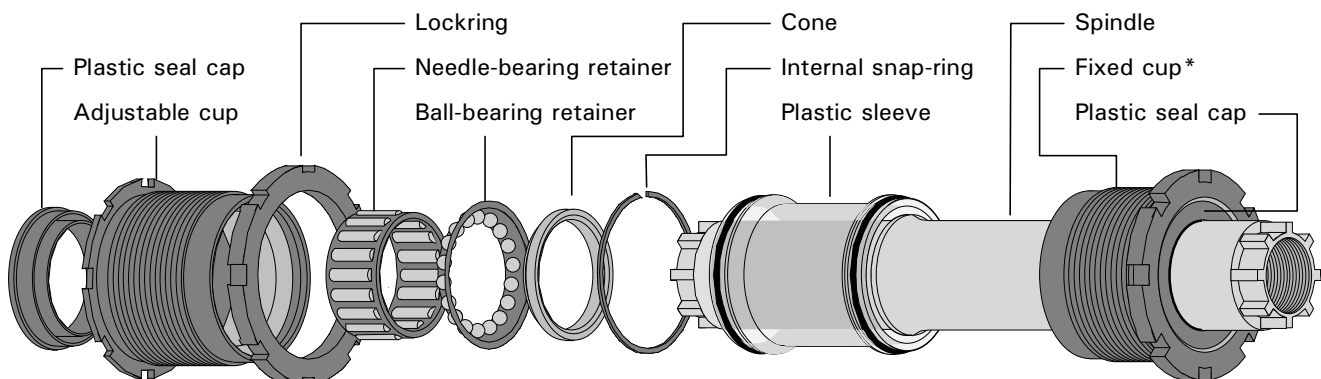
The tools required are listed on page 10-7 in table 10-2. These tools are used to install and remove the fixed cup, and to adjust the adjustable cup. Additionally, the same tools are used to install and remove the lockring that holds the chainring arms to the crank arm on many Shimano crank models.

The seals in this bottom bracket are different because they are a multi-part design. Each cup has a soft rubber seal fixed to the inner perimeter of the hole where the spindle goes through. The fit between the rubber seals and the spindle is somewhat loose. The second part of each seal set is a plastic cap (metal on the right side of the Type 2) that is a very tight fit to the spindle. The rubber seal and the cap engage each other in such a way as to create a labyrinth seal, which is highly effective at keeping out grit.

Both the Type 1 and Type 2 versions of these bottom brackets have bearing cones that are separate from the spindle. They slip onto the spindle and seat against flanges on the spindle that fix the position of the cone. On the Type 1 spindle, these cones are a mild press fit. On the Type 2 spindle, the cones are a loose fit. Because of this difference, when disassembling the Type 1 bottom bracket, the cones tend to remain in place on the spindle during disassembly. By nature of the design of the Type 2 version, the cone stays with the left-side cup and bearing assembly when they are removed from the spindle. On the right side of the Type 2 version, the cone may stay on the spindle or may stay with the cup when separating the right-side cup and spindle.

The final feature of these bottom brackets that sets them apart from conventional adjustable-cup bottom brackets is that there are two sets of needle bearings in addition to the two sets of cup-and-cone ball bearings. The function of the needle bearings is to support most of the radial loads (which tend to be high). Since the ball bearings are not supporting these high loads, they are much smaller than normal bottom-bracket ball bearings (1/8" instead of 1/4"). With the needle bearings supporting the primary radial loads, the only function of the ball bearings is to enable adjustment of play so that the spindle does not move laterally.

TYPE 1



*Includes snap-ring, ball-bearing retainer, and needle-bearing retainer

10 – CARTRIDGE BEARING BOTTOM BRACKETS

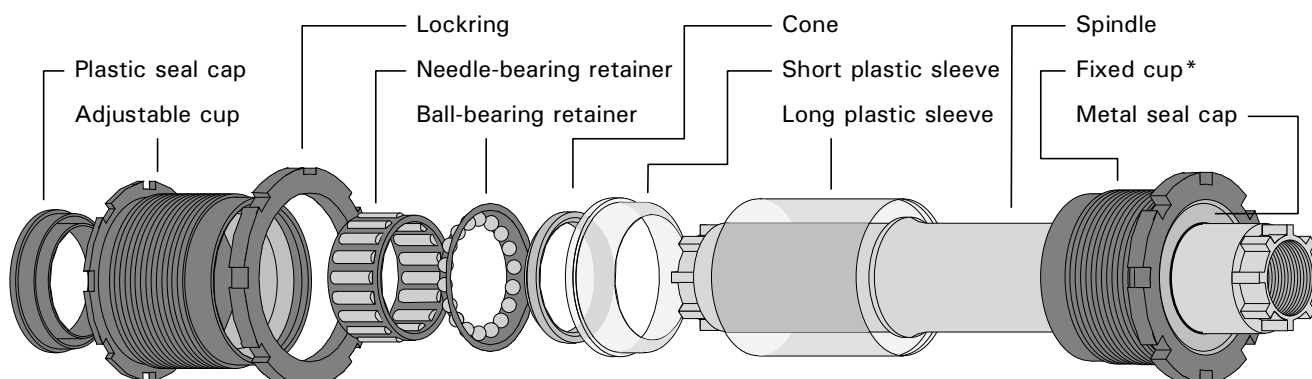
Type 1 disassembly

1. [] Remove both crank arms.
2. [] Look for black plastic cap on right end of spindle to confirm unit is Type 1. If silver metal cap is found, use Type 2 directions.
3. [] Loosen lockring by using lockring spanner to turn it fully counter-clockwise (lockring is larger notched ring on left side of bottom bracket).
4. [] Turn adjustable cup (smaller notched ring) counterclockwise to remove it.
5. [] Pull plastic seal cap out of outer face of cup.
6. [] Pull spindle out left side of bottom-bracket shell.
7. Measure thread diameter of left-side cup to determine if bottom bracket is English/BSC or Italian thread:
 - [] Approximate 35mm O.D. is English/BSC
 - [] Approximate 36mm O.D. is Italian
8. [] Use TL-UN96 (or equivalent) to turn fixed cup clockwise to remove (unless Italian thread).
9. [] Pull plastic seal cap out of outer face of cup.
10. [] Remove plastic seal cylinder from whichever cup it has remained attached to.
11. [] Use seal pick to carefully remove plastic split ring from inside end of each cup. *Be prepared for many small bearings to fall out once ring is removed!*
12. [] Remove ball-bearing retainer from each cup.
13. [] Remove needle-bearing retainer from each cup.
14. [] Remove balls and needles from retainers.

Type 2 disassembly

1. [] Remove both crank arms.
2. [] Look for silver metal cap on right end of spindle to confirm unit is Type 2. If black plastic cap is found, use Type 1 directions.
3. [] Loosen lockring by using lockring spanner to turn it fully counter-clockwise (lockring is larger notched ring on left side of bottom bracket).
4. [] Turn adjustable cup (smaller notched ring) counterclockwise to remove it.
5. [] Pull plastic seal cap out of outer face of cup.
6. [] Use plastic mallet to tap on right end of spindle to remove it from bottom bracket. Watch for metal seal cap that will fall off right end of spindle as spindle is removed. Observe whether cone remained on spindle.
7. Measure thread diameter of left-side cup to determine if bottom bracket is English/BSC or Italian thread:
 - [] Approximate 35mm O.D. is English/BSC
 - [] Approximate 36mm O.D. is Italian
8. [] Use TL-UN96 (or equivalent) to turn fixed cup clockwise to remove (unless Italian thread).
9. [] To remove short plastic sleeve cylinder from adjustable cup, carefully pry under inner perimeter with seal pick. *Be prepared for numerous loose parts held in place only by this plastic sleeve, including a cone, a ball bearing retainer, and a needle-bearing retainer to fall out!*
10. [] To remove long plastic sleeve cylinder from fixed cup, just pull pieces apart with your fingers. *Be prepared for loose parts held in place only by this plastic sleeve, including a cone, a ball bearing retainer, and a needle-bearing retainer to fall out!*
11. [] Remove cones from each cup assembly (unless right-side cone remained on spindle).
12. [] Remove ball-bearing retainer from each cup.
13. [] Remove needle-bearing retainer from each cup.
14. [] Remove balls and needles from retainers.

TYPE 2



*Includes cone, ball-bearing retainer, and needle-bearing retainer

10 – CARTRIDGE BEARING BOTTOM BRACKETS

Type 1 & 2 cleaning and parts replacement

- 15. [] Clean all parts with solvent and dry completely.
- 16. [] Inspect cones for pitting and replace if necessary.

In the previous step, the cones were inspected. If they need replacing, the XTR Type 1 and 2 cones are interchangeable with each other, but the Dura-Ace cones are unique.

- 17. [] Inspect cup races for pitting.
- 18. [] Inspect needle races inside cups for pitting.

In the previous steps, the cups and needle races were inspected. Type 1 cups (XTR or Dura-Ace) are available separately. The Type 2 XTR left-side cup is available separately, but the right-side cup is sold only as part of a cup and spindle assembly. Cups are sold complete with new ball and needle bearings.

- 19. [] Inspect needle races on spindle for pitting.

In the previous step, the needle races on the spindle were inspected. Type 1 spindles (XTR or Dura-Ace) are available separately. The Type 2 XTR spindle is only available as part of a spindle and right-side cup assembly.

- 20. [] Pack all four retainers with grease suitable for high-quality bearings.
- 21. [] Put 18 new 1/8" ball bearings into each ball bearing retainer (insert from outside).
- 22. [] Put 18 roller bearings into each roller bearing retainer (insert from outside).
- 23. [] Inspect seals and seal caps for damage and replace as necessary.

The rubber seals are available only as part of the cup assembly. The plastic seal caps are available separately, but the metal seal cap on the right side of the Type 2 bottom bracket is only available as part of a spindle and right-side cup assembly.

Type 1 assembly

- 24. [] Insert roller-bearing retainers into each cup.
- 25. [] Insert ball-bearing retainers into each cup with smaller-diameter end going in first.
- 26. [] Install plastic split ring into each cup until securely engaged in groove.
- 27. [] Press cones onto spindle until they are seated against flanges.
- 28. [] Press either end of plastic seal cylinder firmly into end of fixed cup.
- 29. [] Insert spindle into fixed cup, then press plastic seal cap over right end of spindle until it bottoms against seal and cup.

Type 2 assembly

- 24. [] Insert roller-bearing retainers into each cup.
- 25. [] Insert ball-bearing retainers into each cup with smaller-diameter end going in first.
- 26. [] Install cone into left-side cup.
- 27. [] Snap short plastic cylinder into left-side cup, and snap long plastic cylinder into right-side cup.
- 28. [] Press remaining cone onto right end of spindle until it seats against flange.
- 29. [] Insert spindle into fixed cup, then press metal seal cap over right end of spindle until it bottoms against seal and cup.

Types 1 & 2 installation and adjustment

- 30. [] If installing new unit, separate left-side cup assembly from clear plastic seal cylinder and remove black plastic seal cap from outer face of left-side adjustable cup.
- 31. [] Thread adjustable-cup lockring inward, then coat threads that were covered by lockring with anti-seize, then thread lockring back out to end of cup.
- 32. [] Coat all exposed threads on both cups with anti-seize.

The bottom bracket comes with several spacer washers, which change location depending on the configuration. The variables are the shell width (68mm or 73mm), the spindle length (112.5mm or 116mm), and whether the front derailleur being used is an E-type (mounts by means of bracket secured behind the fixed-cup flange). Use the following guide for the spacer thickness used with each configuration:

- 68mm shell/112.5mm spindle—2.5mm each side
- 68mm shell/116mm spindle—3.5mm each side
- 73mm shell/112.5mm spindle—no spacers
- 73mm shell/116mm spindle—1mm each side
- All combinations, right side, with E-type derailleur—bracket only on right, no spacers
- 68/112.5mm setup with E-type—2.5mm on left
- 73/116mm setup with E-type—nothing on left
- 33. [] Install correct spacer or bracket on each cup.
- 34. [] Carefully thread right-side cup and spindle assembly into right side of bottom-bracket shell (counterclockwise for English/BSC, clockwise for Italian).
- 35. [] Using Park BBT-8 and TWB-368, secure fixed cup to 435in-lbs.
- 36. [] Double-check that lockring is threaded all the way out on adjustable cup, then thread adjustable cup in until it gently contacts bearings.

37. [] Place BBI bottom bracket tape on shell so that “0” mark lines up with one edge of a notch in the adjustable-cup flange (not a notch in the lockring).

In the next step, you simultaneously stabilize the adjustable cup and secure the lockring. The adjustable cup can be fit by the TL-UN96 or equivalent, but this type of tool requires a second tool for leverage, such as a headset spanner. Since you also have to use another lockring spanner on the lockring, you would end up with three tools, none of which securely attach to each other or the part they engage. Consequently, the best technique is to use two lockring spanners and no TL-UN96 or equivalent. This technique is much less awkward.

38. [] Use one lockring spanner to stabilize adjustable cup, and another to secure lockring.
39. [] Jerk vigorously on end of right crank arm at a variety of positions to check for knock.
40. [] Tighten adjustment (clockwise) by one mark to eliminate knock, or loosen (counterclockwise) to create knock. Final adjustment is first setting clockwise of adjustment with knock that eliminates knock.
41. [] Press black plastic seal cap onto left end of spindle until it is fully seated against seal and cup.

CARTRIDGE-BEARING SPLINED-SPINDLE BOTTOM BRACKETS

Tool compatibility

These bottom brackets include the Dura-Ace model BB-7710 (track), the Ultegra model BB-6500, the 105 model BB-5500, and the XTR model BB-M952. These are all simple cartridge-bearing bottom brackets such as the UN, LP, or CS series. The only difference is that the spindle configuration is splined instead of a squared taper. However, this difference can cause problems with the fit of earlier versions of the tools for this type of bottom bracket. Older versions of the Park BBT-2 or the Shimano tools will not work. Specifically, the BBT-2 with 20mm hex flats on the smaller diameter of the tool is not compatible. The newer BBT-2 has 32mm hex flats on the larger portion of the tool, and is compatible. The Shimano TL-UN65 or TL-UN74-S will clear the larger-diameter splined spindles. The older Shimano tool models TL-UN50, TL-UN52, TL-UN70, and TL-UN70 either are incompatible with the splines in the mounting rings, or lack the internal clearance to clear the larger-diameter splined spindles.

Service

The service techniques are the same as all Shimano UN-series cartridge bottom brackets (pages 10-1 through 10-3). Note, the recommended torques on these pages are less than the Shimano recommendations. They have been well proven in the field, and are preferred on the bottom brackets that have a plastic-mounting ring on the left side. The Shimano recommended torque often leads to damage of the plastic splines. The bottom brackets with splined spindles all have metal splines in the mounting rings, and can easily withstand Shimano's recommended minimum torque of 435in-lbs.

The bottom bracket comes with several spacer washers, which change location depending on the configuration. The variables are the shell width (68mm or 73mm), the spindle length (112.5mm or 116mm), and whether the front derailleur being used is an E-type (mounts by means of bracket secured behind the fixed-cup flange). Use the following guide for the spacer thickness used with each configuration:

68mm shell/112.5mm spindle—2.5mm each side
 68mm shell/116mm spindle—3.5mm each side
 73mm shell/112.5mm spindle—no spacers
 73mm shell/116mm spindle—1mm each side
 All combinations, right side, with E-type
 derailleur—bracket only on right, no spacers
 68/112.5mm setup with E-type—2.5mm on left
 73/116mm setup with E-type—nothing on left

Fit to crank arms

These models of bottom brackets all have a uniform spindle-spline pattern. The critical spline dimensions are that the eight lands (ridges) are 2.2mm thick and 5mm long. As long as the spindle length is suitable, any bottom brackets with these spline dimension are interchangeable. Shimano has another bottom-bracket type (model BB-ES70) with eight lands that are each 2.8mm thick and 9mm long that is not interchangeable with the 2.2mm × 5mm pattern.

LONG-SPLINED SPINDLES

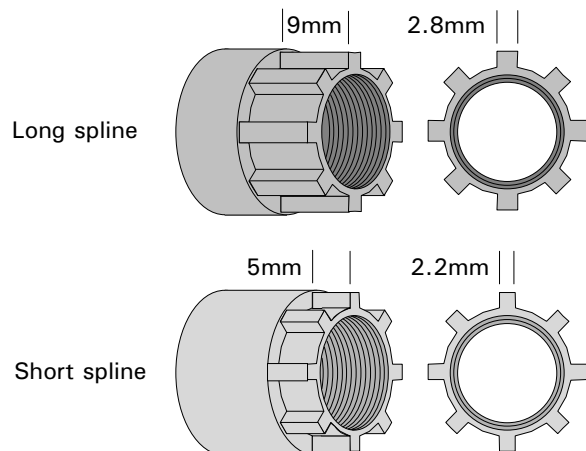
The Shimano model BB-ES70, introduced in 2000, is a simple cartridge-bearing bottom bracket with a different spline pattern than previously introduced splined-spindle models. The service tools and techniques are identical to the sealed splined bottom brackets described in the immediately previous section, **CARTRIDGE-BEARING SPLINED-SPINDLE BOTTOM BRACKETS** (page 10-10).

10 – CARTRIDGE BEARING BOTTOM BRACKETS

Fit to crank arms

This model of bottom bracket has a new spindle-spline pattern. The critical spline dimensions are that the eight lands (ridges) are 2.8mm thick and 9mm long. As long as the spindle length is suitable, any bottom brackets with these spline dimension are interchangeable. Shimano has another bottom-bracket type with eight lands that are each 2.2mm thick and 5mm long that is not compatible. The difference between the 5mm and 9mm long lands is obvious without measurement once you have seen both, so distinguishing between the two spline patterns should not be difficult.

The BB-ES70 is made to fit 2000 model crank arms including Deore XT and LX models with splined arm holes (model numbers FC-M751 and FC-M571). Deore LX model FC-M570 is also considered a 2000 model, but it fits a squared spindle. Deore XT and LX models from 1999 and earlier (1999 model numbers FC-M750 and FC-M570, respectively) both fit squared spindles.



11 – HEADSETS

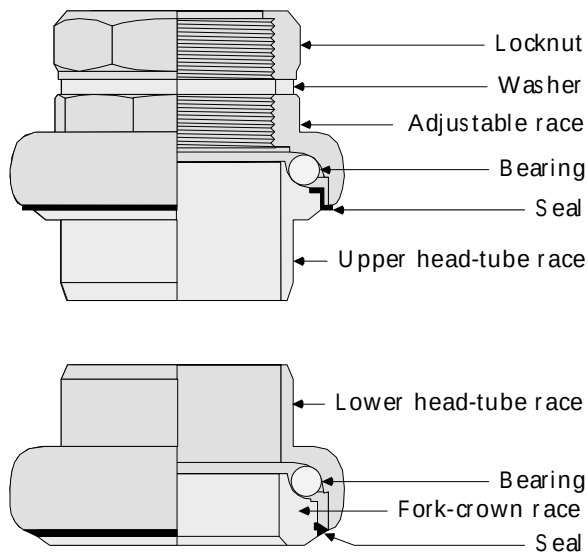
ABOUT THIS CHAPTER

Sections

The first section of this chapter is designed as general information for all types of headsets. The second section of this chapter is about threaded headsets. Threaded headsets press into the head tube, press onto the fork, and thread onto the fork. The third section of this chapter is about threadless headsets. The threadless system uses no fork threads. The fourth section of this chapter is about headsets that use roller bearings instead of ball bearings. The fifth section is about the Mavic headset and similar designs without a locknut. The final section is a table of headset-stack heights to enable selection of an appropriate replacement headset.

GENERAL INFORMATION

TERMINOLOGY



11.1 Parts in a headset.

Headset: The bearing assembly that allows the fork to rotate in the frame's head tube.

Head tube: The semi-vertical tube at the front of the frame that the fork rotates inside of.

Fork: The portion of the frame that attaches directly to the front wheel and allows the front wheel to rotate side-to-side relative to the rest of the frame.

Fork column: The tube at the top of the fork that rotates inside the head tube. The fork column may also be called *steering column*, *steering tube*, *steerer tube*, or *fork steerer*.

Fork-column base: The largest-diameter portion of the fork column, at the absolute bottom of the fork column. The fork-crown race presses onto the fork-column base.

Fork crown: The large joining piece between the base of the fork column and the top of the fork blades.

Crown-race seat: The top surface of the fork crown on to which the fork-crown race sits.

Race: The cone or cup surface on which bearings roll. A misuse of this term is to use it to describe a set of ball bearings held together in a holder, which is more properly called a *retainer*.

Pressed race: A race that is pressed onto the fork column or into the head tube.

Upper head-tube race: The pressed race that installs in the upper end of the head tube. It may be a cone or a cup.

Lower head-tube race: The pressed race that installs in the lower end of the head tube. It may be a cone or a cup, but is virtually always a cup.

Cone: A surface that bearings roll on that is positioned inside the circle of balls. A cone may thread onto the fork column, or it may be pressed into the top end of the head tube or the bottom of the fork column.

Cup: A surface that bearings roll on that is positioned outside the circle of balls. A cup is pressed into either end of the head tube, or may thread onto the fork column.

Adjustable cup or cone: A bearing cup that threads onto the fork column would be an adjustable cup. A cone could serve this function also, so a more generic term might be *adjustable race*, which would include an adjustable cup or an adjustable cone. On a threadless headset the adjustable cone does not thread onto the fork column, but slips effortlessly on.

Adjustable race: A bearing cup or cone that threads onto the fork column would be an adjustable race. On a threadless headset the adjustable race does not thread onto the fork column, but slips effortlessly on.

Fork-crown race: The bearing race that is pressed onto the base of the fork column. It may be a cone or a cup, but is virtually always a cone. Sometimes called a crown race.

Locknut: A nut that threads onto a fork column against an adjustable race to lock the position of the adjustable race to the fork column.

Lockring: Similar to a locknut, but instead of having the flats that are fit by regular wrenches, a lockring is round and has notches that are engaged by a curved tool with hooks.

Retainer: A clip that holds a group of balls that fit in-between a cup and a cone. A retainer is sometimes falsely called a *race*.

Cable hanger: A bracket used by some brake systems that is installed under the headset locknut to serve as a stop for the brake-cable housing.

Reflector bracket: A bracket that mounts under the headset locknut for mounting of a front reflector.

PREREQUISITES

Stem removal

Stem removal is optional for headset adjustment, but required for headset overhaul or replacement. Although other writers have indicated that having the stem in place affects the headset adjustment, scientific testing has shown that this is not the case; however, having the stem in place *does* make the adjustment more awkward. See the chapter **HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS** (page 28-5).

Brake removal/disconnection

Depending on the type and design of the brake, it will be necessary to remove the brake calipers from the fork, or remove the brake cable from the caliper, in order to overhaul the headset. If the cable does not go through a cable hanger that is part of the headset, or cannot be released from the bracket without disconnecting the cable from the brake, then caliper removal is probably the best choice. When the cable cannot be released from the headset or the fork (suspension forks) without disconnecting the cable, leave the calipers in place and just disconnect the cable. See **CABLE-OPERATED BRAKE CALIPERS** (page 36-1).

INDICATIONS

There are several reasons a headset may need to be adjusted, and several reasons it may need to be overhauled. Adjustment should generally be done on the basis of need (looseness or tight rotation). Overhaul

should be done as part of a regular maintenance cycle, the duration of which will change depending on the type of riding conditions, the amount of riding, and the type of equipment.

Maintenance cycles

If starting out with a headset known to be in good condition with good quality grease, it should last thousands of miles without needing an overhaul. If the equipment sees little wet-weather riding, then an appropriate maintenance cycle would be 2000–3000 miles, in most cases. If a lot of wet-condition riding is done, then the maintenance cycle might need to be as often as every 750–1000 miles. Parts rust whether being ridden or not, so another factor is how long the bike may be sitting before being used again. For example, if ridden 200 miles in the rain in the fall then put the bike away four months for the winter, it would probably be a good idea to overhaul the headset before putting the bike away for the winter. With a new bike, there is no way to have an idea how well the bearings were prepped, greased, and adjusted. In particular, it is common that new bikes come with ball retainers in the headset. In the case of headsets, ball retainers lead to premature failure and should always be replaced with loose balls as soon as possible. Ideally, overhaul a new bike within the first 100 miles of use (not usually practical). With a new bike poor factory greasing is common, and the initial break-in period puts a lot of microscopic metal fragments into the grease, two additional good reasons to overhaul the headset almost immediately.

Some other factors affecting the maintenance cycle are whether there is grease injection and whether there are seal mechanisms. *Grease-injection systems do not eliminate the need for overhaul.* They only increase the acceptable time between overhauls; furthermore, they are only as good as the customer is consistent and thorough about pumping in new grease. Seal mechanisms (conventional headsets with rubber seals between the cones and cups) *are not effective water-tight seals.* Their effectiveness varies with the brand and model. At best, they can lengthen the acceptable time between overhauls. With seal mechanisms or grease-injection systems, the best policy is to initially overhaul the headset on a normal length maintenance cycle, and if the grease is found to be in good condition, then extend the cycle the next time.

Symptoms indicating need for overhaul

One of the most common conditions that leads the cycling enthusiast to believe that their headset should be overhauled is when the races are “brinelled.” Brinelled races are races that are dented. A headset with brinelled races does not turn smoothly side-to-side, but moves in distinct increments — almost like an indexed shift lever. When this symptom exists it is *possible* that overhaul will eliminate it, but in most cases the headset will need to be replaced.

The only symptom indicating a need for a headset overhaul is that when performing an adjustment the looseness (free play) in the bearings cannot be eliminated without the bearing becoming excessively tight (it does not turn smoothly). The lack of smoothness could be caused by dry grease, contaminated grease, or worn parts.

Symptoms indicating need for adjustment

The primary symptom experienced indicating that a headset needs adjustment is looseness in the bearings. This can be detected by grasping the end of the fork and jerking it in and out while feeling for a knocking sensation. One method for detecting a loose adjustment that is recommended against is to lock up the front brake and feel for a knocking sensation while rocking the bike forward and back. This method can lead to the impression that the headset is loose when it is not, because a loose brake pivot will feel just like a loose headset. Inspect for loose bearings and a loose locknut after 300–500 miles of use. The only way to check for a loose locknut is to put a tool on the locknut and see if it is secure. Whenever the locknut is loose, simply securing the locknut is not adequate because the adjustment may have been lost while the locknut was loose.

Other reasons to adjust the headset are that it feels tight or feels brinelled (moves in increments). A tight headset shows up when lifting the front of the bike by the top tube and the wheel does not flop to one side under its own weight. The brinelled symptom, if caught early enough, can be eliminated through adjustment, but when it is not known whether there are loose bearings instead of retainers, it is best to overhaul the headset.

TOOL CHOICES

The design or brand of headset will determine the tools needed. Table 11-1 (page 11-4 through 11-5) covers all tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among:

ease of use, quality, versatility, and economy. When more than one tool for one function is **bold**, it means that several tools are required for different configurations of parts.

TIME AND DIFFICULTY

Overhauling the headset including stem and brake caliper/cable removal, stem and brake reinstallation, and headset adjustment is a 25-35 minute job of moderate difficulty. Adjusting the headset alone is a 8-12 minute job of moderate difficulty.

COMPLICATIONS

Headset will not stay tight

There are numerous reasons that headsets loosen up. The reasons include:

- Poorly pressed races seating fully after adjustment.
- Inadequate torque on locknuts/lockrings.
- Chrome plating peeling off race surfaces of inexpensive new headsets.
- Riding on extremely rough terrain (or abusive jumping), when the headset is designed more for light weight than for durability.
- Use of keyed washers between adjustable race and locknut/lockring.

Loose head-tube race

Loose races in the head tube can be due to poor initial tolerance or due to damage to the head tube. If the head tube has been damaged, there will often be a visible flare at the bottom in front or back (see figure 8.29, page 8-16). Loose races due to poor tolerances can be solved by finding a better fitting headset (if available), or by the use of Loctite RC680.

Loose crown race

Loose fork-crown races are usually due to poor manufacturing tolerances in the race or on the fork-column base. The solutions include finding a headset with a more suitable fork-crown-race I.D., using Loctite RC680, or expanding the fork-column base with a Stein KT knurling tool.

Removal tool will not engage head-tube race

The designs of certain head tubes and certain head-tube-race-removal tools are not compatible. When this is the case, the removal tool passes right back through the head-tube race when removal is attempted. The solution is to put the tool in place and install an internal snap ring through the race being removed so that

11 – HEADSETS

HEADSET TOOLS(table 11-1)

Tool	Fits and considerations
LOCKNUT WRENCHES/SPANNERS	
Diamond C79	Old fashioned monkey wrench fits all flattened locknuts better than pre-fit headset wrenches below
Park HW-2	Precise fitting 12" long 32 & 36mm locknut tool, fits 8-flat nuts
Stein HW-32/8	Precise fitting 12" long 32mm locknut tool, fits 8-flat nuts
Stein HW-36/6	Precise fitting 12" long 36mm locknut tool, fits 6-flat nuts
Stein HW-36/8	Precise fitting 12" long 36mm locknut tool, fits 8-flat nuts
Stein HW-40/8	Precise fitting 12" long 40mm locknut tool, fits 8-flat nuts
VAR 988	Fits 8-flat 36 & 40mm locknuts
VAR 65/2	Fits 8-flat 32 & 35mm locknuts
ADJUSTABLE-RACE SPANNERS/PLIERS	
Park HW-1	Anatomically shaped 32 & 36mm adjustable-race tool
Park HCW7	Fits 30 & 32mm adjustable races
Park HCW8	Fits 33 & 34mm adjustable races
Park HCW9	Fits 31 & 40mm adjustable races
Park HCW10	Fits 35 & 36mm adjustable races
Park HCW6	Fits 32mm adjustable races, with 15mm pedal wrench
Park HCW12	Fits 32mm adjustable races, with single-peg bottom-bracket-lockring wrench
Campagnolo 712	Fits 32mm adjustable races, with multiple-peg bottom-bracket-lockring wrench for Campy bottom brackets
Campagnolo 712/1	Fits 32mm adjustable race wrench with bottom-bracket adjustable-cup pin wrench for Campy bottom brackets
Campagnolo 7130033	Fits 36 & 40mm adjustable races
Hozan C431	Fits 36 & 40mm adjustable races, heavy duty and comfortable
Lifu 0600	Fits 30 & 32mm adjustable races
Lifu 0601	Fits 33 & 34mm adjustable races
Lifu 0606	Fits 36 & 40mm adjustable races, with useful offset to 36mm end
Tange 3640	Fits 36 & 40mm adjustable races
VAR 78	Adjustable-race pliers that grasp the race body instead of wrench flats
LOCKRING WRENCHES/PLIERS	
Park HCW12	Single-peg style wrench fits all headset lockrings
Hozan C205	Single-peg style wrench fits all headset lockrings, also fits bottom-bracket lockrings
Hozan C203	Lockring pliers fit all lockrings with even number of notches
HEAD-TUBE-RACE REMOVERS	
Park RT1	Fits all headset sizes
Stein FS	Fork stabilizing tool used to keep fork from turning while adjusting headset
Campagnolo 723	Fits 1" headsets
Campagnolo 1170006	Fits 1-1/8" & 1-1/4" headsets
Wheels Mfg. HR1	Fits 1" headsets
Wheels Mfg. HR2	Fits 1-1/8" headsets
Hozan C436	Fits 1-1/8" & 1-1/4" headsets, excellent quality

HEADSET TOOLS (table 11-1 continued)

Tool	Fits and considerations
CROWN-RACE REMOVERS	
Stein CRR1	Universal, works on most suspension forks and fork-crown shapes
Campagnolo 729	Fits 1" headsets with larger diameter crown races on limited fork-crown shapes
Campagnolo 7170003	Fits some 1–1/8" headsets on limited fork-crown shapes
Campagnolo 7170002	Fits some 1–1/4" headsets on limited fork-crown shapes
Shimano TL-HP20	Fits 1" headsets with smaller diameter crown races on limited fork-crown shapes
Hozan C437	Fits some large diameter races on 1" headsets, plus 1–1/8" & 1–1/4" headsets on limited fork-crown shapes
VAR 983	Fits some large diameter races on 1" headsets, plus 1–1/8" & 1–1/4" headsets on limited fork-crown shapes
HEAD-TUBE-RACE PRESSES	
Hozan C438	Fits all sizes of headsets, uses stepped inserts
United Bicycle Tool TRC & TRC4	Dedicated 1–1/8" & 1–1/4" inserts for Hozan C438 that provide better support and accommodate longer head tubes
VAR 34	Fits all sizes of headsets, uses stepped inserts
Park HHP1	Fits all sizes of headsets, uses stepped inserts (does not maintain headset race alignment adequately), also fits one-piece bottom-bracket cups
CROWN-RACE INSTALLERS	
VAR 146/2	Fits 1" forks, heavy slide hammer
VAR 973	Fits 1–1/8" forks, heavy slide hammer
VAR 972	Fits 1–1/4" forks, heavy slide hammer
Hozan C435	Fits all sizes of forks when used in conjunction with United Bicycle Tool HP50, HP51, and HP52, heavy slide hammer
Campagnolo 722	Fits 1" forks, light-weight slide hammer (but can be hammered)
United Bicycle CRS	Fits 1" forks, light-weight slide hammer, compatible w/ all fork columns
United Bicycle CRS2	Fits 1–1/8" forks, light-weight slide hammer, compatible with all fork columns
United Bicycle CRS3	Fits 1–1/4" forks, light-weight slide hammer, compatible with all fork columns
Shimano TL-HP50	Adapter for other slide hammers that clears any interference with bottom of fork column on 1" forks
Shimano TL-HP51	Adapter for other slide hammers that clears any interference with bottom of fork column on 1–1/8" forks
Shimano TL-HP52	Adapter for other slide hammers that clears any interference with bottom of fork column on 1–1/4" forks
United Bicycle Tool HP50	Adapter for other slide hammers that clears any interference with bottom of fork column on 1" forks
United Bicycle Tool HP51	Adapter for other slide hammers that clears any interference with bottom of fork column on 1–1/8" forks
United Bicycle Tool HP52	Adapter for other slide hammers that clears any interference with bottom of fork column on 1–1/4" forks
THREADLESS-HEADSET TOOLS	
Park TNS-1	Installs star nut for threadless headset in 1" & 1–1/8" fork columns
Park TNS-2	Installs star nut for threadless headset in 1–1/4" fork columns

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it expands and ends up trapped between the race and the end of the removal tool. The tool drives against the snap ring, which has a smaller I.D. than the race, so that the tool cannot pass through.

The correct sizes of internal snap rings to use are as follows: 1-1/16" for 1" headsets, 1-1/8" for 1-1/8" headsets, and 1-1/4" for 1-1/4" headsets.

These may be a little sloppy after being installed past the race, but they are the largest sizes that will pass through the respective race sizes, and will work despite the sloppiness.

The snap ring solution may not work if the head-tube race is unusually tight in the head tube.

Fork will not pull through head-tube races, or crown race will not clear top of fork column

The fork may stick when pulling it through the head-tube races, or the fork-crown race may stick before it comes off the end of the fork column. Both of these symptoms occur when the fork column (below the threads) is bulged as a result of an over-tightened stem-binder bolt.

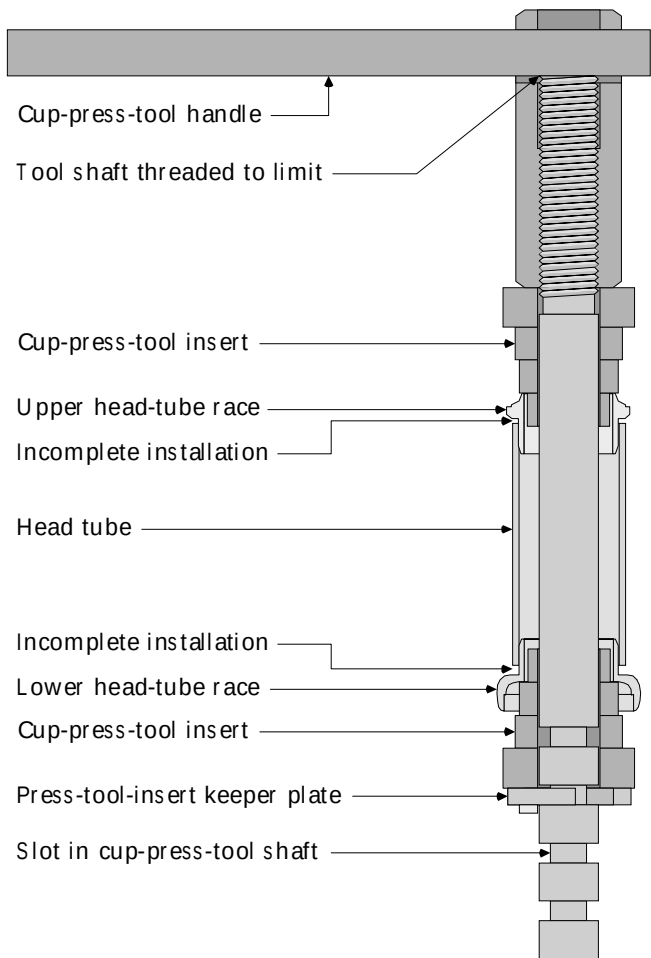
If this problem does occur, there is no alternative except to use whatever force is necessary to get the fork clear of the race, and then dispose of the fork.

Head-tube race will not seat fully

There are several reasons that a head-tube race might not seat fully when being pressed in. If using an inferior pressing tool, the races may cock to the side and jam.

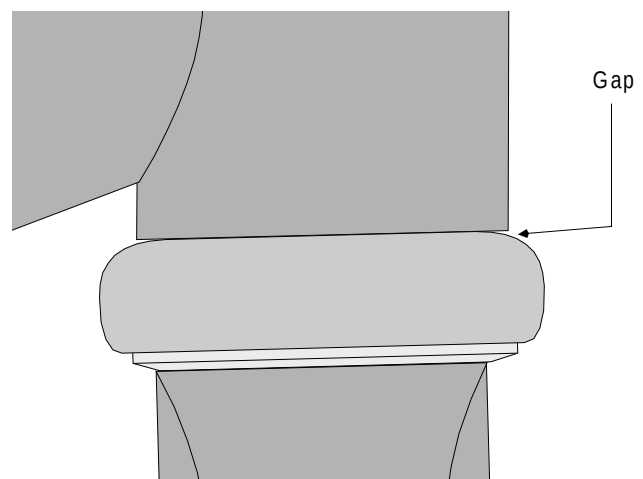
If installing aluminum body races into a steel head tube, a sharp edge on the inner perimeter of the head-tube face may create shavings or burrs that get trapped between the head-tube face and the race. Remove the race, then clean off any burrs or shavings off the race with a file. File or deburr the inner perimeter of the head-tube face with a round file or deburring tool.

Some head-tube-race pressing tools have multiple slots for the keeper plate of the tool to engage with, and a limited range of thread for the handle. Sometimes it is necessary to thread the tool shaft out of the tool head more and move the keeper plate up one slot on the tool shaft to ensure a complete pressing.



11.2 *If the keeper plate is engaged in the wrong slot, then the tool shaft may thread to its limit before pressing is complete.*

A beveled or sloped head-tube face or beveled race body may make a gap appear between the outer perimeter of the head-tube face and the race when, in fact, there is full contact at the inner.



11.3 *The curve of the cup may make it appear as though the race is not fully seated, when it is.*

Slide hammer jams before pressing crown race fully

The recommended VAR slide hammers are sometimes a very tight fit on the fork column, usually due to a buildup of paint or chrome on the fork column. An expansion reamer can be used to easily modify the tool to solve this problem (see chapter 7, page 7-3).

The Hozan C435 I.D. is a very close fit to the fork-column base. If the fork-column base is taller than the fork-crown race being installed, then the tool will jam on the fork-column base before pressing the fork-crown race fully. Use a different brand tool or use Shimano or United Bicycle Tool (HP50, HP51, and HP52) adapters with the Hozan tool.

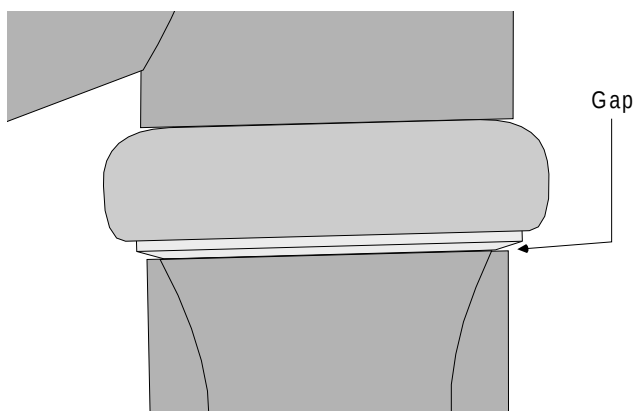
Some forks, particularly some suspension forks, have a taper just above the fork-column base that many slide hammers will not clear. Use United Bicycle Tool slide hammers CRS, CRS2, and CRS3 to solve this problem, or use Shimano or United Bicycle Tool (HP50, HP51, and HP52) adapters with the Hozan, VAR, or Campagnolo tool (see table 11-1, page 11-5).

Some carbon-fiber and aluminum forks have an extra-fat fork column. Hozan, VAR, and Campagnolo tools all jam in the first few inches before pressing ever begins. United Bicycle Tool slide hammers CRS, CRS2, and CRS3 solve this problem (see table 11-1, page 11-5).

Fork-crown race will not seat fully

See the above problem regarding slide hammer jamming before race installs fully. If none of these are the cause of the problem, it may be one of the following items.

A bevel or slope to the crown-race seat or the race body may make a gap appear between the outer perimeter of the crown-race seat and the race when, in fact, there is full contact at the inner perimeter.



11.4 A bevel at the edge of the crown-race seat may make it appear as though the race is not seated fully when the race is seated fully.

If the race is undersized to the fork-column base, or gets cocked during installation, burrs may peel off the surface of the fork-column base. In this case, remove the race, clean off the burrs, check the fit, and if fit is good attempt another installation (watching alignment carefully).

Fork-crown race cracks when being installed

Certain small-profile steel races are very intolerant of fit errors. Check fit carefully, especially when the fork-crown race is very small. Larger races will simply jam before installing completely, instead of cracking, when fit tolerances are poor.

Head-tube races make creaking noises

Aluminum head-tube races may creak in an aluminum head tube even when properly fit. Use Loctite 242 on mating surfaces to solve this problem.

HEADSET FIT

Headset parts press into the head tube, press onto the fork, and thread onto the fork. There are several different fit standards listed in table 11-2 (page 11-8). When replacing the headset, match the thread standard and the press fit dimensions (head-tube-race O.D. and fork-crown-race I.D.). If the bike has JIS standard press fit dimensions, or a mix of JIS and “Campy” standards, use reaming tools to convert the frame and fork to the “Campy” standard (30.0mm head tube and 26.5mm fork-crown base), which is the one that most replacement headsets are available in. Headsets are broken down into three groups: 1", 1-1/8", and 1-1/4" sizes. These numbers refer to the outside diameter of the fork threads. In some cases, a quicker way to identify what size headset is in the bike is by checking the stem's O.D. Some types of headsets are unique to one manufacturer. Old inexpensive English Raleighs (1" × 26tpi), Murrays, and Huffys have unique headsets, as well as some Austrian bikes and other bikes from European countries that would not be considered part of the cycling industry mainstream anymore.

Another important aspect of fit is the “stack height” of the headset, which relates to the difference in the length of the fork column and the head tube. In this area there are no standards, and the worksheets provided give a formula for calculating the maximum acceptable stack height for a replacement headset. Tables at the end of the chapter (page 11-24 through 11-28) help find a headset that is of a suitable stack height to fit the bike.

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HEADSET-FIT FACTORS(table 11-2)

Headset type	1" "Campy"	1" JIS (Asian)	1" American	1" French (actual thread O.D.=25.0mm)	1-1/8" OS	1-1/4" OS
Typical occurrences	Most bicycles from Italy and US factories ¹ , not US brand imports, most quality replacement headsets	Most Asian bicycles ² that are not oversize (OS)	Quality BMX and old Schwinn	Older French bicycles, discontinued in early 1980s	Most mountain bikes with oversize headsets, some tandems	Fisher MTBs ³ , limited other MTBs, some tandems
Stem O.D.	22.15–22.25mm	22.15–22.25mm	21.05–21.15mm	21.95–22.05mm	25.35–25.45mm	28.50–28.60mm
Pitch	24tpi	24tpi	24tpi	1mm	26tpi	26tpi
Fork thread O.D.	25.1–25.3mm	25.1–25.3mm	25.1–25.3mm	24.7–24.9mm	28.3–28.5mm	31.5–31.7mm
Nominal thread description	1" × 24tpi or 25.4mm × 24tpi ⁴	1" × 24tpi	1" × 24tpi	25mm × 1mm	1-1/8" × 26tpi	1-1/4" × 26tpi
Head-tube-race O.D.	30.15–30.30mm	29.95–30.10mm	32.65–32.80mm	29.95–30.10mm	34.00–34.10mm	37.00–37.10mm
Head tube I.D.	29.95–30.05mm	29.75–29.85mm	32.45–32.55mm	29.75–29.85mm	33.75–33.85mm	36.75–36.85mm
Fork-crown-race I.D.	26.30–26.40mm	26.90–27.00mm	26.30–26.40mm	Variable ⁵	29.90–30.00mm	32.90–33.00mm
Fork-column-base O.D.	26.45–26.55mm	27.05–27.15mm	26.45–26.55mm	Variable ⁵	30.05–30.15mm	33.05–33.15mm

¹ Lower quality adult bikes and BMX bikes sold in department stores often have headset dimensions that are unique to the specific manufacturer of the bike. This is most notably true with Huffy and Murray brand bikes.

² Occasional Asian bicycles used mixed standards for the head-tube-race O.D. (Campy standard) and fork crown race I.D. (JIS standard).

³ Fisher MTBs ceased utilizing the 1-1/4" oversize headset in approximately 1994.

⁴ BSC and ISO thread description is 1" × 24tpi. Italian thread description of 25.4mm × 24tpi is fully interchangeable, but not *exactly* the same, resulting in a slightly tight feel in the threads when mixing types.

⁵ Peugeot uses a unique fork-crown-race I.D. of 26.5mm. Some French bikes adhere to the Campy standard and some to the JIS standard.

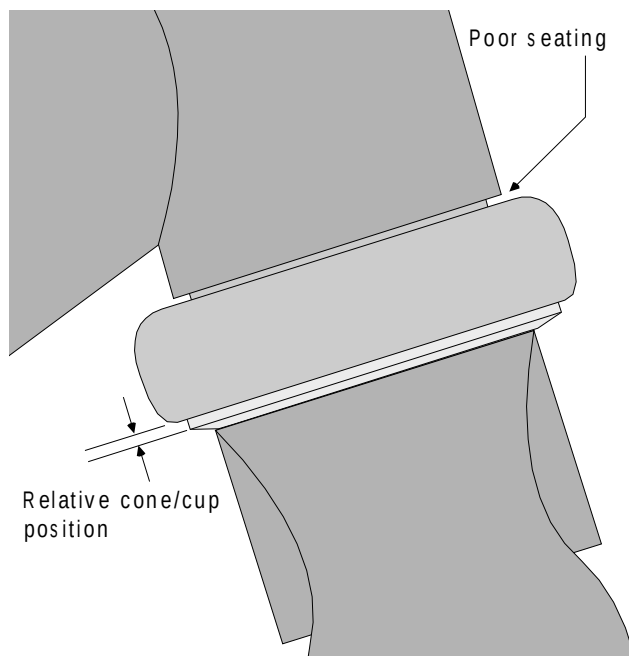
THREADED-HEADSET OVERHAUL AND ADJUSTMENT PROCEDURE

NOTE: If simply adjusting the headset, proceed directly to step 65.

REMOVAL

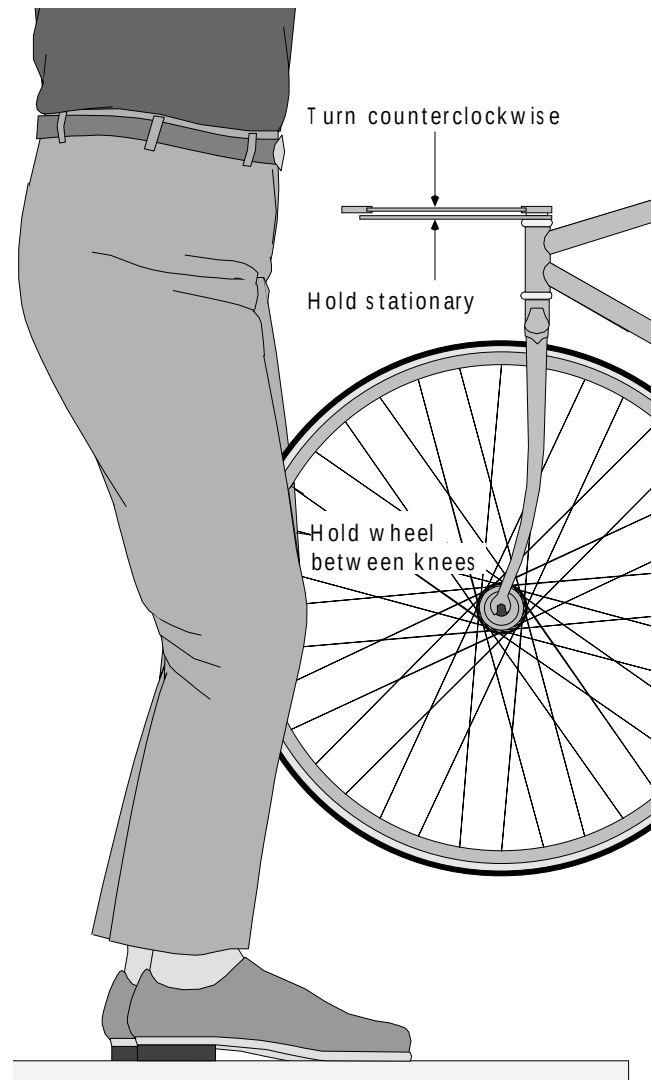
Remove brake calipers from the fork, or remove cable from brake calipers, whichever seems easier to do (keep in mind putting everything back together). If the cable goes through a cable hanger in the headset, or on a fork that has no slot to enable the cable to be released, it will be necessary to remove the cable from the brake.

1. [] Remove brake calipers from fork, or remove cable from brake calipers.
2. [] Mark stem height with felt marker or piece of tape.
3. [] Loosen stem bolt (the one that goes down shaft of stem) about four full turns.
4. [] If stem-bolt head has come up out of stem, tap it down forcefully with plastic hammer or ball peen hammer and block of wood to protect bolt head.
5. [] Pull stem out of fork, and use something to tie bars to top tube, so that weight of bars does not hang against brake and derailleur cables and so that cables are not kinked.



11.5 Look for poorly seated race and depth of cone insertion before disassembly.

6. [] Inspect for poorly seated cups and for relative depth of cones in cups.



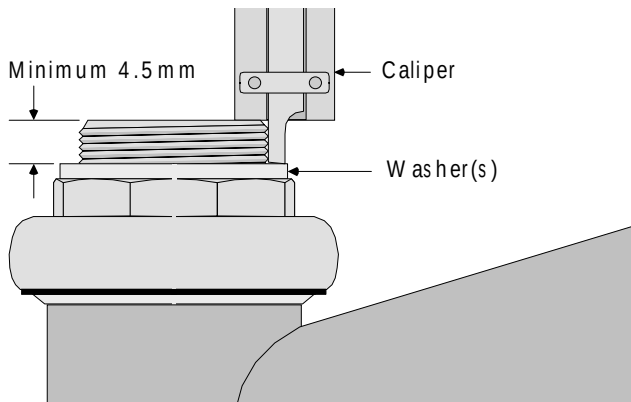
11.6 Removing the locknut.

7. [] Use headset wrench to hold adjustable race stationary while using large adjustable wrench to turn locknut (counterclockwise) to break it loose and remove it. If possible hold wheel between legs while doing this to may make it easier to control.
8. [] Remove front wheel.

In the next step, measure the amount of fork thread exposed above the remaining headset pieces. This number is useful for many things. If this number increases when the headset is assembled, it indicates that pieces were left out or the use of ball bearings that are too small. If this number becomes smaller, it indicates use of balls that are too large or that the ball bearings are out of place. If this number is less than 4.5mm to start with, it indicates that the locknut has

11 – HEADSETS

poor engagement and washers or spacers should be removed from the headset until the exposed thread measures 4.5mm or more.



11.7 Measure the exposed thread available for the locknut.

- 9. [] Use depth gauge on end of caliper to measure exposed thread above washers/brackets and record number here: _____ mm.**

Underneath the locknut there may be one or several washers and brackets (for reflectors or for the brake cable). Sometimes a washer will be difficult to lift off. Usually this means that it has rotated and jammed its key into the threads. In this case, grasp the washer with large pliers (Hozan C203 if you have one) and rotate it back until its key lines up with the slot in the threads. It should lift off easily then.

The sequence of washers and brackets is important. Sometimes there is a special washer that must go against the adjustable race, and often this special washer must face a certain way. If there is a cable hanger bracket, changing its position in the sequence could change the brake adjustment (which could be dangerous if not detected). In some cases, there might be a second locknut or lockring between the top nut and the adjustable race. If there is a lockring, a lockring wrench is needed to break it loose. To keep track of the sequence and orientation of the washers, brackets, and any additional lockring either write descriptive notes, draw an exploded diagram, or bundle them together with something like a plastic bag tie until ready to reinstall them.

- 10. [] Lift any washers and brackets off fork and note their order and orientations.**

- 11. [] Remove lockring (if any).**

- 12. [] Remove additional washers (if any).**

Be prepared for loose ball bearings to drop out in this next step. They should not be reused, and the correct quantity is something that will be determined

by trial and error, so don't be too concerned about keeping track of every last ball. Keep track of at least one for size reference.

- 13. [] Pull down on fork while turning adjustable race (counterclockwise) until fork comes out bottom of head tube. Adjustable race will remain perched on top of head tube.**

In the next steps, look for seal mechanisms (see figure 11.1, page 11-1) and remove them. They will be plastic or rubber rings between the pairs of races at the top and bottom of the head tube. The seal mechanisms can be different at the top and bottom, and which way each one faces is critical as well. If seal mechanisms are switched, or the way they face is reversed, then adjusting the headset will become impossible.

- 14. [] Lift adjustable race off top of head tube and look for seal mechanism and remove it (if any). Bundle it with adjustable race now so it does not get confused with lower seal mechanism. Note its orientation here:**

- 15. [] Remove balls (usually in a retainer) from top part of headset and measure them with Park SBC-1 or caliper. Note upper ball-bearing size here: _____**

- 16. [] Look on fork-crown race, or up inside the race pressed into lower end of head tube for seal mechanism and remove it. Note its orientation here: _____**

- 17. [] Remove balls (usually in a retainer) from bottom part of headset and measure them with Park SBC-1 or caliper. Note lower ball-bearing size here: _____**

CLEANING THE PARTS

- 18. [] Clean head-tube races with solvent.**

- 19. [] Clean adjustable race with solvent.**

- 20. [] Clean fork threads with solvent.**

- 21. [] Clean balls bearings with solvent only if re-using them. (Re-using bearings *not* recommended.)**

INSPECTION

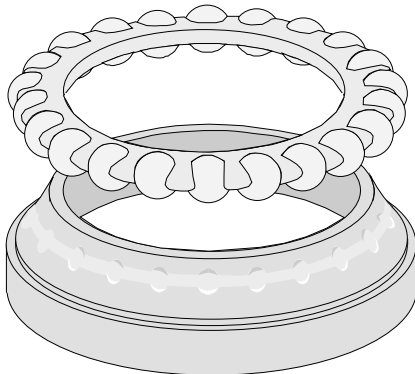
When headsets wear out, the surfaces on which the balls roll develop dents (smooth craters in the metal) called brinelling. Once this occurs, a proper adjustment cannot be made. In some cases there will be galling (rough craters in the metal where the balls roll). The design of the headset is such that the lower pair of races tends to wear out first. Although it is sometimes possible to get individual replacement parts; more often than not, only complete headsets are available. It is not

advisable to mix parts from different headsets in one stack. In any case, if any parts are heavily worn, it is a good idea to replace them all. The dents or pits may show up clearly to the naked eye, but the ultimate test to determine whether there are pits is to trace the wear path the bearings have left on the cup or the cone with the tip of a ball point pen. If the tip of the pen catches anywhere, it is a pit or dent.

Severely over-tightened headsets or badly abused headsets may fail by the lower cup cracking. The cracks will show up on the top of the lower cup, usually in a radial pattern. Another problem found with headsets is that the pressed parts may be loose. This can be due to poor original tolerances, or by an enlargement of the head tube as a result of abusive riding.

Thread damage may also occur on the fork. This will primarily be where a lock washer has been forced to rotate. Occasionally the threads may be stripped at the engagement with the locknut or the adjustable race.

Do not inspect the ball bearings for wear. Significant wear on bearings is not necessarily detectable with the naked eye or by feel. It is recommended to always replace the bearings if going to the trouble to overhaul the headset.



11.8 *Dents in these races are called brinelling and are cause to replace the headset. Note that the positions of the dents correspond to the spacing between the ball bearings created by the retainer.*

22. [] Inspect cup races and cone races for dents from brinelling or galling (pits).

23. [] Inspect lower cup for cracking.

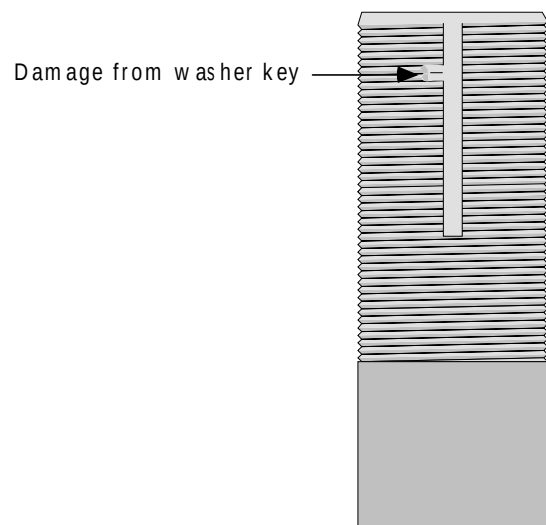
24. [] Inspect pressed races in head tube and on fork crown for looseness by trying to jiggle or twist them. They should be immobile.

25. [] Inspect for damaged fork-column threads or bent fork column (evidence is a bow along the length of the column, any bulges in the column, and any groove worn into the column, particularly about 1–2" above base).

Headsets often have keyed washers between the locknut or lockring and the adjustable race. The key on the washer is not only unnecessary and likely to

damage fork threads, it may even interfere with securing the position of the adjustable race. This type of interference happens when the adjustable race is held stationary and the locknut is torqued down to the adjustable race. The keyed washer tends to rotate and jam its key into the fork threads. When this happens the washer is no longer capable of transferring force down to the adjustable race since it is stuck against the fork threads. The end result is a locknut that is tight but an adjustable race that is not.

This could be prevented by turning the adjustable race up in addition to turning the locknut/lock washer down, but this turns the adjustment process into a trial-and-error fiasco.



11.9 *Fork threads damaged from rotated lock washer.*

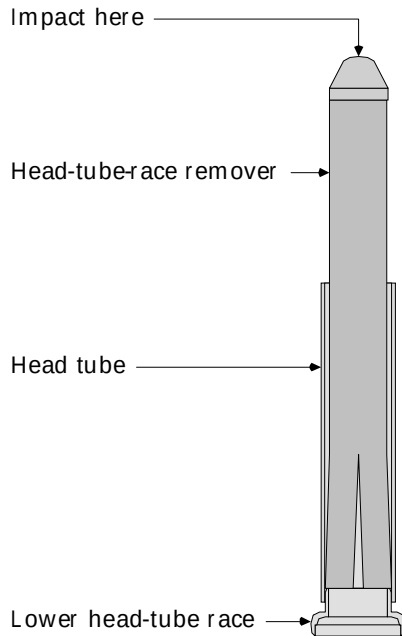
26. [] Inspect keys on inside of lock washers and brackets, and replace washers or brackets if keys are damaged. (It is optional and recommend to replace keyed washers or file out keys on washers.)

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REPLACEMENT OR INSTALLATION

NOTE: If not replacing or installing a headset, skip ahead to step 49.

Removal of pressed races



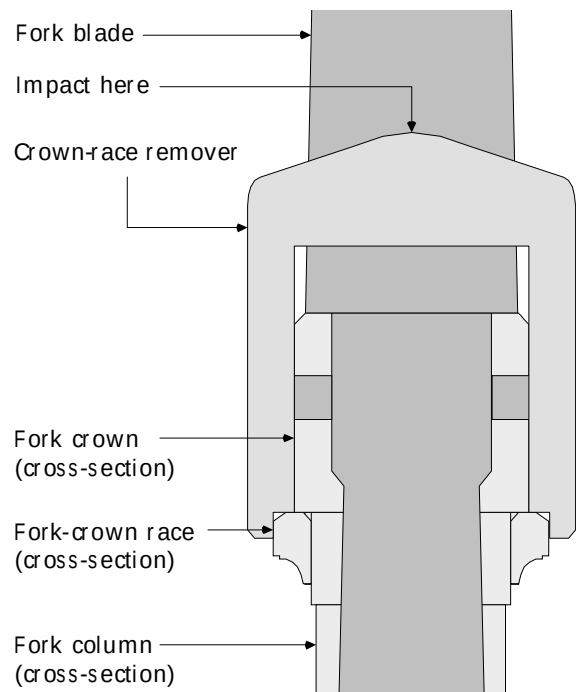
11.10 Removing the lower head-tube race.

27. [] Remove head-tube races.

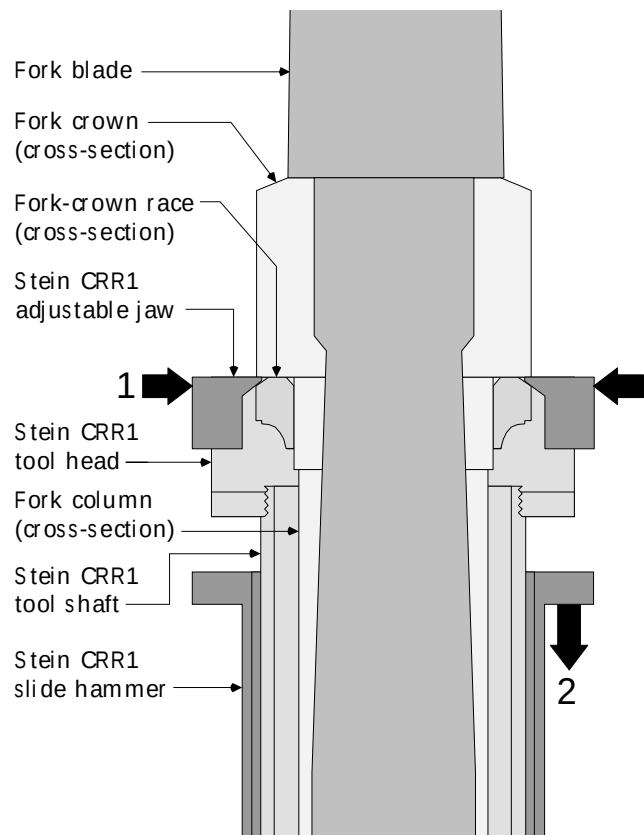
The fork-crown race can be very awkward to remove. There are several styles of tools and techniques.

The traditional tool design looks like an upside-down U or a horseshoe. The tool straddles the fork crown from below and the ends of the tool catch on any of the fork-crown race that extends beyond the profile of the fork crown (see figure 11.11). Fat fork crowns or deep-profile fork crowns both interfere with this type of tool, and it is virtually certain that this tool will be of no use on a typical suspension fork. In addition, many sizes and varieties of this tool are required to fit different sizes and brands of races.

Stein makes a completely different crown-race remover (CRR1) that has two wedge-like jaws that come together from the sides to catch under the edge of the fork-crown race. A hollow shaft that fits over the fork column is joined to these jaws. A slide hammer slides down the shaft to provide the impact that removes the race. The jaws can be pressed together in a vise to wedge the race up slightly to get better engagement of the jaws before using the slide hammer. This design is the most universal yet, with minimal chance of damaging the race or fork crown.



11.11 A traditional crown-race remover in use. This type of tool has very limited usefulness.



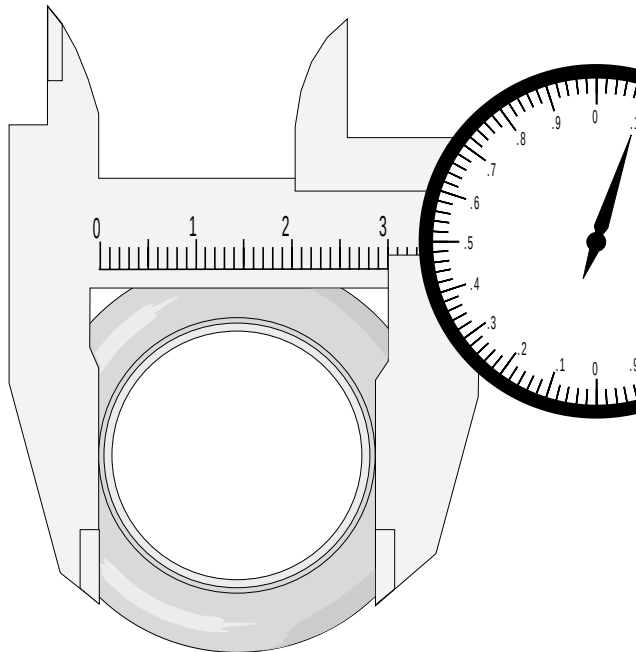
11.12 To use the Stein CRR1 crown-race-removal tool, (1) squeeze the adjustable jaws in until they catch between the crown race and the fork crown (squeeze in vise if necessary), then (2) vigorously accelerate the Stein CRR1 slide hammer down to drive the fork-crown race off.

Traditionally mechanics have used a punch and hammer on the bottom face of the fork-crown race to drive it off, but certain types of races are marred or damaged with this technique and it is completely in-applicable to most suspension forks. The Stein CCR1 makes this technique virtually obsolete.

28. [] Remove fork-crown race.

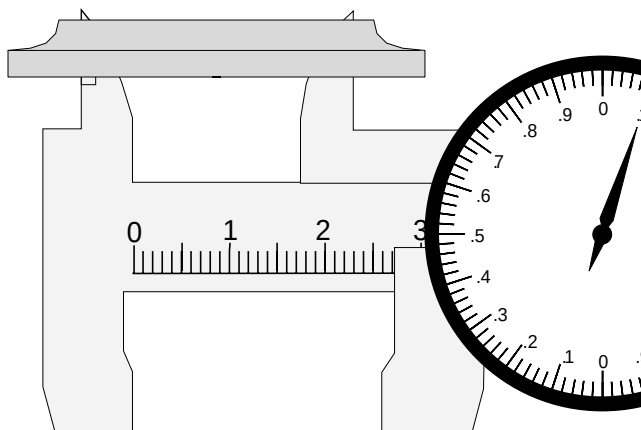
Verification of fit

When replacing parts and the old parts are at hand, measure fork-thread diameter and pitch. Measure the head-tube-race O.D. and the fork-crown-race I.D. Check **HEADSET-FIT FACTORS** (table 11-2, page 11-8) to help determine the headset type to use or order.



11.13 Measuring the head-tube race.

29. [] Record original head-tube-race O.D. here: _____ mm.



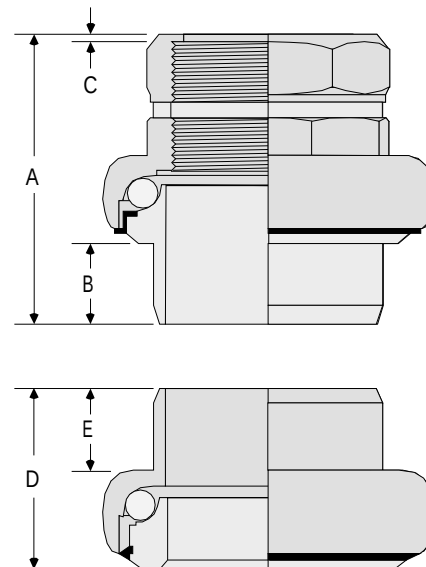
11.14 Measuring the fork-crown race.

30. [] Record original crown-race I.D. here: _____ mm.

31. [] Record original thread description here: _____

Stack height is an important consideration, if not replacing a headset with an identical model. If the new headset has a greater stack height than the old one, then there will not be enough room to install the lock-nut. Shorter is acceptable because washers can be added to the new headset to make it taller. Rather than measuring the old headset, determine the maximum allowable stack height by measuring the length of the head tube and the length of the fork column and subtracting the difference. This number is the maximum stack height for the replacement headset.

To measure stack height of a headset, start by stacking up the parts of the lower half of the headset (including bearings). Measure the total height of the stack, then subtract the length of the cylinder on the pressed race that inserts inside the head tube. Assemble the complete upper stack including washers and locknut(s), measure the total height, subtract the length of the cylinder on the pressed race that inserts inside the head tube, and subtract the thickness of the lip of the locknut that sits on top of the fork column. The stack height of the headset is the upper and lower stack added together. If this number is greater than the difference between the head-tube length and the fork-column length, the headset will not fit.



11.15 Measure A, B, C, D, and E. $(A-B-C)+(D-E)$ = stack height.

32. [] Measure total length of fork column in millimeters with metric tape measure and record here: _____

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33. [] Measure head-tube length in millimeters with metric tape measure and record here:

34. [] Subtract step 33 from step 32 and record difference here: _____ mm. This is maximum stack height.

35. [] Replace headset with one of compatible thread size, press fits, and stack height.

In the next few steps, verify that the press-fit dimensions for the new headset are a good fit, or whether Loctite is needed to make the fit ideal. The process involves measuring the inside diameter of the head tube and the outside diameter of the head races to determine the diameter difference. The head-tube I.D. should be smaller than the race O.D., so that there will be interface when the race is pressed in to the head tube. When subtracting race O.D. from head-tube I.D., a negative answer indicates that there will be interference. The ideal answer range is -2mm to $-.3\text{mm}$. Based on the diameter difference calculated in step #38, choose an option: install as is, augment fit with Loctite, machine the head tube to improve the fit, or get a better fitting headset.

These measurements require an accuracy of $.05\text{mm}$. Measurements of this accuracy not only require a high quality caliper, the method in which the caliper is used is critical. If not 100% confident in the measurements, pay close attention to what happens when attempting to install the parts. If they slip together with little or no effort, it indicates the press fit is marginally loose. Loctite will be needed. If the parts are extremely difficult to press together, the tolerance difference is too great. In this case, either a different headset is needed or some machine work is needed on the fork and/or head tube.

In steps #36 through #38, measurements are taken and a calculation is made to determine the dimensional difference between the head-tube-race O.D. and the head-tube I.D. In step #39, a course of action is chosen, based on the dimensional difference determined in step #38. Consider the following examples.

Example 1:

head-tube I.D.: 30.1mm

race O.D.: 30.0mm .

$$30.1 - 30.0 = .1 (>.0\text{mm})$$

A different headset is needed because the positive $.1\text{mm}$ difference indicates that there will be no interference between the race and head tube.

Example 2:

head-tube I.D.: 30.1mm

race O.D.: 30.2mm .

$$30.1 - 30.2 = -.1$$

The negative difference indicates that there will be some interference to the fit, but it is not enough, so Loctite 680 should be used to improve the fit.

Example 3:

head-tube I.D.: 30.0mm

race O.D.: 30.25mm .

$$30.0 - 30.25 = -.25$$

The negative $.25\text{mm}$ difference is inside the acceptable difference range ($-.2$ to $-.3\text{mm}$), so the part can be installed as is.

Example 4:

head-tube I.D.: 29.9mm

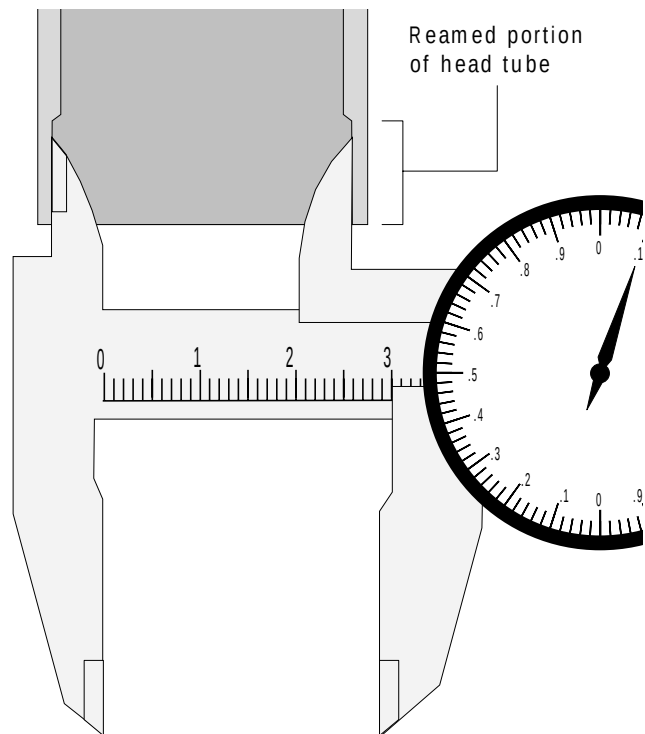
race O.D.: 30.25mm .

$$29.9 - 30.25 = -.35$$

The negative $.35\text{mm}$ difference is outside the acceptable difference range ($-.2$ to $-.3\text{mm}$), so the part can be installed only once the head tube is reamed to improve the fit.

36. [] Measure I.D. of head tube in two or more places and average result. Record here:

$$\underline{\hspace{1cm}} + \underline{\hspace{1cm}} = \underline{\hspace{1cm}} \div 2 = \underline{\hspace{1cm}} \text{ mm.}$$



11.16 Use the caliper jaws to measure inside diameter and make sure that the tips of the jaws are not inserted beyond the reamed portion of the head tube.

37. [] Measure O.D. of new races to be pressed into head tube and record here:
_____mm.

38. [] Subtract step 37 from step 36 and record answer here: _____mm.

39. If step 38 is (check one):

- ☐ **>.0mm, find different headset.**
- ☐ **.0 to -.19mm, install race w/Loctite RC680.**
- ☐ **-.20 to -.30mm, install headset as is.**
- ☐ **<-.30mm, ream head tube (not always possible) or get new headset.**

In the next few steps, verify that the press-fit dimensions for the new headset are a good, or whether Loctite is needed to make the fit ideal. The process involves measuring the inside diameter of the fork-crown race and the outside diameter of the fork-column base to determine the diameter difference. The crown-race I.D. should be smaller than the fork-column-base O.D., so that there will be interface when the race is pressed on to the fork. When subtracting fork-column-base O.D. from race I.D., a negative answer indicates that there will be interference. The ideal answer range is $-.1\text{mm}$ to $-.2\text{mm}$. Based on the diameter difference calculated in step #42, choose an option: install as is, augment fit with Loctite, machine the fork-column base to improve the fit, or get a better fitting headset.

In steps #40 through #42, measurements are taken and a calculation is made to determine the dimensional difference between the crown-race I.D. and the fork-column-base O.D. In step #43, a course of action is chosen, based on the dimensional difference determined in step #42. Consider the following examples.

Example 1:

crown-race I.D.: 27.1mm.
fork-column-base O.D.: 27.0mm
 $27.1 - 27.0 = .1 (>.0\text{mm})$
A different headset is needed because the .1mm difference indicates that there will be no interference between the race and fork.

Example 2:

crown-race I.D.: 27.0mm.
fork-column-base O.D.: 27.05mm
 $27.0 - 27.05 = -.05$
The negative difference indicates that there will be some interference to the fit, but it is not enough, so Loctite 680 should be used to improve the fit.

Example 3:

crown-race I.D.: 27.0mm.
fork-column-base O.D.: 27.15mm
 $27.0 - 27.15 = -.15$
The negative .15mm difference is inside the acceptable difference range ($-.1$ to $-.2\text{mm}$), so the part can be installed as is.

Example 4:

crown-race I.D.: 27.0mm.
fork-column-base O.D.: 27.25mm
 $27.0 - 27.25 = -.25$
The negative .25mm difference is outside the acceptable difference range ($-.1$ to $-.2\text{mm}$), so the part can be installed only once the fork-column base is counter-reamed to improve the fit.

40. [] Measure I.D. of fork-crown race and record here: _____mm.

41. [] Measure O.D. of fork-column base and record here: _____mm.

42. [] Subtract step 41 from step 40 and record answer here: _____mm.

In the first option of step #43, it indicates that if the result of the calculation is greater than .0mm, a different-sized headset must be used. There is one additional option that can be very effective if the result in step #42 is between .0 and .2mm. A Stein KT knurling tool can be used to increase the effective diameter of the fork-column base by up to .2mm. Use Loctite RC680 in addition to knurling.

This knurling technique has the same effect as an old mechanic's trick called "staking." To stake a fork-column base a chisel would be used to make indentations at multiple points around the fork-column base. Both the knurling tool and the staking technique cause some metal to rise up by forcing other metal to be indented. The knurling tool does a more thorough and consistent job without any risk of mis-striking with the chisel when performing the staking technique. The knurling tool serves triple use, enlarging handle-bar centers and seat posts as well.

To use the knurling tool, the tool is put in the vise jaws and the fork column is inserted inside the knurling tool. Close the vise just enough to cause the toothed wheels of the knurling tool to indent the fork-column base, then rotate the fork around several times. If the knurling pattern is not very pronounced, repeat the process with the vise closed tighter.

43. If step 42 is (check one):

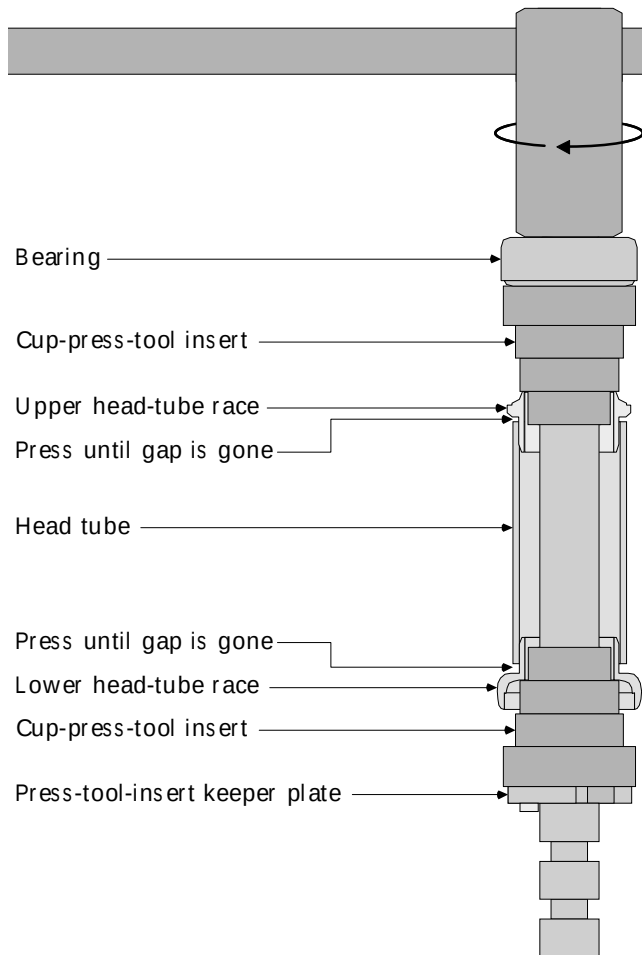
- ☐ **>.0mm, find different headset.**
- ☐ **.0 to -.09mm, install race w/Loctite RC680.**
- ☐ **-.10 to -.20mm, install headset as is.**
- ☐ **<-.20mm, mill fork crown (not always possible) or get better-fitting headset.**

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Installation of pressed races

44. [] Clean with alcohol or acetone all three pressed race mating surfaces: plus outside of fork-crown-race seat, and inside of head tube. Prepare same surfaces with Loctite 242 to prevent corrosion (optional) or Loctite RC680 to improve poor fit (if necessary).

When pressing in the head-tube races, they must be pressed on fully. There is no specific force required, but there will be a distinct “bottomed-out” feeling when they are in fully.

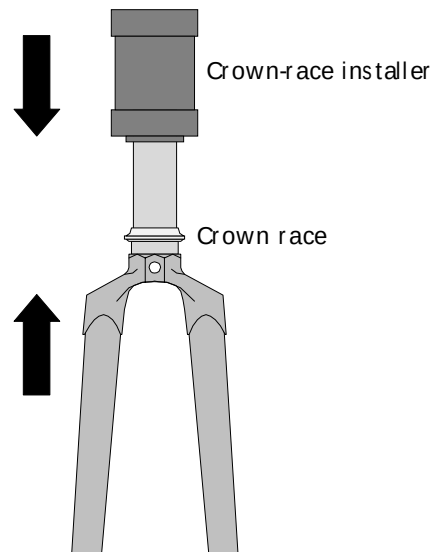


11.17 *Installing the races into the head tube with a Hozan C438.*

45. [] Insert larger race into bottom of head tube and smaller one into top of head tube and press in fully with press. If aluminum races appear to be developing shavings as they press in, remove shavings before completing installation.
46. [] Inspect head-tube races to confirm they appear pressed in fully.

To use a slide hammer to install a fork-crown race, simply place the race on the fork-column base and accelerate the slide hammer down the fork column against the race. *Do not support the fork on its dropouts*

while doing this! Simply hold the fork in mid-air with one hand while accelerating the slide hammer with the other hand.



11.18 *With the crown race sitting on top of the crown-race seat, rapidly accelerate the fork and the crown-race installer towards each other.*

47. [] Press crown race onto fork.
48. [] Inspect that crown race appears fully seated.

Replacing ball bearings

The original ball bearings are usually in a retainer (a clip that holds the balls together in a set). Although there are no mechanical advantages to using retainers, there are several disadvantages. Installing loose balls is always recommended. If installing loose balls, try to find the highest quality ones available. Good balls are described as *grade 25*. Decent ball bearings might be described in the range of *grade 100* to *grade 200*. Any higher number than these is a mediocre bearing.

Balls in a retainer are more expensive to buy in a high grade, and grade information is rarely available for balls in a retainer. Retainers create a fixed relationship between the balls, which is one of the causes of brinelling, the primary cause of headset failure.

Important information if installing ball retainers

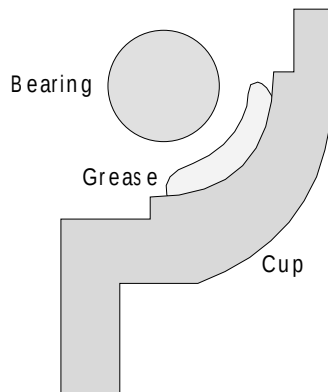
Forget any rules of thumb about which way ball retainers face in relation to the cups and cones, or relative to the ground. There is only one way to get ball retainers in correctly and that is to test-mate them both ways to the cone and both ways to the cup. In one of the four combinations, the clip that holds the balls together (instead of the balls) will be obviously con-

tacting the ball race on the cone or the cup. Install the retainers opposite this. If good measurements of the exposed thread were taken once the locknut was removed, and original retainers were in correctly, and the original or an identical headset has been installed, putting a retainer in backwards will reduce the exposed thread by more than a millimeter.

ASSEMBLY

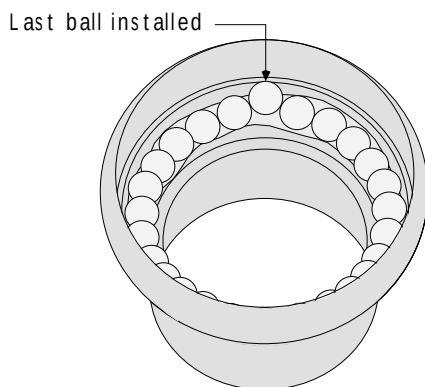
Getting a headset assembled with loose balls can be tricky. Follow these steps carefully and there will be a good chance of success.

49. [] Replace ball bearings (check steps 15 & 17 for sizes).



11.19 Put a light layer of grease in each cup. The thickness of the layer of grease should be less than 1/2 the diameter of the ball bearing.

50. [] Lightly coat cup race with grease. One millimeter thickness of grease should be more than enough. The upper cup could be an adjustable race or upper head-tube race.

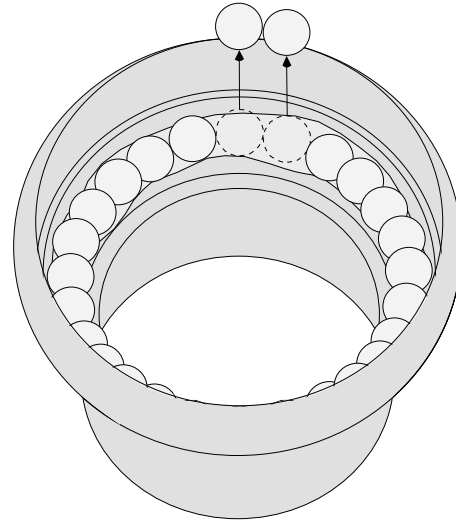


11.20 Place the balls in the cup so that they touch each other. If a gap remains that is too small for a ball, put one more in anyway.

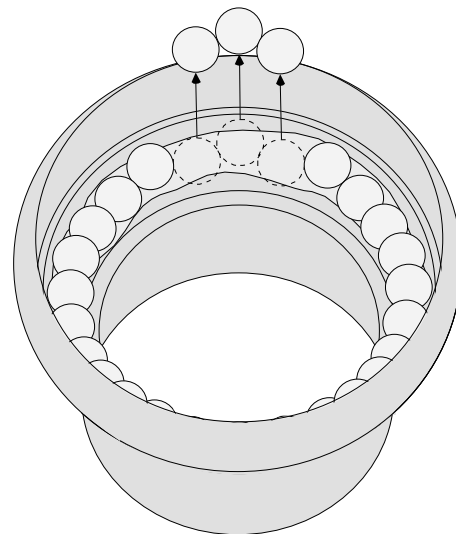
51. [] Fill cup with balls and make sure they are all touching each other.

52. [] Test mate upper cup to upper cone, separate, and inspect balls.

In the next step, some balls will be removed. The reason this is done is to prevent headset failure from brinelling. By leaving the balls room to move around relative each other it guarantees that any brinelling that occurs is in random locations. When ball retainers are used or the cup is left full, the brinelling occurs in the same places over and over again until it reaches a noticeable depth and causes headset failure.



11.21 If the balls are not jumbled after test-mating the parts, remove two balls.



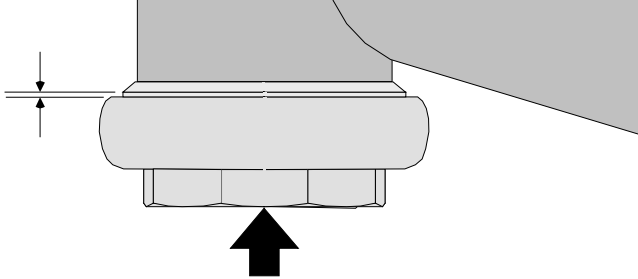
11.22 If the balls remain jumbled after test-mating the parts, remove three balls.

53. [] Remove two balls from cup if they sit level, three balls if jumbled.

In the next step, re-mate the cup and cone back together. The function of this step is to observe the depth of the cone in the cup. This way, if the balls get

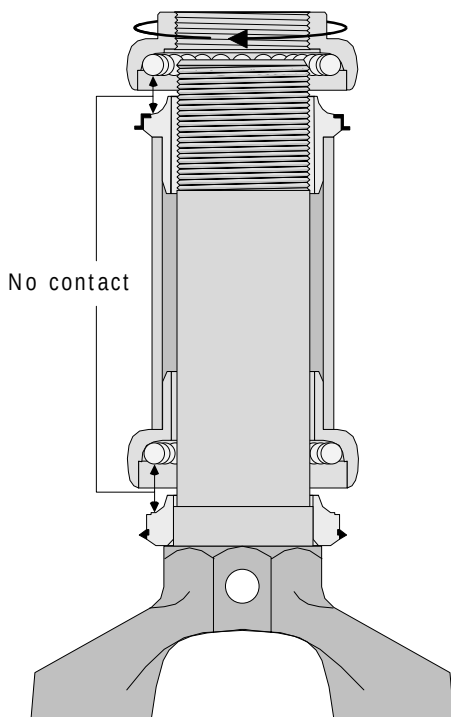
11 – HEADSETS

jumbled during assembly, it will show up as a cone not inserting as far into the cup; take the headset apart and reassemble it before going to the trouble of adjusting it. Also, this same observation was made before disassembly. If the relation between these parts has changed, it probably means the ball size has changed.



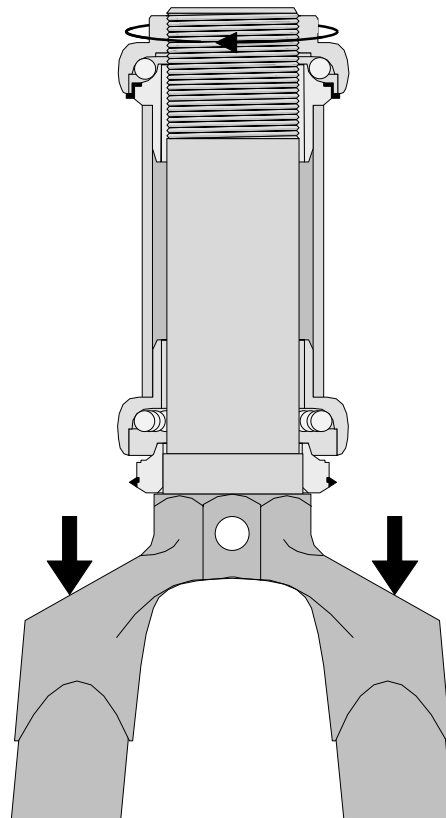
11.23 *Mate the cone and cup together again to seat the balls in place, then check the depth of the cone in the cup. When the headset is finally assembled, the cone should be in the same position relative to the cup, or ball bearings are out of place.*

- 54. []** Test-mate cone and cup again to seat balls and inspect depth of each cone in each cup.
- 55. []** Coat balls lightly with grease.
- 56. []** Insert seal (if any) into cup or onto cone.
- 57. []** Repeat steps 50–56 for lower cone and cup.
- 58. []** Grease fork threads and fork column fully.



11.24 *Engage the adjustable race to the top of the fork, while maintaining no contact between the balls and the cones.*

- 59. []** Assemble fork into head tube and adjustable race onto fork. (*Cones should not insert fully into cups at this point.*)



11.25 *With the upper race seated and with a downward pressure on the fork, turn the adjustable race clockwise to draw the fork up into place.*

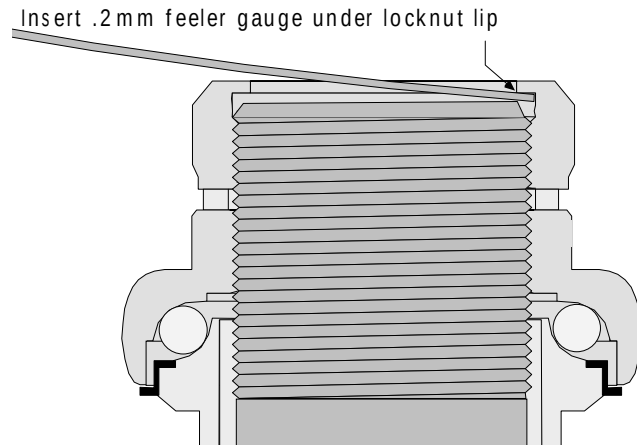
- 60. []** Drop fork down and thread race fully on to draw fork up fully.
- 61. []** Inspect if positions of cones in cups appear similar to how the cone positions appeared when checked in step 54, then check for smooth rotation of fork.
- 62. []** Install washers, lockring (if any), and brackets (if any).

If ball size has increased, a retainer has been inverted, or the balls are jumbled and out of position, it will show up as a reduced amount of thread available for the top locknut. If the ball size has been reduced, or washers or brackets have been left out, it will show up as an increased amount of thread available for the top locknut. In the next step, measure the result and compare it to the measurement taken during disassembly.

- 63. []** Measure exposed thread and verify it matches pre-disassembly dimension (step 9). If installing a new headset check that at least 4.5mm of thread is available for locknut.

If changing the number or washers, whether a bracket is used, or the entire headset, verify that there is not too much thread for the locknut. If there is,

the lip on the top of the locknut will stop against the top of the fork column before securing against the adjustable race.



11.26 Use a thin feeler gauge between the locknut lip and the top of the fork column to verify that the lip is not stopping against the fork column.

64. [] Thread on, but do not secure, locknut. Verify lip does not bottom on top of steering tube.

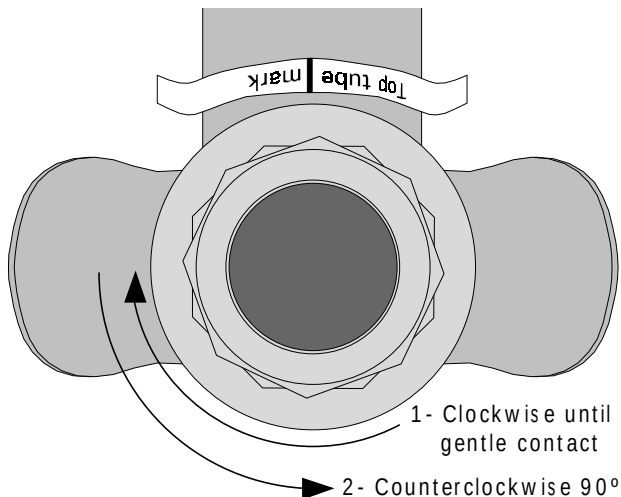
ADJUSTMENT

65. [] If headset has not just been overhauled, break loose locknut and turn adjustable race 1/4 turn (counterclockwise).

66. [] Gently thread race down to contact balls.

67. [] Install wheel if not already installed.

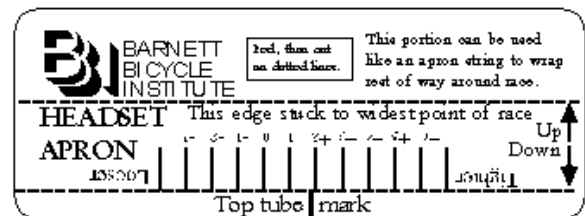
68. [] Hold fork stationary and turn race 90° counterclockwise.



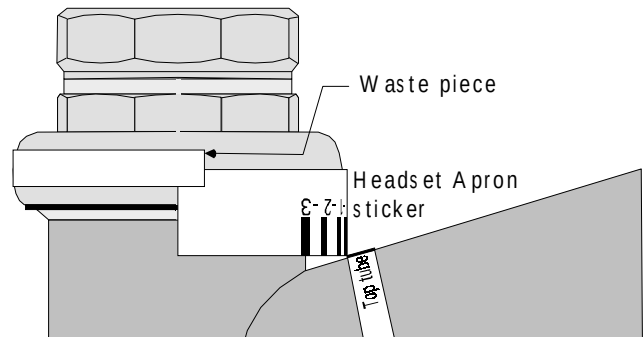
11.27 Turn the adjustable race clockwise until it gently contacts the ball bearings, then turn it at least 90° counterclockwise. Placement of the top tube mark sticker (step #69) is also illustrated.

The following adjustment procedure is very different from the way most mechanics adjust headsets. The procedure uses an adjustment-calibration sticker (a BBI product), but a piece of masking tape that you mark yourself can be used as an alternative to the sticker. This approach (with sticker or tape) may seem awkward at first, but students at BBI that were very experienced with headset adjustment prior to arriving at BBI, endorse this approach wholeheartedly.

69. [] Put sticker with top tube mark (or marked masking tape) on top tube, with mark close to adjustable race and centered on top of top tube (see figure 11.27).



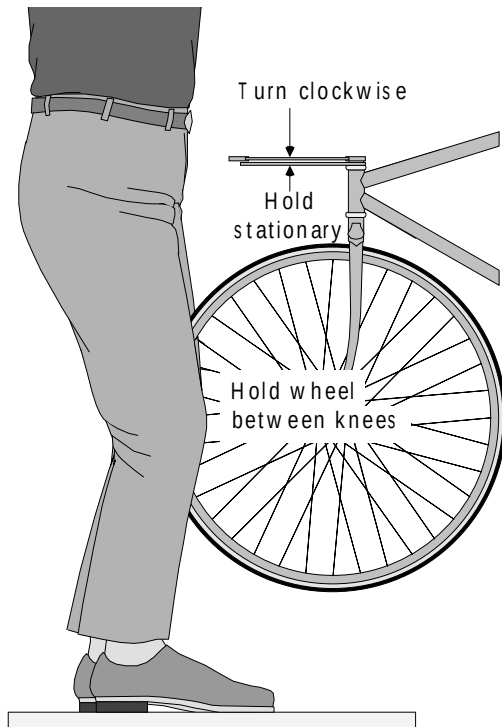
11.28 This is the BBI Headset Apron sticker that is recommended for precise and easy headset adjustment.



11.29 Install the Headset Apron sticker. Note that the Headset Apron Sticker is installed with the numbers upside down and the edge as close to the Top Tube Sticker as possible.

70. [] Hold fork square to frame and put BBI Headset Apron sticker on adjustable race so that it hangs down like an apron and "0" mark lines up with top tube mark. (When sticker is on correctly, calibration lines are on bottom edge and numbers are upside down at top edge of sticker.) If not using Headset Tape sticker, just put matching marks on top tube and masking tape on adjustable race.

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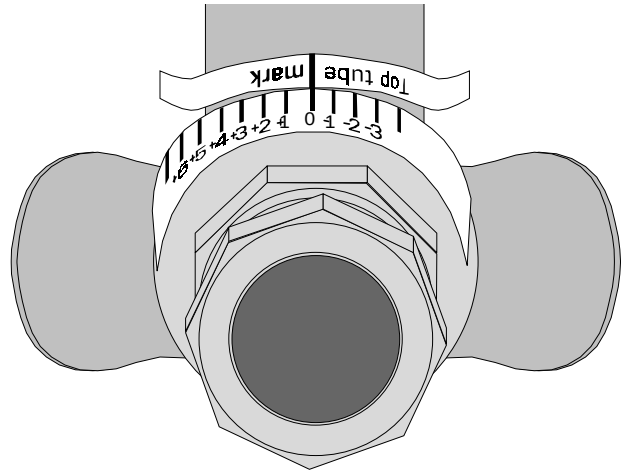


11.30 *Stabilizing the fork while securing the adjustment.*

- 71. [] Stabilize fork with wheel (or Stein FS) between knees, hold race stationary, and secure locknut to 300in-lbs (38lbs@8").**

In step #72, bearing play is checked by jerking on the bottom ends of the fork blades. With non-suspension forks, this method is preferred because it provides the greatest leverage. With suspension forks, it is necessary to jerk on the fork crown or the stanchion (upper) tubes, instead. This is because play between the sliders (lower tubes) and stanchions can be misinterpreted as play in the headset adjustment.

- 72. [] Check for play by grasping both fork blades (or Stein FS clamp) in one hand and bottom of down tube in other hand, then jerking fork forward and back. Rotate fork to several positions and check further for play. If there is no play, check for smooth rotation. If not smooth, restart at step 67, but start with race turned further counterclockwise.**



- 11.31** *With fork square to frame, turn the race clockwise to the next "+" mark to tighten the adjustment, or counterclockwise to the next "-" mark to loosen the adjustment.*

- 73. [] If using Headset Apron Sticker: tighten adjustment by putting the next "+" mark on sticker at top tube mark with wheel lined up with down tube. (If headset had no play, but was smooth, loosen adjustment to next "-" mark instead.)**

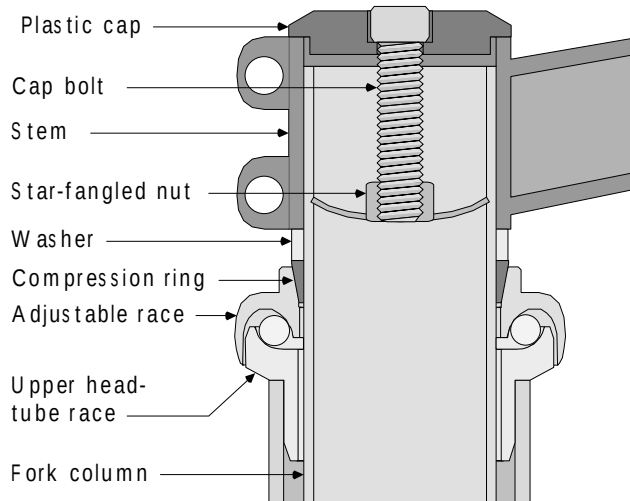
If not using sticker: put new mark 2–3mm counterclockwise from last mark and adjust new mark to line up with top tube mark to tighten adjustment.

- 74. [] Secure locknut to minimum 300in-lbs (38lbs@8").**

- 75. [] Check for play and repeat adjustment as necessary, securing locknut each time before checking for play. (If headset originally had no play, repeat loosening adjustment until play is found, then return to last "no play" adjustment.)**

THREADLESS-HEADSET SYSTEMS

NOTE: If replacing a conventional fork and headset with threadless fork and headset, skip to step 7.



11.32 Cross-section of the top half of a threadless headset installed.

REMOVAL

1. [] Remove wheel from fork.
2. [] Remove brake calipers from fork, or remove cable from brake calipers.
3. [] Remove cap bolt and plastic cap at top of fork column just above stem.
4. [] Loosen stem-binder bolt(s) and remove stem from fork column. (Be prepared for fork to drop out.)
5. [] Slide fork out bottom. (Note adjustable race, compression ring, and spacer washers will be left balanced on top of headset.)
6. [] Do steps 14–24 from *THREADED-HEADSET OVERHAUL, AND ADJUSTMENT PROCEDURE* (page 11-10).

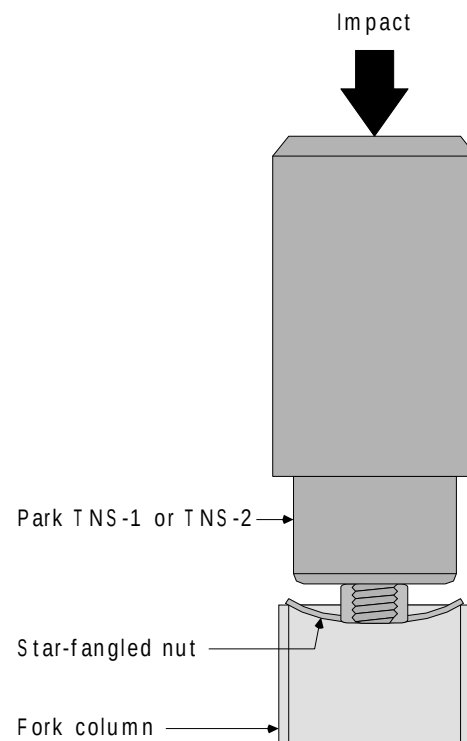
NOTE: If overhauling an existing threadless headset, skip steps 7–12.

CONVERSION TO THREADLESS SYSTEM

A threadless headset installs into the head tube and onto the fork crown just like a normal headset. The difference comes with the installation of the adjustable race. In fact, it is no longer threaded but slips onto the fork column, and is trapped in place by a

special stem that clamps on the outside of the fork column. So, assuming all three pressed races are installed and it is time to slip on the adjustable race, proceed with step #7.

7. [] Do steps 1–31 (page 11-9), then steps 36–48 (page 11-14) from *THREADED-HEADSET OVERHAUL, AND ADJUSTMENT PROCEDURE*.
8. [] Grease stem bolt threads and threads on bolt that goes through cap that mounts on top of fork column.
9. [] Install ball retainers in cups. Slide adjustable race, split cone called “compression ring”, spacer washers, and stem onto fork.
10. [] Mark fork column 3mm below top of stem and remove fork.
11. [] Cut fork column at this point with a hack-saw or tubing cutter. File off any burrs or swells.
12. [] Press star-shaped nut called “the star fangled nut” fully into fork column with Park TNS-1 or TNS-2.



11.33 Installing the “star-fangled nut.”

ASSEMBLY

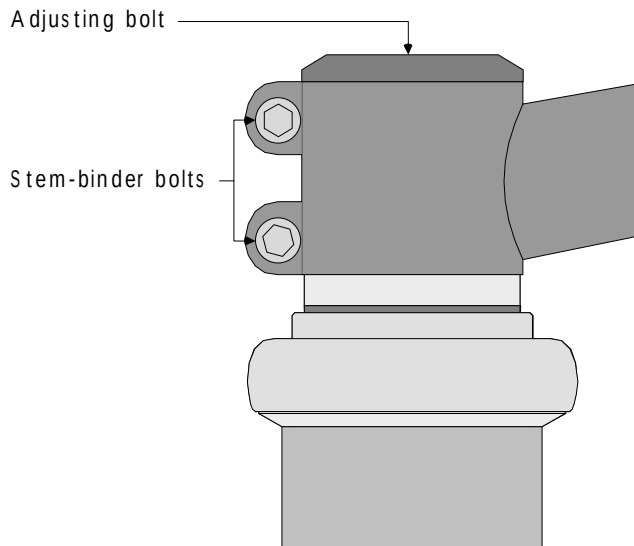
13. [] Do steps 50–57 from *THREADED-HEADSET OVERHAUL, AND ADJUSTMENT PROCEDURE* (page 11-17).
14. [] Put fork in and slide on adjustable race, compression ring, washers, and stem.

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15. [] Put plastic cap with bolt on top of fork column and engage bolt in star-fangled nut threads.

Adjustment

NOTE: If adjusting an already installed threadless headset, loosen the stem-binder bolts before starting the adjustment.

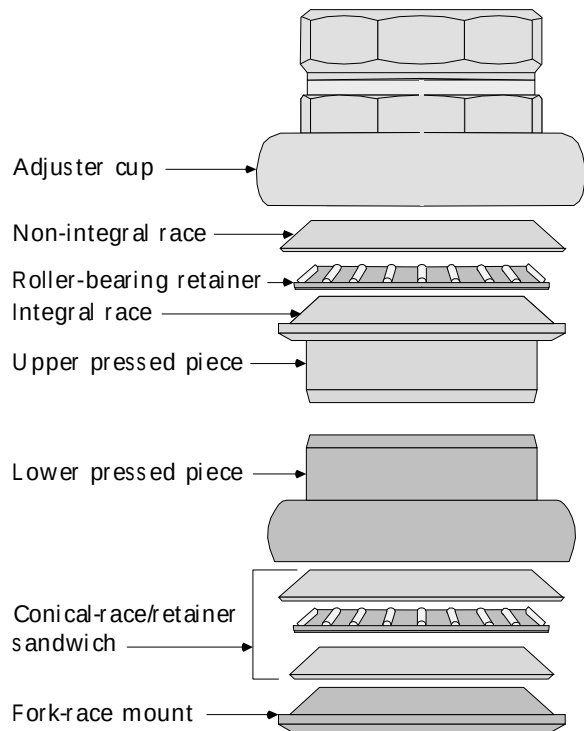


11.34 Loosen stem bolts before starting the adjustment.

16. [] Tighten cap bolt slowly until just a trace of knocking can be felt when jerking on end of fork.
17. [] Align stem and torque bolts to 85in-lbs (24lbs@3" or 21lbs@4") if double-bolt stem, or 100in-lbs (33lbs@3" or 25lbs@4") if single-bolt stem.
18. [] Check again for knocking when jerking on fork. If knocking is not felt, adjustment is done. If knocking is felt, proceed to next step.
19. [] Loosen stem bolts until stem rotates about fork column easily.
20. [] Turn adjusting bolt in plastic cap approximately 1/6 turn (clockwise).
21. [] Align stem and torque bolts to 85in-lbs (24lbs@3" or 21lbs@4") if double-bolt stem, or 100in-lbs (33lbs@3" or 25lbs@4") if single-bolt stem.
22. [] Check again for knocking when jerking on fork. If knocking is not felt, adjustment is done. If knocking is felt, repeat steps 19–22 as many times as necessary.

ROLLER-BEARING HEADSETS

Roller-bearing headsets use cylindrical bearings instead of ball bearings. These cylinders are held in a conical retainer, which is sandwiched between two conical races. The conical races can be machined directly into the pressed cups and cones, or they can be loose and floating.



11.35 A roller-bearing headset.

Assembly

- [] Do steps 1–48 from **THREADED-HEADSET OVERHAUL, AND ADJUSTMENT PROCEDURE** (page 11-9).
- [] If conical races are not integral with pressed pieces, grease both sides of each race.
- [] Grease bearing retainers fully.
- [] If conical races are separate, sandwich retainers between pairs of conical races.
- [] Install retainers/retainer sandwiches in cups.
- [] Insert fork into head tube.
- [] Thread on adjuster cup all the way.

ADJUSTMENT

- [] Do steps 62–75 from **THREADED-HEADSET OVERHAUL, AND ADJUSTMENT PROCEDURE** (page 11-18).

MAVIC HEADSETS WITHOUT LOCKNUTS

Most new Mavic headsets have a locking mechanism built into the adjustable cup, instead of a separate locknut. The adjustable cup has a tiny Allen bolt that is tightened to compress the adjustable-cup threads against the fork threads. **Warning**— there are 32mm wrench flats on the adjustable cup that can easily be rounded off if a wrench is used to turn the cup *without* first loosening the Allen bolt. It is easy to destroy the adjustable-cup threads.

ASSEMBLY OR REPLACEMENT

1. [] Do steps 1–60 from **THREADED-HEADSET OVERHAUL, AND ADJUSTMENT PROCEDURE** (page 11-9), except that no washers or locknuts are removed (unless replacing conventional headset with Mavic).

ADJUSTMENT

2. [] Loosen locking bolt with 2.5mm Allen wrench if not already loose, and turn adjustable cup 1/4 turn (counterclockwise) to prevent over-tightening.
3. [] Adjust adjustable cup (clockwise) gently down against bearings until slight resistance is felt, then back off about 1/8 turn (about 10–15mm at the cup perimeter).
4. [] Use 2.5mm Allen wrench to gently secure locking bolt in cup.
5. [] Grasp the fork and jerk it to check for play.
6. [] To eliminate play loosen locking bolt, turn adjustable cup 3–4mm (clockwise) at its perimeter, then resecure locking bolt. Check for play and repeat as necessary.

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HEADSET-STACK HEIGHT

Headset-stack height is the room that the headset takes up on the fork column. Stack height plus head-tube length should equal fork-column length.

It is acceptable to use a shorter stack height than will fit (washers must be added or fork column shortened), but a headset with too great a stack height cannot be made to fit.

The following table is divided into four sections. These are 1" threaded, 1-1/8" threaded, 1-1/4" threaded, and threadless headsets.

Each section of table 11-3 (pages 11-23 through 11-27) has headsets arranged in ascending order of stack height on the assumption that the desired stack height is known and the suitable brands/models need to be found. This assumption makes the layout of table 11-3 less suitable for situations where the headset is known and the stack height needs to be looked up.

POPULAR HEADSET FITS FOR 1" THREADED-FORK COLUMNS(table 11-3,A)

STACK HEIGHT	BRAND	MODEL	FIT STANDARDS AVAILABLE
30.0mm	Shimano	Dura-Ace (HP-7600)	Campy ¹
31.2mm	Tange-Sekei	MA-60	Campy/JIS ³
32.5mm	Shimano	Sante	Campy ¹
33.0mm	American Classic	Trilock	Campy ¹
33.0mm	Campagnolo	Veloce	Campy ¹
33.0mm	King	Short Stack	Campy ¹
33.0mm	Ritchey	Logic Comp, Pro WCS, Logic Expert	Campy ¹
33.0mm	Shimano	Deore XT (HP-M730, HP-M732)	Campy ¹
33.0mm	Tange-Sekei	Extrude (steel)	Campy ¹
33.4mm	Tange-Sekei	Levin CDS	Campy ¹ , JIS ² , Campy/JIS ³
33.5mm	Shimano	105 (HP-1050)	Campy ¹
33.5mm	Shimano	105SC (HP-1055)	Campy ¹ , JIS ²
33.5mm	Shimano	600 Ultegra (HP-6400)	Campy ¹
33.5mm	Shimano	Deore (HP-MT60), Deore DX (HP-M650, HP-M651)	Campy ¹ , JIS ²
33.5mm	Shimano	Deore XT (HP-M735)	Campy ¹ , JIS ²
33.5mm	Shimano	Exage (HP-M350, HP-A450, HP-M450)	Campy ¹
33.5mm	Tioga	DSL	Campy ¹
33.8mm	Campagnolo	Nuovo Record (track), Gran Sport	Campy ¹
34.0mm	Odyssey	Pro	Campy ¹
34.3mm	Shimano	XTR (HP-M900, HP-M901)	Campy ¹
35.0mm	Specialized	Pro (alloy and steel)	Campy ¹ , JIS ²
35.5mm	Shimano	RX100 (HP-R500)	Campy ¹
35.5mm	Suntour	Superbe Pro	Campy ¹
36.0mm	American Classic	Airlock	Campy ¹
36.0mm	Dia-Compe	Threadhead	Campy ¹
36.0mm	Tange-Sekei	Extrude (alloy)	Campy ¹
36.2mm	Suntour	Superbe Track	Campy ¹
36.3mm	Shimano	Dura-Ace (HP-7400)	Campy ¹
36.5mm	YST	HP-8311	Campy ¹ , JIS ²

¹ Campy means head-tube races are 30.2mm or equivalent and fork-crown race is 26.4mm or equivalent.

² JIS means head-tube races are 30.0mm or equivalent and fork-crown race is 27.0mm or equivalent.

³ Campy/JIS means head-tube races are Campy 30.2mm and fork-crown race is JIS 27.0mm.

(Continued next page)

POPULAR HEADSET FITS FOR 1" THREADED-FORK COLUMNS (table 11-3.A cont.)

[illegible]

¹ Campy means head-tube races are 30.2mm or equivalent and fork-crown race is 26.4mm or equivalent.

² JIS means head-tube races are 30.0mm or equivalent and fork-crown race is 27.0mm or equivalent.

³ Campy/JIS means head-tube races are Campy 30.2mm and fork-crown race is JIS 27.0mm.

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POPULAR HEADSET FITS FOR 1-1/8" OS THREADED-FORK COLUMNS (table 11-3,B)

[illegible]

11 – HEADSETS

POPULAR HEADSET FITS FOR THREADLESS-FORK COLUMNS_(table 11-3,D)

NOTE: The height of the stem must be added to the following stack-height figures when calculating fit.

[illegible]

HEADSET TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>As the headset is turned, there is a constant pattern of the adjustment feeling tight at one point and loose at another.</i>	
Head tube and/or fork crown need facing and are causing the races not to be in line with each other.	Face both always.
Fork column is bent, causing the races not to be in line with each other.	Replace the fork.
Races are not fully seated, causing the races not to be in line with each other.	Inspect, then disassemble headset and repress the races (all three).
SYMPTOM: <i>As the headset is turned, it has one or more positions that it tends to settle at, as though it were indexed. Also, the fork tends to lock in the straight-ahead alignment and will not stay on its own if turned a degree or two to the side. The symptom is sometimes described as automatic pilot. The proper name is brinelling.</i>	
Dents in the races of the lower stack. (Aggravating factors are use of ball retainers and over-tight adjustments.)	Replace the lower stack or entire headset. Use loose balls, two less balls than the maximum, and do not over-tighten the adjustment.
Dents in one portion of the race more than another indicate races have been out of alignment.	Face the head tube and fork crown (shop) and replace the lower stack or complete headset.
SYMPTOM: <i>When adjusting the headset, it changes from having a trace of play to being obviously over-tight with only one ten-degree adjustment.</i>	
Wrong size balls (likely if ball size was assumed or guessed).	Disassemble and try the next likely size.
Inverted retainer(s).	Disassemble, inspect and assemble correctly.
Mismatched brands of parts within one stack.	Replace necessary parts.
Head tube and fork crown need facing, particularly if loose spot is at only one location of rotation.	Face head tube and fork crown.
Dry grease (particularly if headset is old).	Overhaul headset.
SYMPTOM: <i>An erratic symptom of tightness or looseness appears and disappears, particularly when the fork is rotated, or a sound of clicking, popping or snapping accompanies a change from an adjustment that is tight to one that is loose when the fork is turned, but the headset has not been adjusted. Any erratic tightness or looseness.</i>	
Ball(s) out of position in races.	Disassemble, inspect, reassemble.
Too many balls in a cup.	Disassemble, inspect, reassemble.
SYMPTOM: <i>Headset will not hold its adjustment after riding bike.</i>	
Inexpensive, new headset breaking in.	Readjust.
Locknut inadequately secured.	Tighten locknut.
Locknut properly tightened, not remaining secured.	Use Loctite 242 on threads.
Aluminum locknut not remaining secured.	Replace with steel locknut or use Loctite 242 on threads.
Headset pressed races not fully pressed.	Inspect, repress if necessary, and readjust.
SYMPTOM: <i>Headset feels very sluggish, but not rough, when it is rotated and the adjustment is correct.</i>	
O-ring type seal out of position.	Inspect, disassemble and reassemble with seal in place.
Seal mechanism inverted.	Disassemble, inspect and reassemble with seal correctly oriented.
Grease is dry and congealed.	Disassemble, inspect and overhaul.

(Continued next page)

HEADSET TROUBLESHOOTING (Cont.)

Cause	Solution
SYMPTOM: <i>Headset squeaks when rotated.</i>	
Grease is dry.	Overhaul headset.
SYMPTOM: <i>Creaking noises come from the headset area when the bike is being ridden.</i>	
Loose stem.	Secure stem.
Loose handlebars.	Secure handlebars.
Handlebars creaking internally at ferrule.	Ignore or replace handlebars.
Loose pressed races.	Inspect, disassemble, reinstall with Loctite 242 or install a better fitting headset.
Aluminum pressed pieces in aluminum head tube, even if press fit tolerances are correct.	Reinstall with Loctite 222.
SYMPTOM: <i>Looseness cannot be eliminated even by over tightening the adjustment.</i>	
Loose pressed pieces.	Replace with better fitting headset or reinstall with Loctite RC680.
Locknut lip stopping against steering tube instead of stopping against the screwed race.	Inspect and install stack washer under locknut.
SYMPTOM: <i>Headset makes a rumbling sound when riding over bumps.</i>	
Loose adjustment.	Check and readjust.
Loose pressed pieces.	Check and correct.
SYMPTOM: <i>Headset locknut will not secure.</i>	
Stripped fork-column threads.	Remove locknut and inspect. Replace fork if threads are stripped.
Fork column has collapsed at washer key slot.	Visually inspect inside of fork column for deformation, or test-fit stem into fork column.

12 – ADJUSTABLE-CONE HUBS

ABOUT THIS CHAPTER

Adjustable-cone hubs have a threaded axle, loose balls or cones that thread onto the axle, and cups that are fixed inside the hub shell. This includes adjustable-cone front hubs, adjustable-cone rear hubs that accept a thread-on freewheel, and freehubs (rear hubs that have the freewheel integrated into the hub). Shimano Parallax hubs are adjustable-cone hubs that sometimes require a special adjustment procedure, which is covered in a separate section later in this chapter.

There are also cartridge bearing hubs, with cartridge bearings that press into the hub shell. These are covered in a separate chapter, **CARTRIDGE-BEARING HUBS** (page 13-1). This additional chapter covers Suzue sealed hubs, SunTour/Sanshin/Specialized hubs, Bullseye hubs, Ringle hubs, Mavic hubs, and other brands that are similar in design to the listed brands.

GENERAL INFORMATION

TERMINOLOGY

Hub shell: The main structure of the hub. The hub shell includes the housing for the bearings, a hub core, and two hub flanges.

Axle: The shaft that goes through the hub about which the hub turns.

Quick-release axle: A hollow axle, so the quick-release mechanism can be installed through the axle to retain the wheel to the bicycle.

Solid axle: An axle that has axle nuts threaded onto it that retain the wheel to the bicycle.

Cone: A conical-shaped piece of metal that the bearings roll on that is positioned inside the circle of balls. A cone may be a built-in feature on an axle, or it may thread onto an axle.

Cup: A surface that bearings roll on that is positioned outside the circle of balls. A cup is usually a permanent part of the hub shell.

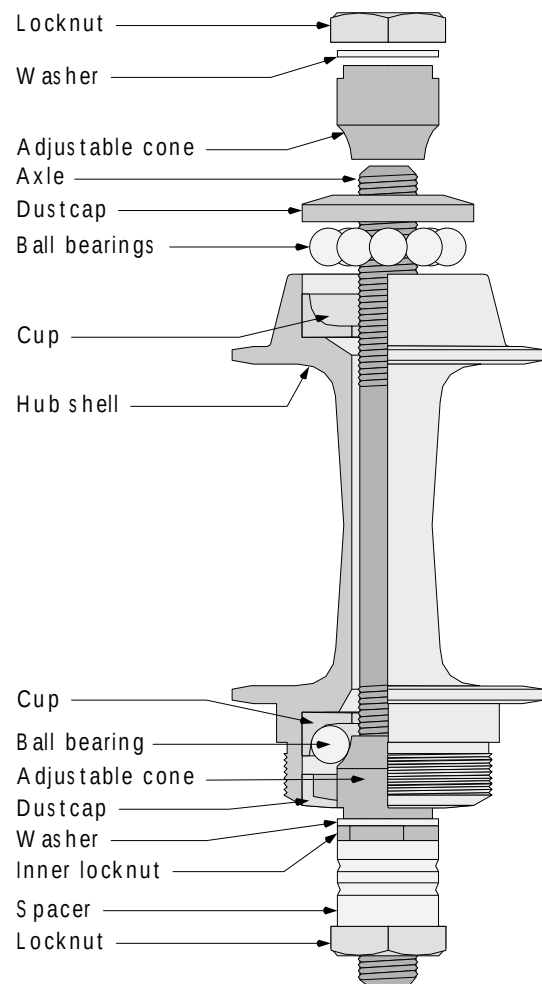
Race: The surface of a cup or cone on which ball bearing rolls.

Locknut: A nut that threads onto an axle and tightens against a cone to lock the position of the cone relative to the axle.

Dustcap: A piece of plastic, metal, or rubber that threads or presses onto the outer end of the hub shell to cover the hole through which the bearings are accessed. In some cases, the dustcap attaches to the cone instead of the hub shell.

Seal: A rubber piece attached to the dustcap, cone, or axle spacer that fills the gap between the axle and dustcap to reduce the entry of dirt.

Freewheel: A set of gears on a freewheeling mechanism that threads onto a rear hub.

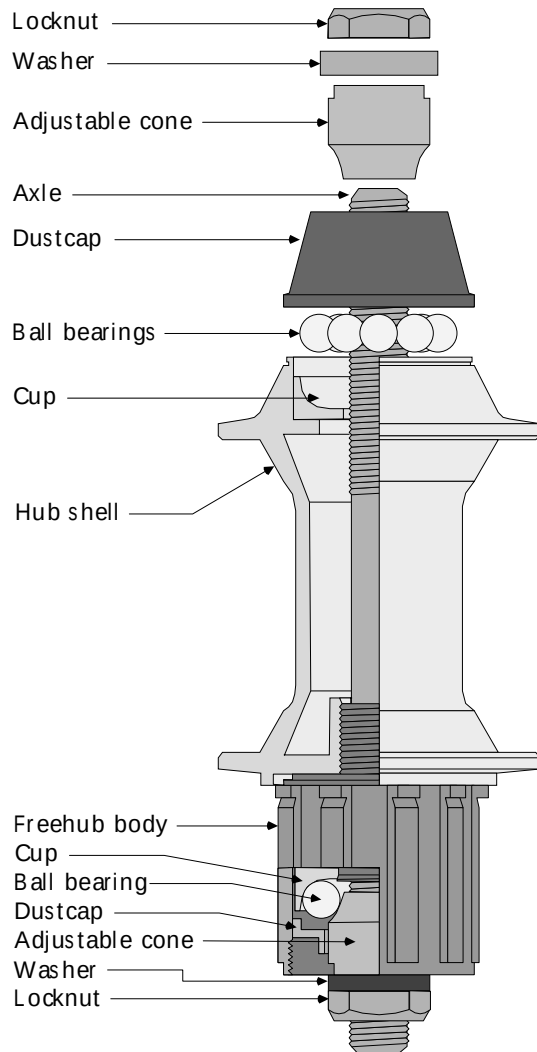


12.1 Adjustable-cone rear hub for thread-on freewheel.

12 – ADJUSTABLE-CONE HUBS

Freehub: A hub that uses the freewheeling mechanism as part of the hub.

Freehub body: The portion of a freehub that is the freewheeling mechanism.



12.2 Adjustable-cone freehub.

PREREQUISITES

Wheel removal and installation

Before overhauling or adjusting a hub, the wheel is removed from the bike. See the **WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION** chapter (page 18-6) if unsure about wheel removal and installation.

Freewheel removal and installation

To overhaul or adjust a rear hub with a thread-on freewheel, the freewheel must be removed. See the **FREE-HUB MECHANISMS AND THREAD-ON FREEWHEELS** chapter (page 25-9) for freewheel removal. If not yet be acquainted with chapter 25, it may be unclear whether the hub has a thread-on freewheel or is a freehub. There are two ways

to determine this. If the hub is a Shimano or Campagnolo model and has a bulge on the hub core just inside the right-side hub flange, it is definitely a freehub. If the hub is a SunTour brand, the hub core will appear fatter than the core of the same front hub. If unsure or mistaken in identifying whether the rear hub is a freehub, it will not be a big problem. If the rear hub is actually a freehub, then when attempting freewheel removal no notches or splined hole in the face of the freewheel will be found to engage the freewheel remover. This chapter is also needed to perform an optional freehub-body removal and installation on a freehub.

INDICATIONS

There are several reasons to overhaul the hub(s), and several reasons to adjust them. An overhaul should be done as part of a regular maintenance cycle, the duration of which will change depending on the type of riding, the amount of riding, and the type of equipment. Adjustments should be done on the basis of need.

Maintenance cycles

If starting out with hub(s) known to be in good condition with good quality grease, they should be able to be ridden thousands of miles without needing an overhaul. If the equipment sees little wet-weather riding, then an appropriate maintenance cycle would be 2000–3000 miles in most cases. If a lot of wet-condition riding is done, then the maintenance cycle might need to be as often as every 750-1000 miles. Parts rust whether being ridden or not, so another factor is how long the bike may be sitting before it will be used again. For example, if ridden 200 miles in the rain in the fall then put away for four months of winter, it would probably be a good idea to overhaul the hub(s) before putting the bike away for the winter.

Other factors affecting the maintenance cycle are the presence of a grease injection system and/or whether there are seal mechanisms. *Grease-injection systems do not eliminate the need for overhauling.* They only increase the acceptable time between overhauls; furthermore, they are only as good as the customer is consistent and thorough about pumping in new grease. Seal mechanism hubs (adjustable-cone hubs with rubber seals between the cone and dustcaps) *do not have effective water-tight seals.* Their effectiveness varies with the brand and model. At best, they can lengthen the acceptable time between overhauls. With seal mechanisms or grease-injection systems, the best policy is to initially overhaul the hub(s) on a normal-length maintenance cycle and see if the grease is found to be in good condition. If so, then extend the maintenance cycle the next time.

Symptoms indicating need of overhaul

What symptom would lead to feeling the hub(s) should be overhauled? One is that when performing an adjustment, the looseness (free play) in the bearings cannot be eliminated without the bearing becoming excessively tight (does not turn smoothly). The lack of smoothness could be caused by dry grease, contaminated grease, or worn parts. Another symptom is that when removing the wheel and rotating the axle, the end of the axle oscillates, indicating a bent axle (which should always be replaced). Finally, there may be a broken axle, which may not be obvious until the quick-release skewer is removed, and then the axle falls out in two pieces.

Symptoms indicating need of adjustment

The primary symptom experienced indicating the hub(s) need adjustment is looseness in the bearings. This can be detected by grasping the rim (with the wheel mounted in the bike) and jerking it side-to-side while feeling for a knocking sensation. Inspect for loose bearings and loose locknuts every 300–500 miles. The only way to check for a loose locknut is to put a tool on the locknut and see if it is secure. Another

possible symptom indicating that hubs need adjustment is that when loosening the quick-release lever 45° from its fully-closed position, *play cannot be detected at the rim*. A properly adjusted quick-release hub has no play when installed to full security in the bike, but does have play when the skewer is not clamping with full force. Non-quick-release hubs simply feel tight when removed and the axle is rotated. A quick-release axle that feels a little tight out of the bike is *extremely* tight when installed in the bike.

One other case in which it is recommend to adjust the hub(s) is on any new bike. Factory adjustments are not very reliable. Due to poor factory setup, hubs may be completely worn out after as little as 1000 miles of use.

TOOL CHOICES

The design or brand of hub(s) will determine the tools needed. Table 12-1 covers tools for adjustable-cone hub(s) only. This table covers all tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy.

ADJUSTABLE-CONE-HUB TOOLS (table 12-1)

Tool	Fits and considerations
Hozan C354	Axle vise w/threaded holes for holding axle during hub disassembly, grips very securely
Campagnolo P	Axle vise w/smooth holes for holding axle during hub disassembly
Park AV-1	Axle vise w/smooth holes for holding axle during hub disassembly
Stein HV-1	Hub vise for holding hub during adjustment
Bicycle Research TC/S	Thread chaser set for numerous thread descriptions of axles with inch pitch
Campagnolo 1170004	Dustcap puller for Campagnolo C-Record hubs
Bicycle Research CW1	13, 14, 15, & 16mm cone wrench
Campagnolo Q1	13 & 14mm cone wrench, lacks leverage and hand protection
Campagnolo Q2	15 & 16mm cone wrench, lacks leverage and hand protection
Hozan C57	Three cone wrenches fit 13/14mm, 15/16mm, & 15/17mm
Kingsbridge 250A	11 & 12mm cone wrench, lacks leverage and hand protection
Kingsbridge 250B	13 & 14mm cone wrench, lacks leverage and hand protection
Kingsbridge 250C	15 & 16mm cone wrench, lacks leverage and hand protection
Kingsbridge 250D	17 & 18mm cone wrench, lacks leverage and hand protection
Kingsbridge 250E	14 & 17mm cone wrench, lacks leverage and hand protection
Kingsbridge 250F	13 & 15mm cone wrench, lacks leverage and hand protection
Park SCW-13 thru SCW-18	Six high-quality cone wrenches from 13–18mm with good leverage and hand cushioning, thin design fits all cones
VAR 20/1	13 & 14mm cone wrench, too thick and lacks hand protection
VAR 20/2	15 & 16mm cone wrench, too thick and lacks hand protection
VAR 20/3	17 & 18mm cone wrench, too thick and lacks hand protection
Wheels Mfg. C1	13 & 14mm cone wrench, lacks hand protection
Wheels Mfg. C2	15 & 16mm cone wrench, lacks hand protection
Wheels Mfg. C3	15 & 16mm cone wrench, lacks hand protection

TIME AND DIFFICULTY RATING

Overhauling a hub, including freewheel (or cog) removal and bearing adjustment, is a 30-45 minute job of moderate difficulty. Adjusting the hub alone (including freewheel removal) is a 10-12 minute job of moderate difficulty.

COMPLICATIONS

Bent axles

The only complication created by a bent axle is that there is no point to adjusting the hub if the axle is bent. The job description must be changed to overhauling the hub.

Broken axles

It is not unusual to have a job description of adjusting a hub with a quick-release axle, and upon removing the wheel and quick release it is found that the axle is broken. In this case the job description must be changed to hub overhaul.

Worn-out cups

After disassembling the parts and cleaning, the first thing that should be inspected for is pitted cups. Cups are not replaceable and this would be the end of the job. The only repair would be hub or wheel replacement.

Cones not available

Many older hubs and inexpensive new ones have no parts available. This becomes critical if cones are needed. There is a section of this chapter about cone interchangeability. If it is no help, then the hub with bad cones will need to be replaced or ridden until it “dies.”

Damaged dustcaps

Dustcaps for many hubs are not an available replacement part. If they are damaged or lost it can be the “end of the line” for the hub.

Mysterious play

There are two things that can cause a mysterious play in the bearings of the hub that will not go away no matter how the adjustment is refined. A loose cup in the hub shell will cause this problem, and so will a loose locknut on the side of the hub not being adjusted.

HUB-AXLE THREADS (table 12-2)

Pitch	Approximate axle O.D.	Approximate nut or cone I.D.	Nominal measurement (thread type) ¹	Typical occurrences
1mm	8.70–8.90mm	7.80–8.10mm	9mm × 1mm (Metric/ISO)	QR axle front hubs on most road and mountain bikes from Europe and Asia. Front hub solid axles ² on SunTour/Specialized and Shimano (modern) hubs.
1mm	9.70–9.90mm	8.80–9.10mm	10mm × 1mm (Metric/ISO)	QR axle rear hubs on most road and mountain bikes from Europe and Asia. Rear hub solid axles ² on SunTour/Specialized and Shimano (modern) hubs.
26tpi	7.70–7.90mm	6.80–7.10mm	5/16" × 26tpi ³ (BSC)	Solid axle ² front hubs on most European road bikes (not Campagnolo) and from Asia (includes older Shimano).
26tpi	8.70–8.90mm	7.80–8.10mm	9mm × 26tpi (Italian)	Campagnolo (and other Italian brands) and some Joy Tech (Jou Yu) front QR axles.
26tpi	9.30–9.50mm	8.40–8.70mm	3/8" × 26tpi ⁴ (BSC)	Solid axle ² rear hubs on most European road bikes and from Asia (includes older Shimano). Occasional older solid axle front MTB hubs (usually w/flats on the axle ends).
26tpi	9.70–9.90mm	8.80–9.10mm	10mm × 26tpi (Italian)	Campagnolo (and other Italian brands) and some Joy Tech (Jou Yu) rear QR axles.
24tpi	7.70–7.90mm	6.80–7.10mm	5/16" × 24tpi (BSC)	Solid axle ² front hubs from American hub manufacturers found on many bikes from department stores.
24tpi	9.30–9.50mm	8.40–8.70mm	3/8" × 24tpi ⁴ (BSC)	Solid axle ² rear hubs on bikes with a coaster brake or three-speed type hub.

¹ The listed thread types are only the ones that occur commonly. Other thread types exist and should be identified by measuring the diameter and pitch.

² Solid axles are those that use axle nuts to hold the wheel to the frame/fork.

³ The 5/16" diameter is sometimes called 8mm. This is incorrect because the resulting mixed-unit diameter and pitch end up sounding like an Italian thread when it is, in fact, a BSC thread.

⁴ The 3/8" diameter is sometimes called 9.5mm. This is incorrect because the resulting mixed-unit diameter and pitch end up sounding like an Italian thread when it is, in fact, a BSC thread.

Unusual bearing sizes

Almost all hubs use 3/16" balls in the front hub and 1/4" in the rear. The consistency of this is so great that it lulls mechanics into thinking that all hubs use these sizes. Consequently a wrong size gets used and the hub either adjusts or wears poorly. Campagnolo hubs are the most likely cause of trouble, with their frequent use of 7/32" balls, which are barely distinguishable from 3/16".

THREADS

Axle threads come in several standards. Measure pitch and diameter and make sure a replacement axle matches. This is usually not an issue unless trying to upgrade a non-quick-release axle to a quick-release axle, or have Joy Tech (Jou Yu) or Campagnolo brand hubs, which have relatively unique threads. See table 12-2 (page 12-4) for axle-thread information.

CONE INTERCHANGEABILITY

In every possible case, replace a worn cone with an identical cone. There will be many times when this will not be possible so it becomes necessary to know how to pick a correct substitute cone. For this there are some general guidelines and testing procedures that can be used to determine compatibility.

These general guidelines are based on certain tendencies that are common to certain brands.

Shimano has made more models of hubs over the years than anyone could possibly keep track of. Many of these models are externally different only. It is quite common that the cones in one model are identical to another model. Even when not identical, the cones may differ only in ways such as quality, finish, design of seal, or overall length. If seal differences exist, then the quality of the seal may be compromised but not the functionality of the hub. If only a length difference exists, it can often be made up for with a spacer change. The Shimano Parts Dealer Parts Catalog has excellent descriptive information about cones. If the dimensions for two different cones match, they are usually interchangeable with few critical complications. Wheels Mfg. makes duplicates of certain Shimano cones. Some distributors (including United Bicycle Parts and Quality Bicycle Products) have created compatibility

charts or systems to make it easier to determine which Shimano cone substitutes for another Shimano cone.

Suzue hubs are knockoffs of some older Shimano hubs, so there is often compatibility between Suzue and Shimano cones.

Atom, Normandy, Maillard, and some "Schwinn Approved" hubs are all different names that appear on what are essentially the same hub, so cones of one type can often be used on a hub with one of the other names. Sachs has bought the Maillard company and sometimes the older parts will be called Sachs when they fit the older Maillard, Normandy, and Atom hubs.

"Schwinn Approved" has appeared mostly on Maillard products (early seventies through the mid-seventies), but during the same time period "Schwinn Approved" appeared on Sanshin and Shimano products on occasion. Sanshin, Sunshine, and SunTour are different brand names that appear on hubs made by the Sanshin company, so compatibility often exists between hubs with these brand names. Jou Yu and Joy Tech are two names for the same company.

Wald company makes a number of replacement axle sets that fit a variety of historical and current American-made front hubs that are found on department-store bikes and older fat-tire one-speeds. These brands include Wald, Weco, Union, Schwinn, Ross, New Departure, Excel, and Enlite.

The test to determine cone compatibility has a number of steps that originally test for a likely replacement cone, and then empirically tests for compatibility. See figures 12.3, 12.4, 12.5, 12.6, 12.7, and 12.8 (page 12-6).

Hold the old cone and possible substitute together small end to small end.

Check whether the small-end diameters match.

Check whether the curves of the two cones appear symmetrical.

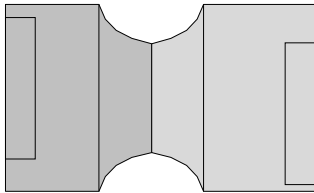
Check whether the overall cone length of the possible replacement is equal or longer (replacement can't be shorter).

Check whether replacement's overall diameter is equal to or less than original (replacement diameter cannot be larger unless hole in dustcap can be enlarged).

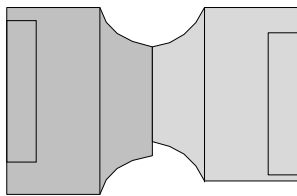
12 – ADJUSTABLE-CONE HUBS

Test-mate the replacement cone against the balls in place in the hub cup and see if the grease print on the cone indicates that the balls will be rolling on the middle of the cone race (balls cannot roll on either end of the cone race).

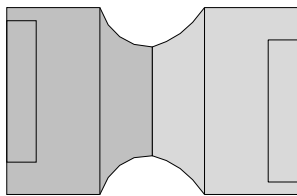
If everything is acceptable except that the thread descriptions don't match, replace the axle and hardware as well.



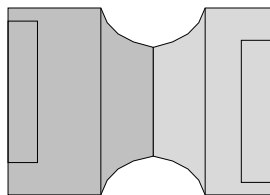
12.3 The right cone is possibly a suitable replacement for the left cone because the small-end diameters match and the curves of the races match.



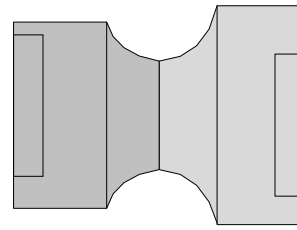
12.4 Although the curves of the races match, the right cone is not likely to be a suitable replacement for the left cone because the small-end diameters do not match.



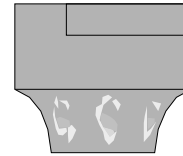
12.5 Although the small-end diameters match, the right cone is not likely to be a suitable replacement for the left cone because the curves of the races do not match.



12.6 Although the small-end diameters match and the curves of the races match, the right cone is an probably an unsuitable replacement for the left cone because of its shorter overall length. Due to the length difference, the cone wrench flats are likely to end up inaccessible (below the face of the dustcap).



12.7 Although the small-end diameters match and the curves of the races match, the right cone is an probably an unsuitable replacement for the left cone because of its larger overall diameter. Due to the diameter difference, the right cone is unlikely to fit in the hole in the dustcap.



12.8 The grease prints in the middle of the race on this cone indicate that the ball bearings will contact the correct area on the race.

When a compatible cone cannot be found, there is one additional thing to try short of running the hub with worn-out cones or replacing the hub or wheel. If a substitute cone was found that failed the grease print test because the balls were contacting too high or low on the cone race, then it may still be useable by changing the ball-bearing size.

Smaller balls will allow the cone to insert further so the contact will be further from the small end of the cone (watch for the wrench flats ending up below the dustcap face). Larger balls will position the cone further out so the contact will be closer to the small end of the cone race. Using smaller balls may reduce the wear life, but the hub has no wear life left without replacing the worn cones, so anything that works is a meaningful gain. When the ball-bearing size changes so will the quantity. Just put in the maximum number of balls that will fit in the cup without jamming.

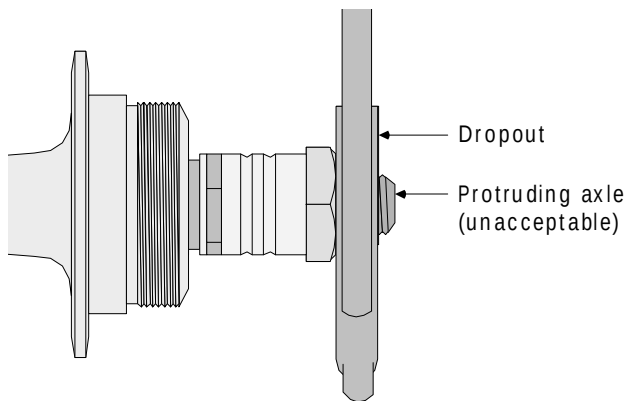
For this purpose it is useful to have some odd-size balls on hand, such as 11/64", 7/32", 15/64", and 17/64". These ball sizes (except 7/32"— used in Campagnolo hubs) are likely to be available only by special order from larger industrial bearing supply houses.

ADJUSTABLE-CONE-HUB OVERHAUL & ADJUSTMENT PROCEDURE

NOTE: If just adjusting hub and not overhauling it, do steps 1–7, then skip to **PRELIMINARY ADJUSTMENT** just after step 57.

COMPONENT REMOVAL AND PRE-DISASSEMBLY INSPECTION

1. [] Remove wheel from bike and skewer (if any) from hub.
2. [] Place wheel back in dropouts.



12.9 It is unacceptable for the quick-release axle to protrude beyond the face of the dropout.

3. [] Observe wheel in bike and determine whether QR axles protrude beyond dropout faces.
4. [] If QR axles protrude, measure dropout thickness. This is maximum axle protrusion. Maximum axle protrusion is: _____ mm.
5. [] Rotate axle and check for oscillation at ends that indicates bends.
6. [] Rotate axle and feel for severe grittiness that indicates worn out parts.

Adjustable-cone rear hubs with thread-on freewheels require freewheel removal for hub adjustment or overhaul. It is recommended, but not required, to remove freewheel cogs when overhauling a freehub, but there is no reason to remove the cogs to adjust a freehub bearing.

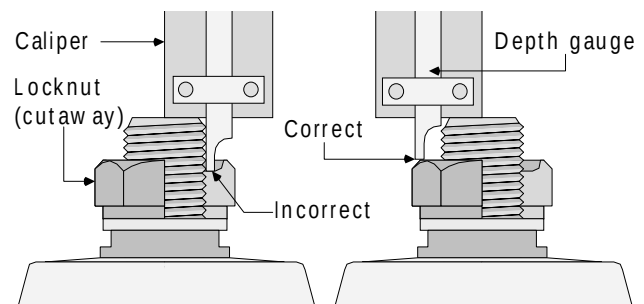
7. [] Remove freewheel (if any, for overhaul or adjustment) or freehub cogs (for overhaul only, not adjustment).

In the next step, determine the correct axle protrusion (the distance the end of the axle protrudes beyond the face of the locknut that is found just inside of the dropout). In most cases, the axle protrusion should be

equal on both sides. One rare exception is when one dropout is thicker than the other (in which case the axle protrusions should differ by the amount the dropout thickness differs). Certain inexpensive bikes have a plate of metal that the derailleur attaches to, which bolts onto the outer face of the right-rear dropout. This is called a bolt-on derailleur hanger. The bolt-on derailleur hanger is part of the dropout, so in this case consider the right dropout to be thicker than the left dropout by the thickness of the bolt-on hanger.

In the next steps, measure the two axle protrusions and average them to determine the correct axle protrusion. If the right-rear dropout is thicker, add half the difference in thickness to the average axle protrusion for the correct right-side protrusion, and subtract half the thickness difference from the average axle protrusion for the correct left-side protrusion.

When measuring the axle protrusion, use the depth gauge of a caliper and measure from the high point on the face of the locknut to the end of the axle. Some axles have a recess in their face. *Do not measure down into any recess.*



12.10 Measuring the axle protrusion.

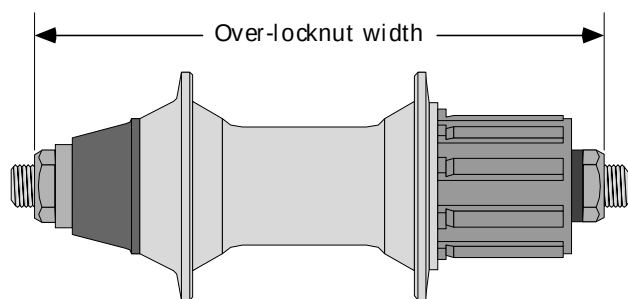
Determine correct axle protrusion

8. [] Right-side axle protrusion: _____ mm.
9. [] Left-side axle protrusion: + _____ mm.
10. [] Total axle protrusion is: = _____ mm.
÷ 2
11. [] **AVG. AXLE PROTRUSION** = _____ mm.

Measure over-locknut width

In the next step, measure the overall width from the left locknut to the right locknut. This measurement will be needed if parts are replaced with non-exact replacements. If some sort of substitute part that is not the same effective width as the original is used, it could affect the fit of the wheel to the frame or fork. By knowing how much the final width differs from the original width, it will be known how many washers to add or subtract on the side of the hub that has the substitute part.

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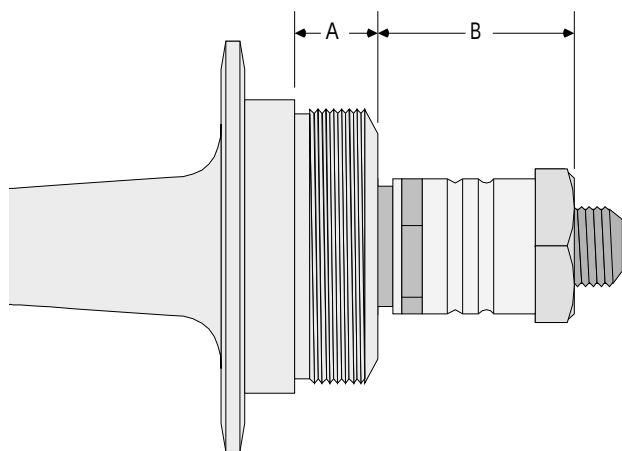
12.11 Measure the over-locknut width.

12. [] Measure over-locknut width.

OVER-LOCKNUT WIDTH IS: _____ mm.

NOTE: Front hubs, go to step 17.

Steps #13 through #16 apply to rear hubs only. The purpose of these steps is to get a measurement that corresponds to the distance the freewheel or freehub cogs sit from the dropout. This distance must be maintained when overhauling the hub or the rear derailleur might need adjustment or the freewheel may not even have enough room to be re-installed. The measurement will not be needed unless right-side parts are replaced with non-identical parts, or if left-side and right-side parts get mixed up.



12.12 Determine freewheel space by adding measurement A to measurement B.

NOTE: Freehubs, go to step 16.

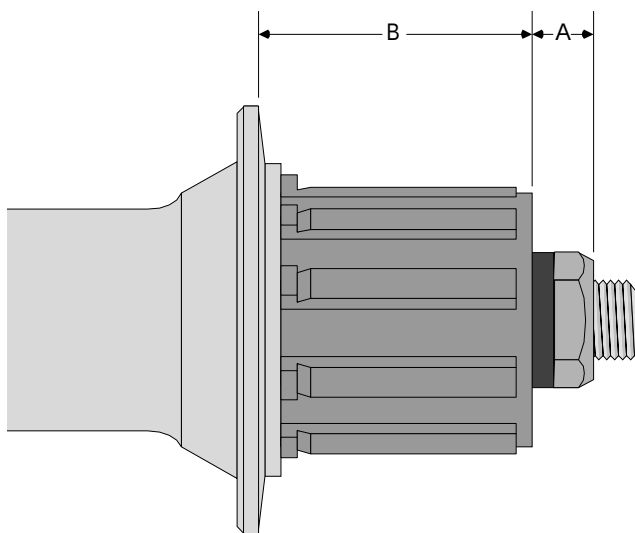
Measure and calculate freewheel space:

13. [] Freewheel shoulder to end-of-shell: _____ mm

14. [] End-of-shell to locknut face: + _____ mm

15. [] FREEWHEEL SPACE = _____ mm
(Skip to step 17.)

Measure and calculate freehub space



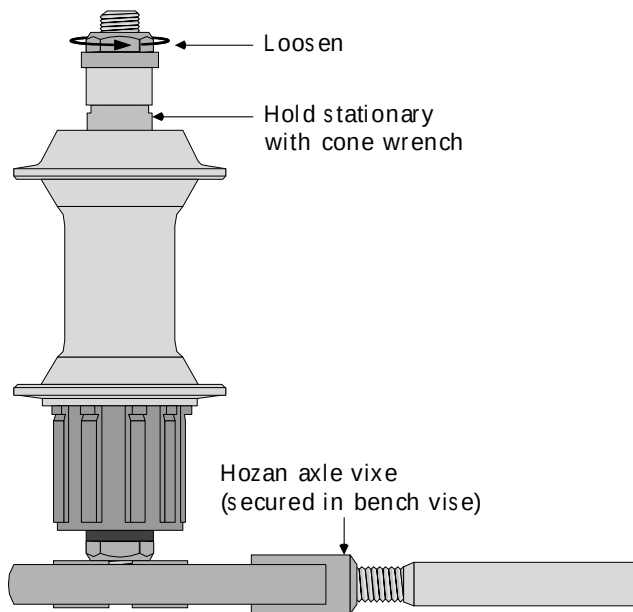
12.13 Determine freehub space by adding measurement A to measurement B.

16. [] For freehubs, measure from end of freehub body (where cogs came off) to locknut face. Add this to measurement from right flange to outer end of freehub body to calculate freehub space.

Freehub body to nut face:	_____ mm
Body flange to outboard end of freehub body	+ _____ mm
FREEHUB SPACE	= _____ mm

DISASSEMBLY

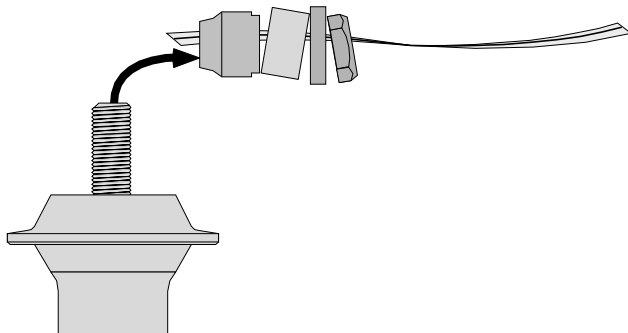
Disassembling the first end of the axle is a lot easier if the axle is not free to turn. The ideal way to do this is to have the end of the axle that is not being disassembled held in a bench vise. When securing the axle in a vise, it is easy to damage either the axle or the locknut. If the axle is a not-quick-release type, there is enough axle to grasp securely with the axle directly in “soft jaws.” Soft jaws are inserts made of aluminum, copper, plastic, or wood that cover the face of the vise jaws. All of these materials are softer than the axle threads so the axle threads will not be damaged. Quick-release axles do not protrude far enough to get a good grip with soft jaws, which might lead to clamping the vise tighter, which could crush the hollow quick-release axle. For this reason, a special axle vise is required for use with quick-release axles. Grasping the axle by the locknut can lead to damage of the locknut.



12.14 With the hub secured in a Hozan axle vise, use a cone wrench to hold the cone while breaking loose the locknut.

- 17. [] Clamp right end of QR axle in axle vise, or right end of solid axle in soft jaws.**
- 18. [] Hold left cone stationary with cone wrench while breaking loose left locknut with adjustable wrench. (Use cone wrench on locknut only if locknut has round face.)**

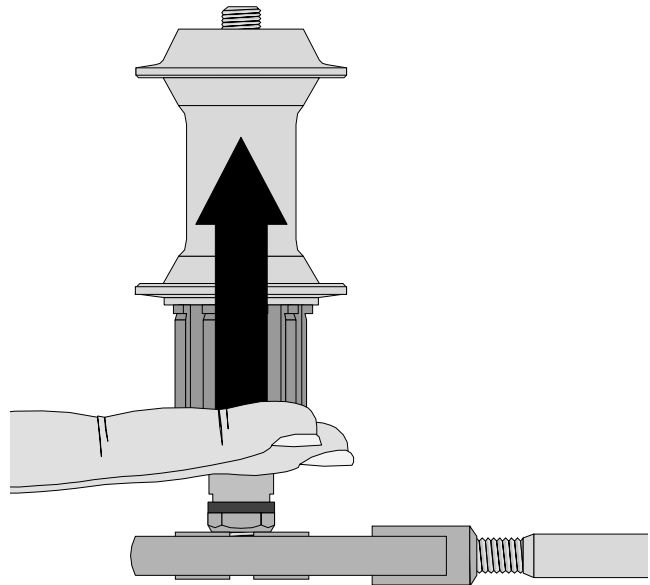
There are few standards about the number and sequences of parts on the end of the axle. Furthermore, keeping left-side and right-side rear-axle parts separate is critical on rear hubs (front hubs usually are symmetrical). For this reason, the next step suggests transferring parts directly from the axle to a bundling tie (wire or plastic bread-bag ties work). Some parts, particularly outer locknuts, have a certain way they need to face, so it is just as important to maintain the specific orientation of each part as it comes off the axle as it is to maintain the order.



12.15 Transfer the parts one-by-one from the end of the axle to a bundling tie to maintain the correct order and orientation.

- 19. [] Thread left-end parts off axle and onto bundling tie (maintaining order and orientation).**

- 20. [] Lift hub off axle, cupping hand below hub to catch ball bearings.**



12.16 Cup a hand under the hub with the axle between two fingers while lifting off the hub in order to catch any ball bearings that fall out.

Steps #21 through #24 are about removing the right-side axle parts. Removing these enables checking for a bent axle, damaged threads, replacing the cone if damaged, and resetting the right-side axle protrusion if necessary. The tendency is to skip these steps if the cone is not in need of replacement, but some important problems could be missed, especially if this is the first time overhauling this hub.

If the hub is a rear hub with a thread-on freewheel, a variety of parts configurations might be found in the next step. These will break down into one of two fundamental categories, axle sets with a single locknut on the right and axle sets with a double locknut on the right. Some of the variations might be whether there is a big spacer built into the outer locknut of a double-locknut design and whether there are single or multiple spacers.

In these next steps, use *two* ties to bundle the right-side parts. This will enable keeping track of the left-side (first off, single tie) and right-side (second off, two-ties) parts.

- 21. [] Reverse axle in axle vise or soft jaws.**
- 22. [] Hold cone (or lower locknut of double-locknut hub) stationary with cone wrench while breaking loose locknut with adjustable wrench. (Use cone wrench on locknut only if locknut is round.)**
- 23. [] Only if double-locknut hub: hold cone stationary while breaking loose lower locknut.**

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24. [] Thread right-end parts off axle and onto two bundling ties, while maintaining order and orientation.

Rubber seals on dustcaps or cones rotate relative to the part they are attached to. Seal effectiveness can be improved and seal drag reduced by lubricating between the seal and what it is attached to. Seals will be removed at this time to enable greasing later. Seals can possibly be re-installed backwards, so note their orientation if removing them from a dustcap, or simply leave them on the left-side and right-side parts bundles if removing them from a cone.

25. [] Remove rubber seals (if any) from dustcaps (note orientation) or cones (leave seals on bundles).

Next, remove the ball bearings. This is a critical step because bearing sizes and quantities are not universal. For front hubs, 10– 3/16" balls per side is most common. The most likely exception that will not be obvious is that some older Campagnolo hubs use slightly oversize 7/32" balls. For rear hubs, the most common quantity and size are 9– 1/4" balls per side. The quantity of balls for the right side and left side of any hub is almost always universally equal, so if eleven are counted on the right and nine on the left, it is certain that a ball dropped from one side to the other and that ten per side is the correct amount. On the other hand if the quantity per side differs by one, it is extremely possible that one ball was lost.

26. [] Remove ball bearings one side at a time and determine quantity and size per side and record observations here:

Quantity:	Left _____	Right _____
Size:	Left _____	Right _____

Dustcap removal is next. It is optional, with removal only making cleaning and inspection easier. That dustcap removal is optional is important, because with some hubs it is *easy* to bend or break the dustcap when attempting to remove it. This happens most often with some Shimano freehubs. To pry out the dustcap use a plastic tire lever. Lever gently in one location, then move a few degrees and lever a little more, then move again and lever a little more. Continue like this until the dustcap eases out. If it will not come out easily, *do not remove it*.

27. [] Pry dustcaps out unless damage is likely. Were dustcaps very loose? Yes? No? (circle one)

The next step only applies to rear freehubs, and is optional. The hub can be cleaned with the freehub body still attached. It makes for extra work when drying after cleaning. Techniques for freehub-body re-

moval are not covered here, as they are optional and *are* covered as part of the **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** chapter (page 25-9).

28. [] Only if working on rear freehub, remove freehub body (optional).

29. [] Clean all parts, including outside of hub shell.

INSPECTION

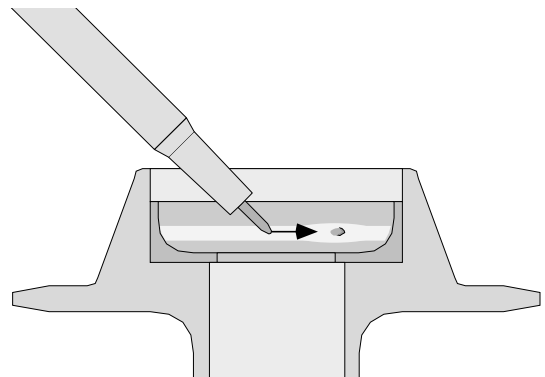
Hub-shell damage in regard to the bearings is rare. Cracks may appear on some inexpensive steel hubs on the backside of the bearing area when the bearings become extremely over-tight. Some inexpensive hub shells made of multiple parts joined together may fail at the joints. The evidence of this type of failure is greasing oozing out a seam in the hub shell. This external inspection is done first because any failure is non-repairable and the job is over.

30. [] Inspect outside of hub shell for damage. Good? Bad?

The bearing cups are supposed to be permanently pressed into the hub shell. Occasionally they work loose. If not inspected for, this might cause substantial frustration when trying to eliminate play when making the adjustment. Firmly press a finger into a cup and try to force it to rotate. If it does rotate, it must be fixed by dripping Loctite 290 behind the cup.

31. [] Inspect pressed in cups for looseness. See if they rotate or jiggle. Good? Bad?

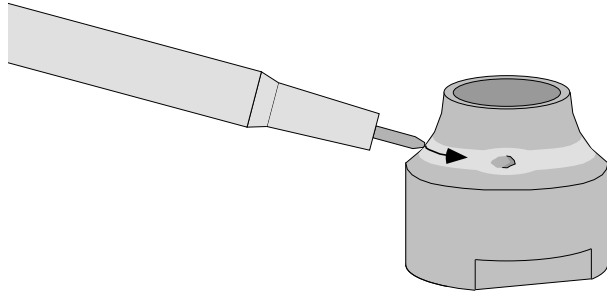
By design hub cups wear out long after the cones have worn out. This is good because the cups cannot be replaced. When a cup wears out, a new hub is needed. Check for cup wear by looking in the cups for the wear line left by the balls. Trace this wear line with the tip of a ball point pen. If it snags on anything, the cup is shot and the hub should be replaced.



12.17 Inspect the cup for pits with the tip of a ball point pen.

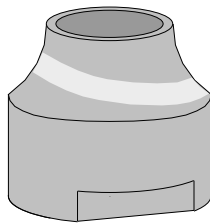
32. [] Trace ball path in cups with a ball point pen to check for pits. Good? Bad?

If the cups were worn out, the cones are virtually certain to be. If not, be sure to check the cones carefully so that a worn out one will not damage a cup, leading to a hub replacement. Cones wear out by developing pits (galling). Find the shiny wear line left by the balls on the conical portion of the cone. Trace this wear line with the tip of a ball point pen to check for pits.

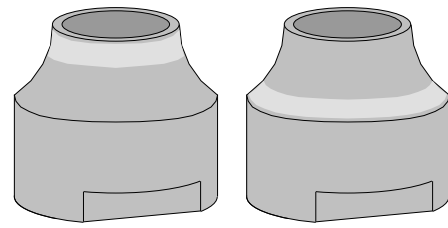


12.18 *Inspect the cone for pits with the tip of a ball point pen.*

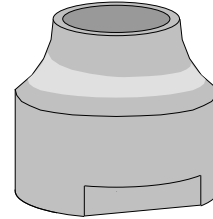
When inspecting the cone for pits, other symptoms with the wear line might be detected. If the wear line wanders from high on the cone race to low on the cone race, the cone may still be useable but the wear pattern indicates a probable bent axle. If the wear pattern is at the top or bottom of the cone race, it indicates that the cone is the wrong one for that particular hub, or that the wrong-size bearings are in use. An unusual looking wear pattern that does not indicate a particular problem is when the wear line is fat halfway around the cone and thin on the other half. This happens because the cone does not rotate during use so all the load is experienced on the bottom half. This pattern is not seen all the time because in many cases the rear wheel is in and out often, and the axle and cones end up rotated into a different positions with each installation of the wheel.



12.19 *A wear line that is low on the cone race at one point and high on the cone race at another point indicates the axle is bent.*



12.20 *A wear line that is at the top of the cone race (left cone), or bottom of the cone race (right cone) indicates that the cone is the wrong one for the hub or that the balls are the wrong size.*



12.21 *When the wear pattern is fatter on half the cone race it indicates that the axle has been in the same position for most of the life of the hub, no particular problem is indicated.*

33. [] Trace ball path on cones with a ball point pen to check for pits and inspect for other wear problems. Good? Bad?

Next, inspect the axle for bends. Roll the axle on a flat smooth surface such as a Formica counter top or a glass display case. Look under the axle as it rolls for a humping up and down that indicates it is bent. A bent axle is an axle in the process of breaking, and should be replaced, not straightened. A bent axle can be caused by misaligned dropouts. Axles can also bend from severe impact to the wheel or high pedaling loads.

34. [] Inspect axle for bends. Good? Bad?

Threads can be damaged on the axle from getting nicked, from a keyed lock washer rotating around the axle, or from excess torque on a locknut, which results in stripped threads. If the threads are nicked from impact against something or damaged by a rotated lock washer, they can be repaired with the thread file (metric-pitch quick-release axles) or Bicycle Research thread chaser (inch-pitch solid axles). Threads stripped from an over-tightened locknut cannot be repaired. Replace the axle.

35. [] Inspect axle for damaged threads. Good? Bad?

Some axles have slots along their length. A key on the lock washer engages the slot. The only function of the key is to enable the factory to adjust the hub without a cone wrench. However, the washer often rotates around the axle and the key damages the threads as well as itself. If a key is damaged, the washer

12 – ADJUSTABLE-CONE HUBS

is sure to rotate again. File out the damaged key or replace the washer with an unkeyed one. If installing a replacement axle without a slot, get rid of the keys on the inside of the washers.

36. [] Inspect keyed lock washers for damaged keys. Good? Bad?

Inspect the locknuts for damage, usually resulting from being over-tightened or from poor wrench fit or use. Locknuts have to match the original thread and thickness. If the new locknut has a different thickness, make up the difference by adding or subtracting washers.

37. [] Inspect locknuts for damaged threads, cracks, warpage, and rounded off flats. Good? Bad?

Inspect the dustcaps for looseness and damage. If they were loose (determined during removal), then re-install them with Loctite 242. If a dustcap is bent, try to straighten it out. It is only critical if the dustcap is deformed to the point that it rubs on a part of the axle set that the dustcap overlaps.

A simple technique for straightening a bent dustcap is to put the dustcap on the bench face down and insert a socket that is a close fit inside the dustcap and tap on the dustcap with a soft mallet.

38. [] Inspect dustcaps for looseness (done in step 27) and damage. Good? Bad?

ASSEMBLY

If installing a new axle, the length does not have to match exactly. For quick-release axles, the minimum axle protrusion per side should be no less than one-half the dropout thickness, and the maximum should be no more than the dropout thickness. For non-quick-release axles, the minimum length should be no less than the sum of the dropout thickness, plus the thickness of the washers under the axle nuts, plus the thickness of the axle nuts.

Calculate new axle protrusion

NOTE: If not replacing axle with new one of different length, go to step 42.

39. [] Repeat original average axle protrusion from step 11 here: _____ mm.

40. [] Measure difference between axles and divide by two.

Difference is: _____ mm
÷ 2

1/2 axle difference = _____ mm

41. [] If new axle is shorter, subtract difference (or if longer, add) from/to old protrusion.

Old protrusion (step 39) _____ mm

1/2 axle difference (step 40) ± _____ mm

New protrusion is: _____ mm

Parts replacement

42. [] Replace bad parts on bundles with good parts.

Preparation of hub shell for assembly

If the freehub body has been removed in step #28, it is time to replace it. Be sure it is dry and oiled inside. Techniques for cleaning, drying, oiling, and installation are all covered in the freewheel chapter.

43. [] Install freehub body if it was removed in step 28.

Fill both cups generously with grease and put the balls into the cups. If unsure of the ball quantity, fill the cups with balls without forcing any in.

The most important thing about dustcap installation is to make sure that they end up level rather than tipped. Tap the dustcap in with a rubber or plastic mallet. Do the best possible to level the dustcap at this point, and then when the hub is assembled, give the wheel a spin and check whether the dustcaps wobble as they spin. Straighten them as necessary.

44. [] Pack grease and balls in one side of hub, then install dustcap.

45. [] Pack grease and balls in other side of hub, then install dustcap.

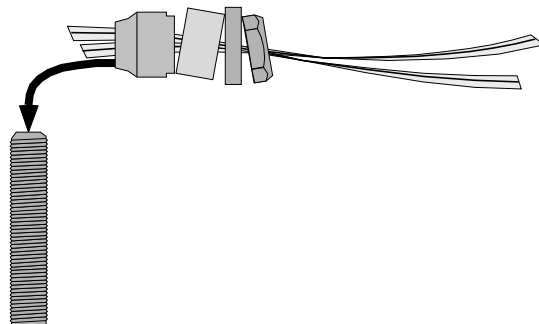
46. [] Grease seals, if any, and install on dustcaps or cones.

Set right-side axle protrusion

47. [] Grease axle threads.

48. [] Install axle in axle vise or soft jaws with right end up. (Right end is longer-threaded end if right parts bundle is bigger bundle, or shorter-threaded end if right parts bundle is smaller bundle.)

When disassembling the axle set, the assumption is that all the parts are in the correct orientation. If these parts were not correctly oriented, or if the bundle came apart during cleaning and the order and orientation is uncertain, make sure the outer locknuts go on correctly. If one side of the locknut is flat and smooth and the other side is not, the non-smooth side faces out, so as to grip the inside face of the dropout and hold the wheel more securely in the bike.



12.22 Transferring the parts from the bundling tie to the axle.

49. [] Transfer all parts from right-side bundle (two ties) to axle.
50. [] Position top locknut so axle protrusion equals average axle protrusion plus .2mm.
51. [] Hold top locknut stationary with wrench and tighten parts below it snugly up against locknut.
52. [] Measure axle protrusion, then adjust protrusion if necessary.
53. [] Loosen axle slightly in axle vise (or vise) so that axle is free to turn.
54. [] Hold cone with cone wrench and torque locknut to 120–180in-lbs (30–45lbs@4").

Install axle in hub

55. [] Turn axle over in axle vise (or vise).
56. [] Drop hub (right-side down) onto axle.
57. [] Transfer left-side parts bundle to axle.

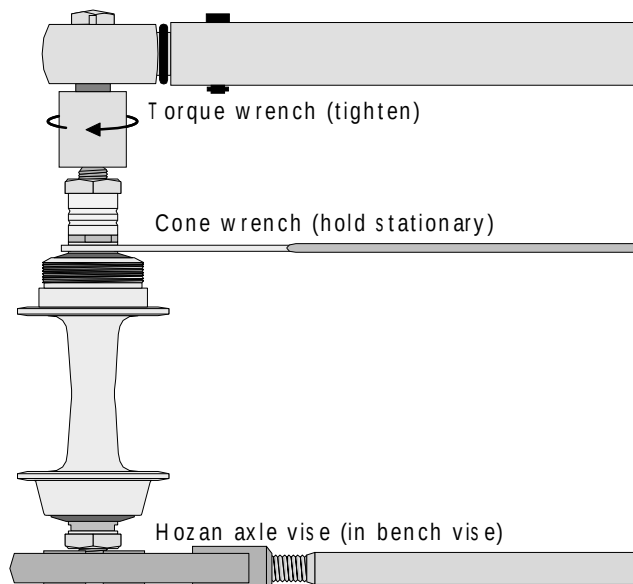
PRELIMINARY ADJUSTMENT

NOTE: If just adjusting a front hub or thread-on-freewheel rear hub:

1. Do steps 1 through 7,
2. Break loose left-side locknut from cone by holding cone stationary and turning locknut counterclockwise.
3. Hold right cone with cone wrench and torque locknut to 120–180in-lbs (30–45lbs@4").

NOTE: If just adjusting (not overhauling) a freehub:

1. Back cone off enough to push right side of axle out far enough to access right-side cone.
2. Secure right-side cone and locknut together to 120–180in-lbs (30–45lbs@4").
3. Place right side of axle in axle vise/soft jaws.



12.23 Preparing a hub for adjustment.

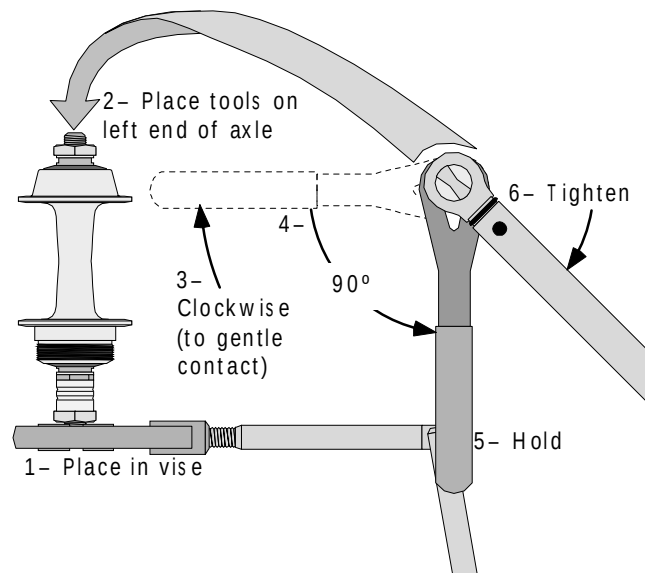
The next few steps are a preliminary to adjusting the hub. The left-side parts will be put in a position close to their final position, but *deliberately at a very loose adjustment*. This prepares the hub for adjustment because the adjustment procedure is based on starting too loose and eliminating the looseness. A very high degree of initial looseness is required for quick-release hubs because the axle is compressed by the load of the closed quick release, which will take up some of the excess play before the adjustment is even started.

The adjustment procedure recommends using calibration stickers (BBI Hub Dial stickers). The stickers will be put on the hub to calibrate the adjustment. The surfaces must be grease-free for the stickers to stick well, particularly on the cone. Even if not using the stickers, it will be necessary to mark the hub in some way, so cleaning is still required.

The adjustment procedure (page 12-15) is very different from the way most mechanics adjust hubs. The procedure uses an adjustment-calibration sticker (a BBI product), but a piece of masking tape that you mark yourself can be used as an alternative to the sticker. This approach (with sticker or tape) may seem awkward at first, but students at BBI that were very experienced with hub adjustment prior to arriving at BBI, endorse this approach wholeheartedly.

If parts were replaced, or right and left parts were mixed together, it is time to check the over-locknut width and freewheel-space/freehub-space measurements against the originals.

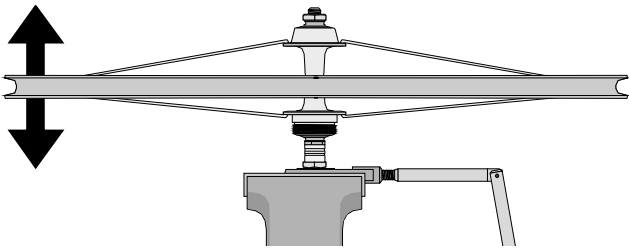
58. [] Tighten cone until it very gently contacts bearings, then back it off a full 90°.
59. [] Hold cone stationary and tighten locknut to it to 120–180in-lbs (30–45lbs@4").



12.24 Preliminary setting of the cone.

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60. [] Jerk rim up and down and check for *obvious* (even extreme) knocking. If adjustment is not adequately loose, go back to step 58 and start even looser.



12.25 Jerk up and down on the rim to check for obvious knocking that indicates that the adjustment is loose enough.

61. [] Clean left dustcap and left cone thoroughly (with acetone or alcohol).
62. [] If non-matching right-side hub parts were installed, check freewheel/freehub-space from steps 15 or 16 and adjust if necessary.
63. [] If non-matching hub parts were installed, compare to over-locknut width in step 12 and adjust if necessary.

FINAL ADJUSTMENT

Adjusting a hub can be challenging. The first challenge of adjusting a hub is that the cone needs to be adjusted relative to the axle. The axle wants to turn unless fixed somehow. This could be done in the vise, but there is another challenge in that the quick-release axle in the bike is compressed compared to its length out of the bike. If a perfect adjustment of a quick-release axle out of the bike were made, it would be over-tight in the bike and with no easy way to tell. The wheel can't be mounted *inside* the dropouts to make the adjustment because then there is load on both outer locknuts and they can't be turned. Yet one more challenge is to keep track of the adjustments. The cone position must be compared to where it was relative to the axle; however, the axle is so small that there is no way to mark it to track the progress of the adjustment.

The following adjustment procedure solves all these problems. It pre-loads the axle so that the in-the-bike adjustment will not be tighter than when performing the adjustment. It fixes the axle from rotating, and by also fixing the hub from rotating, this technique allows tracking the cone position relative to the hub rather than relative to the axle.

This adjustment procedure assumes a Stein HV-1 hub axle vise is being used to hold the wheel stationary. Although the HV-1 is an inexpensive and excel-

lent tool, as an alternative the wheel can simply be mounted to the *outside* of a rear dropout on a bike. Alternatively, cut a few inches of chainstay and a rear dropout out of a trashed frame to clamp in the vise to substitute for the HV-1.

Non-quick-release hub adjustment preparation

NOTE: For quick-release axles, go to step 65.

64. [] Clamp Stein HV-1 in vise and use axle nut to bolt right end of axle into hole of HV-1 securely (about 240in-lbs).

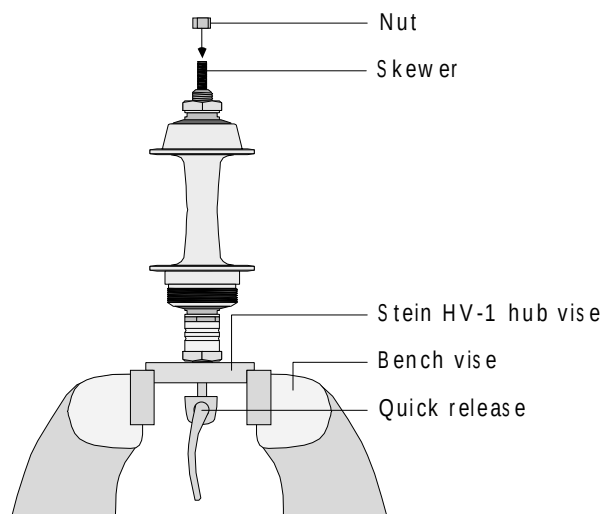
Quick-release hub adjustment preparation

NOTE: For non-quick-release axles, go to step 70.

65. [] Put Stein HV-1 in vise securely.

66. [] Insert QR skewer through bottom of HV-1 and into right end of axle (no springs).

In the next step, a nut (standard 5mm × .8mm or quick-release adjusting nut) is put on the end of the skewer so that it will bear against the end of the axle when the skewer is secured. The nut then transfers the load through the axle, simultaneously securing the axle from rotation and compressing the axle in the same fashion that it will be when the wheel is installed in the bike. When the wheel is mounted normally in the bike, the force is applied through the dropout to the outer locknut and then to the axle.



12.26 *The hub is mounted in the Stein HV-1 vise (in bench vise jaws), using a 5 × .8mm nut on the end of the quick-release skewer.*

Using a 5mm × .8mm nut instead of the quick-release adjusting nut has some advantages. Sometimes the large diameter of the quick-release adjusting nut interferes with an open-end or adjustable wrench be-

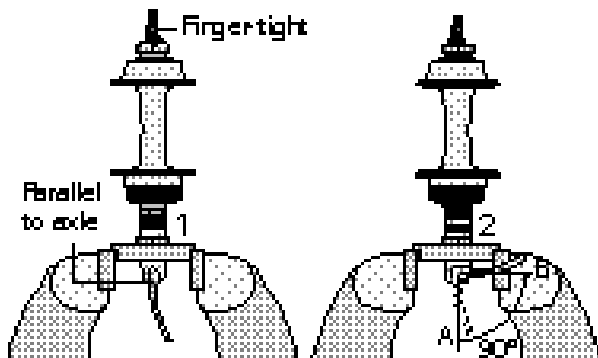
ing used on the locknut. The regular nut allows use of any wrench, including a deep socket (so that a ratchet drive or torque wrench can be used to secure the adjustment). Some older French skewers and some American skewers are not compatible with a 5mm nut so use the quick-release adjusting nut in these cases.

67. [] Put nut (no spring) on skewer.

The quick-release lever must be clamped with the same force during the adjustment as it is during normal wheel installation for the adjustment to be accurate. The common tendency is to not secure the lever tight enough. When it is properly set, force is required to close the lever starting when the lever is parallel to the axle and the lever must be closed down all the way until it is perpendicular to the axle. Many quick-release levers are curved; when the lever is curved, the straight portion at the base of the lever is the only part to be concerned with regarding the starting and ending positions. See figure 12.27.

68. [] With base of quick-release lever parallel to axle, secure nut tight with fingers.

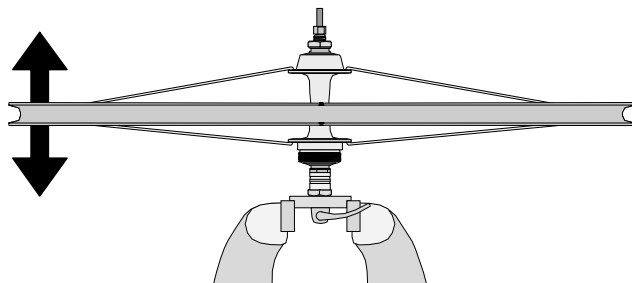
69. [] Close quick-release lever 90° until base of lever is perpendicular to axle.



12.27 Adjust the quick release so force to close begins at A and close the lever until it matches position B.

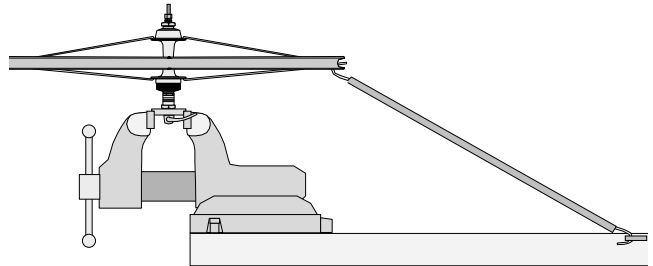
Adjustment Procedure

70. [] Jiggle rim to check hub for looseness, and set left cone and locknut to looser position if no play is felt.



12.28 With a finger on the end of the axle to feel for knocking, jerk up and down on the rim.

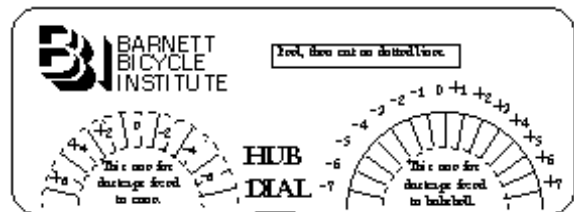
Next, the rim needs to be fixed from turning so the cone can be adjusted relative to the hub. A bungee cord or its substitute is used. It will need to be attached, detached, and re-attached several times without losing the position of the hub, so set up the bungee cord to a fixed point on the rim and a fixed point on the bench or vise.



12.29 Attach a bungee cord to the rim at the valve hole (or valve), then attach the other end to a fixed point on the bench.

71. [] Attach a bungee cord to valve/valve hole, and to fixed point on bench/vise to fix rim from turning.

The following adjustment procedure is very different from the way most mechanics adjust hubs. The procedure uses an adjustment-calibration sticker (a BBI product), but a piece of masking tape that you mark yourself can be used as an alternative to the sticker. This approach (with sticker or tape) may seem awkward at first, but students at BBI who were very experienced with hub adjustment prior to arriving at BBI endorse this approach wholeheartedly.



12.30 A BBI Hub Dial Sticker.

If the hub has a dustcap that rotates with the hub shell, the cone needs to be marked with a scribe between the wrench flats, or use one edge of one of the wrench flats as the cone mark.

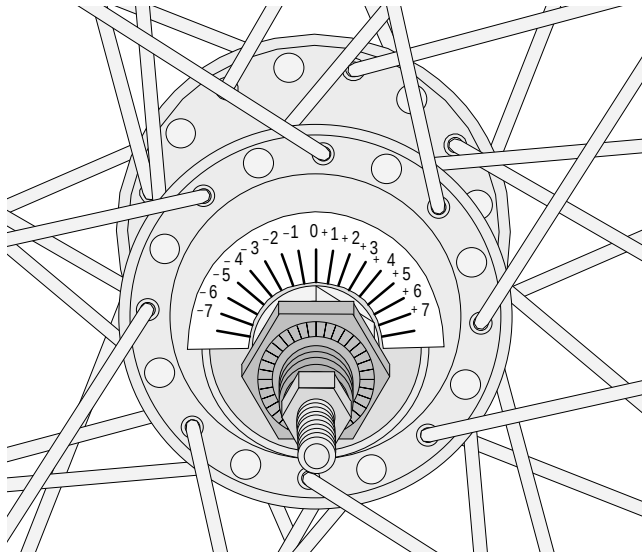
If the hub has a dustcap that remains stationary as the hub shell rotates, use a fine-tip felt marker to put a mark on the hub shell right at the edge of the stationary dustcap.

72. [] Check whether dustcap rotates with hub shell and mark cone if dustcap rotates or hub shell if dustcap is stationary.

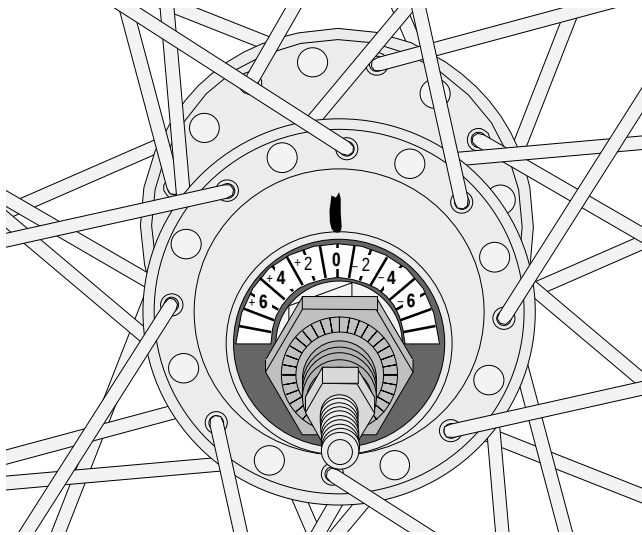
12 – ADJUSTABLE-CONE HUBS

If the hub has a dustcap that rotates with the hub, use the BBI Hub Dial sticker that has numbers outside of the dial marks. If the hub has a dustcap that remains stationary as the hub rotates, use the BBI Hub Dial sticker that has numbers on top of the dial marks.

The Hub Dial sticker needs to be cut out and attached to the dustcap so that the calibration lines are right against the cone and so that the “0” mark lines up with the cone mark or hub-shell mark.



12.31 BBI Hub Dial Sticker placed on a rotating dustcap so that the “0” mark lines up with the edge of a cone-wrench flat.



12.32 When the BBI Hub Dial Sticker goes on a stationary dustcap, mark the hub shell in line with the “0” on the sticker.

73.[] Cut out Hub Dial sticker and put it on dustcap so that “0” mark lines up with cone mark or shell mark. If not using a BBI Hub Dial sticker, draw a mark on dustcap lining up with cone mark or hub-shell mark.

In the next step, hold the cone stationary while breaking loose the locknut. If the cone and locknut both turn counterclockwise simultaneously, the axle may turn with them. This will cause the locknut on the other end of the axle against the HV-1 to break loose. This will not be obvious, but as adjustment continues to be set tighter and tighter, a slight amount of play will persistently remain. The play being felt will be the loose locknut on the end of the axle against the HV-1. By this time the adjustment is probably way over-tight and the right-side locknut and cone need to be resecured. Start over. Avoid this by *keeping the cone absolutely stationary while breaking loose the locknut.*

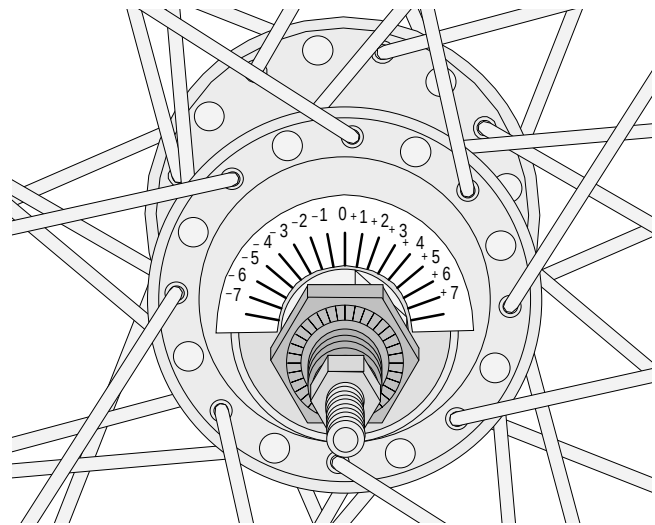
74.[] Holding left cone *absolutely* stationary, loosen left locknut.

75.[] Adjust cone clockwise to next dial mark (+), hold cone *absolutely* stationary and secure locknut 120–180in-lbs (30–45lbs@4”). If not using a BBI Hub Dial sticker, simply draw a new mark 1–2mm clockwise from original on dustcap.

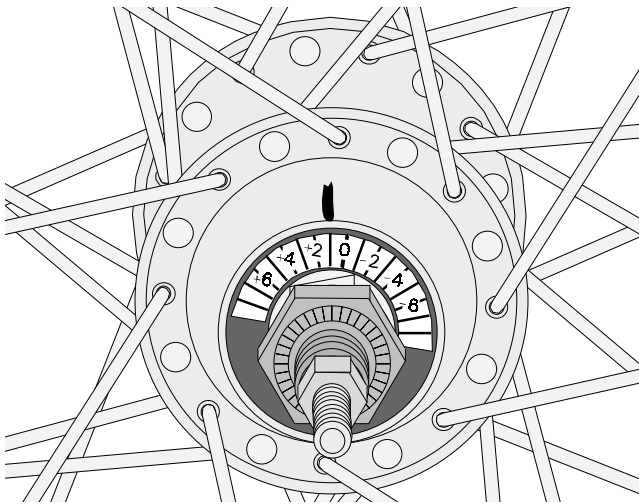
The next step is to jiggle the rim and feel if there is knocking that indicates the adjustment is too loose, then reset the cone to the next positive mark on the Hub Dial. This adjustment needs to be very precise. If the mark is under- or over-shot, try again. See figures 12.33 and 12.34.

76.[] Remove bungee cord and check for knock in hub by jiggling rim (rotate wheel and check at many points about rim).

77.[] Re-attach bungee cord and repeat adjustment process to next “+” mark. If not using a BBI Hub Dial sticker, draw a new mark 1–2mm clockwise on dustcap or hub shell.



12.33 The cone has been turned 10° clockwise so that the edge of the wrench flat lines up with “+1” on the sticker.

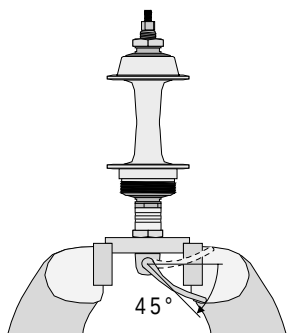


12.34 The cone (and sticker) has been turned 10° clockwise so that the “+1” on the sticker lines up with the mark on the hub shell.

NOTE: If knock is felt easily in step 76, perform steps 77–78.

78. [] Repeat step 71, then 74–76 as many times as necessary (each time moving cone mark to next “+” mark on hub dial), until play is not felt. If at any time play becomes detectable intermittently (play can be felt at some points on rim, but not at all points on rim) the next adjustment should only be halfway to next mark.

The objective in the next step is to loosen the quick-release lever enough to take the compression load off the axle, but to leave it tight enough so that the wheel will not wiggle relative to what it is mounted to, when jiggling the rim to check for free play in the adjustment. To accomplish this, the lever needs to be opened halfway back from the perpendicular-to-axle position a position parallel to the axle (45°). If the wheel ends up loosely mounted at this quick-release position, the quick release was not properly set initially, and the adjustment should be started over again.



12.35 Loosen the quick-release lever 45°, then check for knock.

79. [] Once knock is eliminated, remove bungee, loosen QR lever 45°, and check for knock.

NOTE: If knock is not felt in step 79 (with lever loosened), perform step 80, otherwise go to step 81.

80. [] Secure skewer lever, re-attach bungee, return halfway to last adjustment and repeat check with bungee off and QR lever loosened 45°.

NOTE: Once knock is felt in step 80 (with lever loosened) perform steps 81–83.

81. [] Adjustment is good: Yes? No?

82. [] Remove wheel from HV-1, remove skewer and nut if any, install freewheel or freehub cogs, install wheel normally.

83. [] Check at rim for knocking and adjust skewer setting tighter (within normal range) if knocking is felt.

SHIMANO PARALLAX HUBS

Shimano makes several front hubs that are in a style group called “Parallax.” Some of these hubs are completely conventional in every way except the over-size diameter of the hub-shell core. Some of them have special axle designs that requires some slightly different techniques.

All models of Parallax hubs have rubber seal covers that hide the access to the cones. These soft seals must be pulled over the locknut and off the end of the axle before servicing the hub.

The way to tell the difference between the varieties of Parallax hubs is simple. If a threaded axle protrudes past the face of the locknut, the hub is completely conventional. If a smooth unthreaded stud protrudes from the face of the locknut, then the hub has a special axle.

There are actually two different special axles. One is a 10mm conventional axle with a 9mm unthreaded end that protrudes past the locknut. The other is a 11mm axle that does not protrude through the locknut at all. Both of these designs require a different approach from each other and different approach from other hubs.

The way to identify the 10mm design is to break loose the locknut. If the smooth stud remains stationary while the locknut turns, then the axle is the 10mm variety. Currently hubs of this design have the designation “Parallax 100” on a gold sticker, but this could change or the sticker might be removed. Another indicator that the hub may be of this variety is that the smooth protruding stud is black steel; however, this could change also.

12 – ADJUSTABLE-CONE HUBS

The certain way to identify the 11mm design is to break loose the locknut. If the smooth stud rotates while the locknut turns, then the axle is the 11mm variety. Currently hubs of this design have the designation “Parallax 110” on a gold sticker, but this could change or the sticker might be removed. Another indicator that the hub may be of this variety is that the smooth protruding stud is chrome steel; however, this could change also. Some of the 11mm-axle hubs have special locknuts with a built in rotating washer shaped like the letter “D.” If this washer is present, then the hub definitely is the 11mm-axle variety. (See figure 12.36.)

SERVICING 10MM-AXLE PARALLAX HUBS

There are only two special considerations with servicing these hubs. When overhauling this variety, a different technique is required for holding the axle. Also, although the axle-thread description is a conventional 10mm × 1mm, the special reduced diameter 9mm ends and extra thread length require the axle to be replaced with original matching parts only.

The recommended Hozan C354 axle vise with threaded hole is adequate but not ideal for grasping the end of the axle for disassembly purposes. Better choices would be Park AV-1, United Bicycle Tool AX, or Campagnolo P.

SERVICING 11MM-AXLE PARALLAX HUBS

There are actually two varieties of this hub. One has a simple round-face locknut on the end of the axle. The other has a built-in rotating washer that is shaped like the letter “D” and has a tab in the face of the washer that fits into the axle slot.

Complications

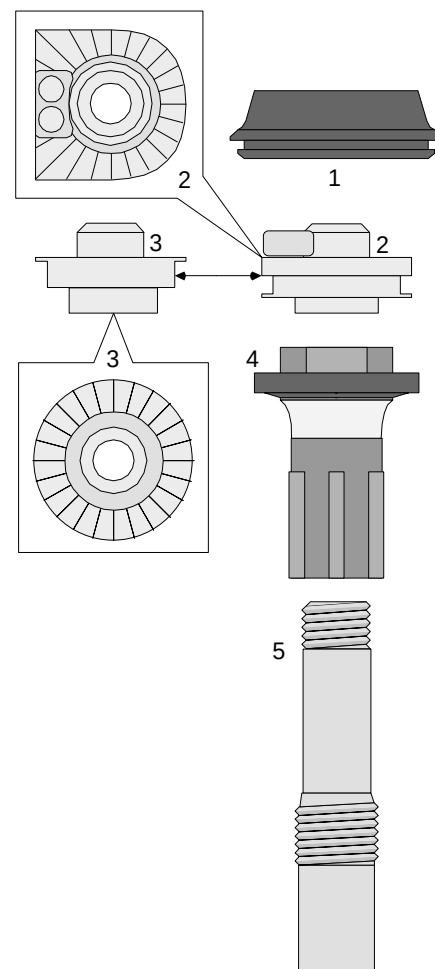
The fact that the axle does not protrude through the locknut means that there is no way to pre-load the axle and then adjust the hub. This reduces the hub adjustment to pure trial-and-error; furthermore, the design of the hub makes it impossible to use the Hub Dial Stickers or any other marking system to track the increments of adjustment. Estimating the amount that the cone wrench moves for each adjustment is the only way to control the size of each adjustment.

The presence of the “D”-shaped washer makes it virtually impossible to grasp the axle in any kind of a vise and makes it extremely difficult to grasp the end of the axle to feel for free play or a tight adjustment.

The steel locknut threads onto an aluminum axle with very little thread engagement due to the low profile of the locknut. The possibility of stripping axle threads is high. There is no way to measure torque, so the mechanic must subjectively reach a tightness that will not strip the axle or allow the cone to work loose. Using Loctite 222 on the cone and locknut threads greatly reduces this problem.

Service procedures

The hub with no “D”-shaped washer can be held by grasping the smooth stud protruding from the locknut face in a smooth jaw axle vise such as the Park AV-1.



12.36 Parts of a Shimano Parallax hub with an 11mm axle: 1. rubber seal, 2. locknut/ “D”-washer assembly, 3. alternate regular locknut, 4. cone w/ seal, 5. 11mm axle.

To hold the axle while disassembling a hub with a “D”-shaped washer, gently grasp the smooth stud and the tab on the face of the “D”-shaped washer in a smooth-jawed vise.

When adjusting the hub, grasp the axle in an axle vise or bench vise so that it cannot rotate. Start with the cone backed off at least 90° from the point it first contacts the bearings. Secure the locknut. Jiggle the end of the axle to check for free play. Do not interpret the looseness of the “D”-shaped washer as play in the bearings.

When the amount of free play is correct, it should disappear when the wheel is securely mounted in the fork and reappear when the skewer is loosened 45° . It will take repeated trial and error adjustments to find the subtle setting that has no play when the skewer is fully tight but has play when the skewer is loosened 45° .

ADJUSTABLE-CONE-HUB TROUBLESHOOTING^(table 12-3)

Cause	Solution
SYMPTOM: <i>The axle feels tight or rough to rotate when play is first eliminated (or on a quick-release hub it fails to develop play when the quick-release lever is loosened 45°).</i>	
Last adjustment was too large.	Try to find an in-between adjustment.
Misinstalled dustcap rubbing on axle set.	Observe whether dustcap turns true as the wheel turns and reset if needed.
Bent axle causes portion of the axle set to rub dustcap.	Inspect for bent axle and replace.
Dry grease.	Disassemble, inspect, overhaul.
Cones and/or cups galled.	Disassemble, inspect, replace parts.
Seal mechanism drag.	Check that seal mechanisms are not incorrectly positioned and/or lubricate seals.
Wrong size balls.	Disassemble, measure balls.
SYMPTOM: <i>Play cannot be eliminated without severely over-tightening the adjustment.</i>	
Locknut on end of axle set that is mounted in vise not secured.	Check locknut security.
Cups and/or cones galled.	Disassemble, inspect and replace.
Loose cups in hub shell.	Disassemble, inspect and repair with appropriate Loctite.
SYMPTOM: <i>Properly adjusted bearings feel sluggish but not rough when rotating the axle.</i>	
Seal mechanism drag.	Grease seal mechanisms.
Dry grease.	Disassemble, inspect, overhaul.
Plastic dustcap rubbing.	Align dustcap.
SYMPTOM: <i>When adjusting or inspecting the hub, an erratic looseness or tightness is detected that comes and goes and changes location.</i>	
Too many balls in the cup(s).	Disassemble and check ball quantity.
SYMPTOM: <i>When rotating the axle set, a pattern is detected of a consistent tight spot and a consistent loose spot.</i>	
Bent axle.	Inspect for bent axle and replace.
Low-precision parts.	None.
SYMPTOM: <i>When inspecting the cone, a wear pattern is detected that is high on the cone race on one-half of the cone and is low on the cone race 180° away.</i>	
Bent or broken axle.	Inspect and replace.
SYMPTOM: <i>Axle is bent or broken.</i>	
Dropouts are misaligned.	Check and align dropouts.
Weak dropouts combined with a weak axle.	Avoid using quick-release axle, or upgrade quality of solid axle.
High torque from very low gear pulls cog set and hub forward beyond the elasticity of axle.	Use strongest axle available.
SYMPTOM: <i>When riding the bike, a clicking sound is heard from a hub (usually the front), but the hub feels normal when inspected.</i>	
Loose balls rotating around the cone drop over the top of the cone and bump into the last ball over the top.	Normal, but possibly the hub is short on grease.
SYMPTOM: <i>When inspecting the cone, the wear pattern is very high or very low on the cone race. Wear life has probably been very short.</i>	
Wrong size balls.	Measure balls.
Inappropriate cone for hub.	Inspect cone.

13 – CARTRIDGE-BEARING HUBS

ABOUT THIS CHAPTER

This chapter is about cartridge-bearing hubs. These hubs are often called sealed-bearing hubs, but both adjustable-cone hubs and cartridge-bearing hubs can have sealed bearings. The design of cartridge-bearing hubs varies tremendously, with almost every manufacturer designing hubs in a different way. About the only factor all cartridge-bearing hub manufacturers have in common is that they all use a cartridge bearing that is pressed into the hub shell. Hadley and Conrad are names that are sometimes used for the cartridge bearing. Cartridge-bearing hubs include front hubs, rear hubs that accept a thread-on freewheel, and freehubs (rear hubs that have the freewheel mechanism integrated into the hub).

There is no way all brands and models can be covered in this chapter, so several common or representative types have been selected. The first hub covered here is a SunTour type with a threaded axle, much like an adjustable-cone hub. This type of cartridge-bearing hub is sold under the SunTour name and under the names Matrix, Sanshin, Specialized, and Performance. Cane Creek hubs are similar to the SunTour type. The second type of cartridge-bearing hub has an unthreaded axle. Nuke Proof is an example of this type of hub. It is similar (but not identical) to hubs made by American Classic, Bullseye, and Cook Bros. The third type is the Hügi hub, which is a unique design, but common enough to merit covering it. The fourth hub is a Ringle hub, which is also unique. The fifth type is a Phil Wood FSA model. The next hub is a White Industries TI Cassette Hub, and finally the Chris King hub. There is also a section on special tools required for these hubs.

GENERAL INFORMATION

TERMINOLOGY

Hub shell: The main structure of the hub. The hub shell includes the housing for the bearings, which contains a hub core and two hub flanges.

Axle: The shaft that goes through the hub, about which the hub turns.

Bearing cartridge: A fully self-contained bearing unit that cannot be disassembled. A bearing cartridge includes ball bearings and an inner and outer race. The bearings are usually hidden behind seals. The entire assembly is shaped like a short cylinder with a hole through the center.

Inner race: The cylinder at the inner perimeter of a bearing cartridge.

Outer race: The cylinder at the outer perimeter of a bearing cartridge.

Locknut: A nut that threads onto an axle and against another locknut or the bearing cartridge to lock the position of the bearing cartridge relative to the axle.

Sleeve nut: A locknut that threads onto an axle and inserts into the bearing cartridge to lock the position of the bearing cartridge relative to the axle.

Dustcap: A piece that threads or presses onto the outer end of the hub shell to cover the hole through which the bearings are accessed.

Circlip: A metal ring that fits in a groove on the outside or inside of a cylinder to trap the location of another item, on or in, the cylinder. Its shape must be deflected to get a circlip out of its mounting groove. Sometimes called a *snap-ring*.

PREREQUISITES

Wheel removal and installation

Before overhauling or adjusting a hub, the wheel must be removed from the bike. See the **WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION** chapter (page 18-6) if unsure about wheel removal and installation.

Freewheel removal and installation

To overhaul or adjust a rear hub with a thread-on freewheel, it is necessary to remove the freewheel. See the **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** chapter (page 25-9) for freewheel removal. If not yet be acquainted with chapter 25, it may be unclear whether the hub has a thread-on freewheel or is a freehub. If the hub is a SunTour brand freehub, the hub core will appear unusually fat. If unsure, or if a mistake identifying whether the hub is a freehub is made, it will not be a big problem. If unsure or mistaken in identifying

13 – CARTRIDGE-BEARING HUBS

whether the rear hub is a freehub, it will not be a big problem. If the rear hub is actually a freehub, then when attempting freewheel removal no notches or splined hole in the face of the freewheel will be found to engage the freewheel remover. This chapter is also needed to perform an optional freehub-body removal and installation on a freehub.

INDICATIONS

There are several reasons to overhaul the hub(s), and several reasons to adjust them. An overhaul should be done as part of a regular maintenance cycle, the duration of which will change depending on the type of riding, the amount of riding, and the type of equipment. Adjustments should be done on the basis of need.

Maintenance cycles

If starting out with hub(s) known to be in good condition with good quality grease, they should be able to be ridden thousands of miles without needing an overhaul. If the equipment sees little wet-weather riding, then an appropriate maintenance cycle would be 2000–3000 miles in most cases. This short cycle may be surprising. It is commonly thought that cartridge-bearing hubs are maintenance-free because they are “sealed.” The seals in these hubs are effective for keeping dirt out, and increase the longevity of the grease by minimizing exposure to air that dries out grease. The seals are no guarantee that water will not get in the bearings, and they do not prevent internal wear from contaminating the grease with microscopic abrasive particles of metal. If a lot of wet-condition riding is done, then the maintenance cycle might need to be as often as every 750–1000 miles. Parts rust whether being ridden or not, so another factor is how long the bike may be sitting before it will be used again. For example, if ridden 200 miles in the rain in the fall, then put away four months for the winter, it would probably be a good idea to overhaul the hub(s) before putting the bike away for the winter.

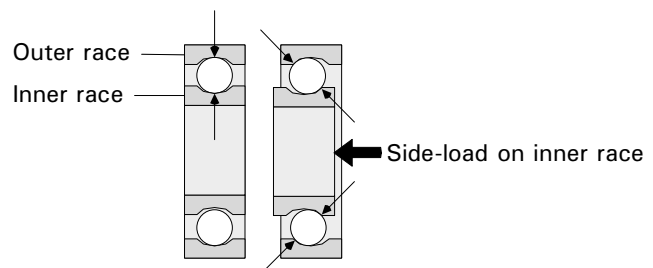
Another factor affecting the maintenance cycle is whether there is grease injection. *Grease-injection systems do not eliminate the need for overhaul.* They only increase the acceptable time between overhauls; furthermore, they are only as good as the customer is consistent and thorough about pumping in new grease. At best, they can lengthen the acceptable time between overhauls. With grease-injection systems, the best policy is to initially overhaul the hub(s) on a normal length maintenance cycle, and if the grease is found to be in good condition, then extend the cycle the next time.

Symptoms indicating need of overhaul

What symptom would lead to the feeling that the hub(s) should be overhauled? One is that when turning the axle it does not turn smoothly. Since there are no adjustments on most cartridge-bearing hubs, the tightness is unlikely to be caused by a poor adjustment. The lack of smoothness could be caused by dry grease, contaminated grease, or worn parts. Another is that when removing the wheel and rotating the axle, the end of the axle oscillates, indicating a bent axle (which should always be replaced). Yet another symptom is a squealing or clicking sound coming from the hub that indicates a bearing is loose in its mount. Finally, the hub may have a broken axle, which may not be obvious until the quick-release skewer is removed, and then the axle falls out in two pieces.

Symptoms indicating need of adjustment

Technically, cartridge bearings cannot be “adjusted.” This is because, unlike an adjustable-cone hub which has a cup facing out toward the end of the axle and a cone facing in toward the middle of the axle, a cartridge bearing has an inner race facing out from the *axis* of the axle and an outer race facing in toward the *axis* of the axle. On an adjustable-cone hub, the bearing is adjusted by moving the cone on the axle so that it becomes closer to or further from the cup. In a cartridge-bearing hub, moving the inner race closer or further from the outer race could only be accomplished by expanding or shrinking the race, which is impossible since it is hardened steel. On the other hand it is possible to *mis-adjust* a cartridge bearing on a threaded axle. If the hardware on the axle just outside of the inner race is threaded onto the axle too far, it will *displace* the inner race from the correct orientation with the outer race, causing the ball bearings to bind between them. This happens because the balls ride in shallow troughs in each race. When the troughs do not line up with each other, the effective width of the channel they create together becomes narrower than the ball bearings.



13.1 The side-load on the inner race of the right bearing cartridge causes contact to occur between the races and the ball bearings at inappropriate points (contact points indicated by arrows).

The symptom created when the hardware is too tight against the inner race is that of a tight bearing. In the case that the axle is quick release (usually), the symptom may go away when the wheel is removed from the bike because of the nature of quick-release axles to expand when the load of the quick-release skewer is released. Therefore, a hub that is apparently fine when checked out of the bike could be over-tight in the bike (when there is no way to check it). Mavic hubs are an exception to this because they are designed to be adjusted while the wheel is mounted in the bike.

For this reason, adjusting the hub(s) is recommended for any new bike. On threaded-axle cartridge-bearing hubs, the only way to know that the hardware is not too tight is to adjust it. Most retail outlets assume the factory has done its job correctly, and don't check the adjustment. Factory adjustments are not very reliable. Hubs may be completely worn out after as little as 1000 miles of use, due to poor factory setup.

ABOUT THE REST OF THIS CHAPTER

From here on, this chapter is divided into nine sections. The sections are for servicing the SunTour type hubs, the Nuke Proof type hubs, Hügi hubs, Ringle hubs, Phil Wood FSA hubs, White Industries hubs, and Chris King hubs. The final section is about tools for servicing cartridge-bearing hubs. Remember, the SunTour steps apply almost verbatim to certain Matrix, Specialized, Sanshin, and Performance hubs. The Nuke Proof steps apply *loosely* to American Classic, Bullseye, and Cook Bros. The remaining sections are completely specific to the hub each is written about.

SUNTOUR HUBS AND SIMILAR HUBS

As of the summer of 1995, the SunTour company has quit doing business in the U.S. This situation presents some potential service limitations. Fortunately, axles for SunTour hubs are not unique, and neither are the cartridge bearings. The sleeve nuts are the only unique part in this type of hub, and these are unlikely to wear out. Wheels Manufacturing of Boulder, Colorado, makes an item called the Dropout Saver DS-1 (used for replacing threads in a derailleur hanger) that is an adequate substitute. To use the Dropout Saver, a cone wrench would need to be thinned down on

the grinder, because the height of the wrench flats on the Dropout Saver is less than the thickness of any cone wrench.

TOOL CHOICES

The following table covers tools for SunTour-type cartridge-bearing hub(s) only.

SUNTOUR HUB TOOLS (table 13-1)

Tool	Fits and considerations
SunTour TA-340	Removes and installs bearing cartridges, no longer sold.
CalVan 28	Removes bearing cartridges only.

TIME AND DIFFICULTY RATING

Overhauling the hub, including freewheel removal and bearing replacement, is a 15–20 minute job of little difficulty. Adjusting the hub alone (including freewheel removal) is a 5–10 minute job of little difficulty.

COMPLICATIONS

Difficult bearing removal

If using the SunTour TA-340 removal tool, the tool sometimes pops out of the bearing before the bearing removes from the hub shell. This may happen because the tool being used to drive against the TA-340 is the wrong shape, or because the TA-340 has been distorted. The driving tool needs to be close in diameter to the hole in the middle of the bearing and should be completely flat on the ends. An old 10mm quick-release axle is adequate, but an 11mm round shaft with a flat end is better. See figure 13.10 (page 13-7).

Once the TA-340 removal tool is forced through the hole in the middle of the bearing, it becomes distorted and is more likely to push through again. Bend the tool so that the two ends are even and parallel.

Difficult bearing installation

Bearings are usually not difficult to install in this type of hub unless they become misaligned during installation. If the bearing, installation washer, and sleeve nut are assembled as a unit and kept together, this will not be a problem. Make sure that the bearing and installation washer are both on the sleeve of the sleeve nut before beginning installation. See figure 13.11 (page 13-9).

13 – CARTRIDGE-BEARING HUBS

Mysterious squeals, clicks, and pops

Mysterious noises of these types usually occur only while riding the bike. They are caused by the bearing moving inside the hub shell, or by motion between the sleeve nut and the inner race of the bearing. The bearing cartridge is supposed to be a press fit to both the shell and the sleeve nut, so Loctite 222 or 242 should be used when these noises occur and there is evidence that the bearing is a loose fit inside or outside.

Lack of correct tools

The SunTour TA-340 tool set is no longer distributed by SunTour. For bearing removal, the CalVan 28 (United Bicycle Tool) is a good substitute. The SunTour tool set also comes with special washers for pressing in the bearings. These washers have a lip at the outer perimeter that presses against the outer race of the bearing without pressing on the inner perimeter. They also are slightly smaller in diameter so that they could drive the bearing inside the hub shell without getting stuck themselves. The best substitute for these washers is a pair of used bearings. Use a small grinding stone on a rotary or Dremel tool to recess the lip of the inner race of the old bearings by a small amount. Spin the outside of the old bearings against a grinding wheel for a moment to reduce their O.D.

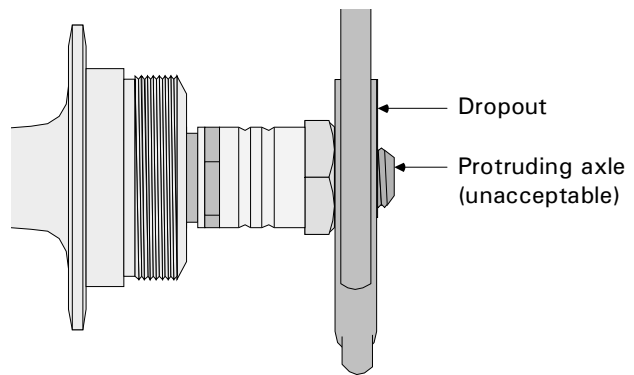
HUB-AXLE THREADS

Axle threads for these hubs (regardless of brand and whether the axle is solid or quick release) are 9mm × 1mm for the front hub and 10mm × 1mm for the rear hub. These diameters are nominal, the 9mm axle measures between 8.7–8.9mm and the 10mm axle measures between 9.7–9.9mm. The inside diameter of the nuts that fit on the 9mm axle will range from 7.8–8.1mm and the inside diameter of the nuts that fit on the 10mm axle will range from 8.8–9.1mm.

NOTE: *If just adjusting hub and not overhauling it, do steps 1–7, then skip to heading FINAL SETTING just after step 66 (page 13-9).*

COMPONENT REMOVAL AND PRE-DISASSEMBLY INSPECTION

1. [] Remove wheel from bike and skewer (if any) from hub.
2. [] Place wheel back in dropouts.



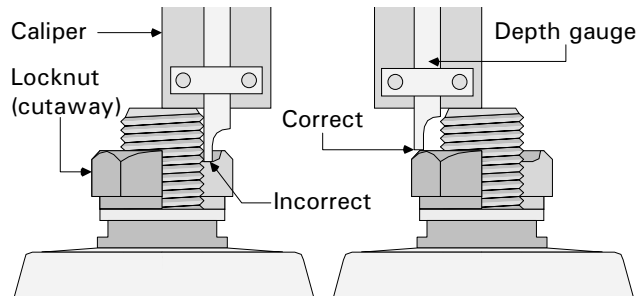
13.2 *It is unacceptable for the quick-release axle to protrude beyond the face of the dropout.*

3. [] **Observe wheel in bike and determine whether QR axles protrude beyond dropout faces.**
4. [] **If QR axles protrude, measure dropout thickness. This is maximum allowable axle protrusion. Maximum axle protrusion (dropout thickness) is: _____ mm.**
5. [] **Rotate axle and check for oscillation at ends that indicates bends.**
6. [] **Rotate axle and feel for severe grittiness that indicates worn out parts or over-tight adjustment.**
7. [] **Remove freewheel (if any, for overhaul or adjustment) or freehub cogs (for overhaul only, not adjustment).**

In the next step, the correct axle protrusion will be determined (the distance the end of the axle protrudes beyond the face of the locknut that is found just inboard of the dropout). In most cases, the axle protrusion should be equal on both sides. One rare exception is when one dropout is thicker than the other (in which case the axle protrusions should differ by the amount that the dropout thicknesses differ). Certain inexpensive bikes have a plate of metal that the derailleur attaches to, which bolts onto the outer face of the right-rear dropout. This is called a bolt-on derailleur hanger. The bolt-on derailleur hanger is part of the dropout, so in this case consider the right dropout to be thicker than the left dropout by the thickness of the bolt-on hanger.

In the next steps, measure the two axle protrusions and average them to determine the correct axle protrusion. If there is a right-rear dropout that is thicker, add half the difference in thickness to the average axle protrusion for the correct right-side protrusion, and subtract half the thickness difference from the average axle protrusion for the correct left-side protrusion.

When measuring the axle protrusion, use the depth gauge of a caliper and measure from the high point on the face of the locknut to the end of the axle. Some axles have a recess in their face. *Do not measure down into any recess.*



13.3 Measuring the axle protrusion.

Determine correct axle protrusion:

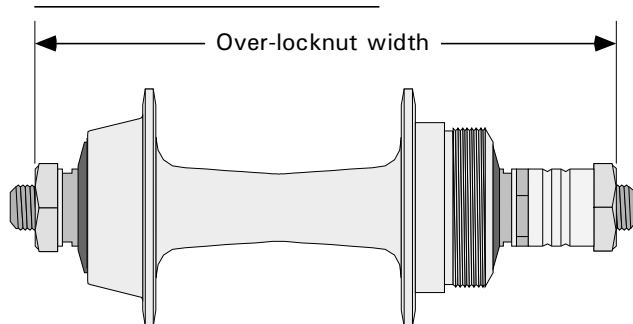
8. [] Right-side axle protrusion: _____ mm
9. [] Left-side axle protrusion: + _____ mm
10. [] Total axle protrusion is: = _____ mm

÷ 2

11. [] AVG. AXLE PROTRUSION IS: = _____ mm

Measure over-locknut width

In the next step, measure the overall width from the left locknut to the right locknut. This measurement is needed if replacing any parts on the hub with non-exact replacements. If some sort of substitute part that is not the same effective width as the original is used, it could affect the fit of the wheel to the frame or fork. By knowing how much the final width differs from the original width, it will be known how many washers to add or subtract on the side of the hub where the substitute part was installed.



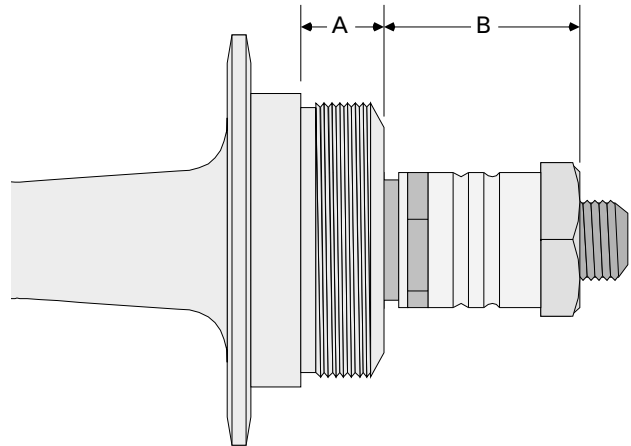
13.4 Measuring the over-locknut width.

12. [] Measure over-locknut width.
OVER-LOCKNUT WIDTH IS: mm

NOTE: Front hubs skip to step 17.

Step #13 through #16 apply to rear hubs only. The purpose of these steps is to get a measurement that corresponds to the distance the freewheel or freehub

cogs sit from the dropout. This distance must be maintained when overhauling the hub or the rear derailleur might need adjustment or the freewheel may not even have enough room to be re-installed. The measurement will not be needed unless replacing right-side parts with non-identical parts, or if left-side and right-side parts get mixed up.



13.5 Measure freewheel space by adding these two measurements together.

NOTE: Skip to step 16.

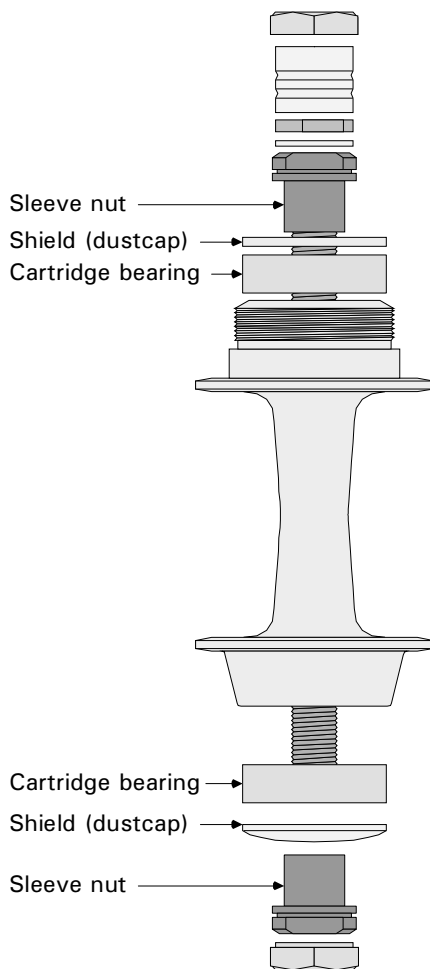
***Thread-on-freewheel rear hubs only,
measure and calculate freewheel space***

13. [] Freewheel shoulder to
end-of-shell: _____ mm
14. [] End-of-shell to
locknut face: + _____ mm
15. [] FREEWHEEL SPACE: = _____ mm

NOTE: Skip to step 17.

16. [] For freehubs, measure from end of free-wheel-mechanism body (where cogs came off) to locknut face.
FREEHUB SPACE IS: _____ mm

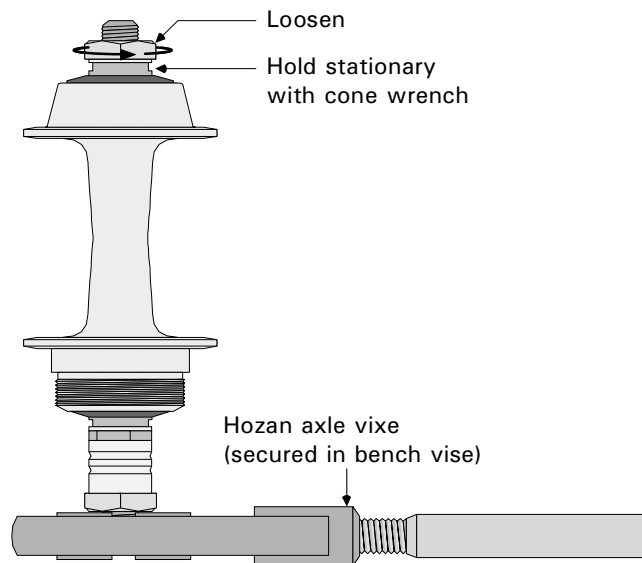
13 – CARTRIDGE-BEARING HUBS



13.6 A SunTour cartridge-bearing hub.

DISASSEMBLY

Disassembling the first end of the axle is a lot easier if the axle is not free to turn. The ideal way to do this is to have the end of the axle that is not being disassembled held in a bench vise. When securing the axle in a vise, it is easy to damage either the axle or the locknut. If the axle is a not-quick-release type, there is enough axle to grasp securely with the axle directly in “soft jaws.” Soft jaws are inserts made of aluminum, copper, plastic, or wood that cover the face of the vise jaws. All of these materials are softer than the axle threads so the axle threads will not be damaged. Quick-release axles do not protrude far enough to get a good grip with soft jaws, which might lead to clamping the vise tighter, which could crush the hollow quick-release axle. For this reason, a special axle-vise is required for use with quick-release axles. Grasping the axle by the locknut can lead to damage of the locknut.

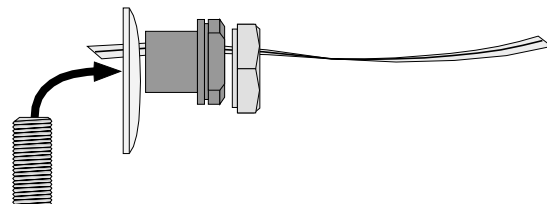


13.7 With the hub secured in a Hozan axle-vise, use a cone wrench to hold the inner nut while breaking loose the locknut.

17. [] Clamp **right** end of QR axle in axle-vise, or **right** end of solid axle in soft jaws.

18. [] Hold left inner nut stationary with cone wrench while breaking loose left locknut with adjustable wrench. (Use cone wrench only if locknut is round.)

There are few standards about the number and sequences of parts on the end of the axle. Furthermore, keeping left-side and right-side axle parts separate is critical on rear hubs (front hubs usually have symmetrical parts). For this reason, transfer parts directly from the axle to a bundling tie (wire or plastic bread-bag ties work) one at a time. Some parts, particularly outer locknuts, have a certain way they need to face, so it is just as important to maintain the specific orientation of each part as it comes off the axle as it is to maintain the order.



13.8 Transfer the parts one-by-one from the end of the axle to a bundling tie to maintain the correct order and orientation.

19. [] Thread left-end parts off axle and onto bundling tie while maintaining order and orientation. If hub rises up as inner nut is turned (called a sleeve nut because of sleeve that extends inside bearing), push down firmly on wheel to get it free of sleeve nut.

20. [] **Lift hub off axle. It may require a bit of a jerk to get it to release from lower sleeve nut.**

Steps #21 through #24 remove the right-side axle parts. This enables checking for a bent axle, damaged threads, and to reset the right-side axle protrusion if necessary. The tendency is to skip these steps but some important problems could be missed, especially if this is the first time overhauling this hub.

In these steps, put the right-side parts onto two bundling ties. This will enable keeping track of the left-side (first off, single tie) and right-side (second off, two ties) parts.

21. [] **Reverse axle in axle-vise or soft jaws.**

22. [] **Hold sleeve nut (or lower locknut of double-locknut hub) stationary with cone wrench while breaking loose locknut with adjustable wrench. (Use cone wrench if locknut is round.)**

23. [] **If double-locknut hub: hold sleeve nut stationary while breaking loose lower locknut.**

24. [] **Thread right-end parts off axle and onto two ties, while maintaining order and orientation.**

Some models of this hub may have a metal dustcap between the sleeve nut and the bearing. The dustcaps are symmetrical on front hubs, but rear hubs usually have different dustcaps on the right and left sides. If there is confusion as to which dustcap goes on which side, the right one is usually less “attractive” than the left one. The left one may have a brand name on it, and will have a shiny polished finish.

25. [] **Remove metal dustcaps, if any, from bearings and attach to appropriate bundles.**

Next, either remove the bearing seals in order to clean and regrease the inside of the bearing cartridges, or remove the bearing cartridges in order to replace them. The act of removing the cartridges involves impacts that can destroy the bearing. Never attempt cartridge-bearing removal unless planning to replace the bearings and it is known where to get replacements. There are numbers on the seal that indicate the bearing type to help find replacements, if needed. On most models the number is 6001.

26. [] **Rotate inner races to inspect their condition and decide whether to attempt cleaning and regreasing or full replacement of cartridges.**

Regreasing bearing cartridges

NOTE: If replacing, skip to step 31.

If, when rotating the inner race of the bearings, they feel rough or sluggish, they may need cleaning and regreasing, or replacement may be required. If they don't feel good after cleaning and regreasing they will need to be replaced.

If just wanting to clean and regrease the bearings, they should be left in the hub. Removing the seals is a little tricky, but it can be done. The seal looks like black rubber, but actually it is a flat metal ring pressed into the outer race and coated with rubber. At its inner perimeter, there is a rubber lip that a small screwdriver or seal pick can pass by and catch under the metal ring in order to lift it out. The metal ring is easily bent, so pry gently and try prying at several points right next to each other if the seal does not lift right out. If it is only bent a little bit, it can be flattened and reused.



13.9 Removing the seal from the bearing.

27. [] **Gently insert tip of a 1/8" slotted screwdriver or seal pick under soft lip at inner perimeter of black rubber seal on face of bearing and lift out seal.**

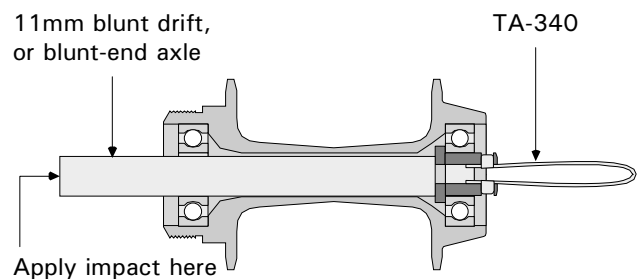
28. [] **Clean grease out of bearing area with solvent and a toothbrush and dry thoroughly.**

29. [] **Pack bearings with grease and press seals back in.**

30. [] **Skip to heading INSPECTION.**

Removing bearing cartridges

31. [] **Insert removal-tool portion of SunTour TA-340 tool set into either of bearings so that lips catch behind bearing.**



13.10 Driving out the bearing cartridge.

32. [] **Insert axle from opposite side of hub against inward end of removal tool and tap on axle with a ball peen hammer to drive tool and bearing out of hub.**

33. [] **Look for a spacing washer (only some models) in hub shell that was behind the bearing and attach it to appropriate parts bundle.**

13 – CARTRIDGE-BEARING HUBS

34. [] Repeat steps 31–33 for second side.

The next step only applies to rear freehubs, and is optional. The hub can be cleaned with the freehub body still attached. It makes for extra work when drying after cleaning. Techniques for freehub-body removal are not covered here, as they are optional and *are* covered as part of the **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** chapter (page 25-18).

35. [] Only if working on rear freehub, remove freehub body (optional).

36. [] Clean all parts, including outside of hub shell.

INSPECTION

Hub-shell damage with regard to the bearings is rare. Primarily this will occur if the original tolerances were poor and the bearing cartridge was a loose fit in the hub shell. Loose bearing cartridges would have been noticed during bearing removal, or before even attempting removal. The hub shell is now oversized, but the problem can be solved by reinstalling the bearing cartridge with Loctite 242.

37. [] If bearing cartridges have been regreased, turn inner race to feel for any roughness. If they are rough they should be replaced. Return to step 31.

38. [] Inspect fit of bearing cartridges to hub shell. Good (tight)? Bad (loose)?

The sleeve nuts are supposed to be a mild press fit inside the bearing cartridges. If they slip in and out effortlessly, or if the outside of the sleeve on the sleeve nut has a polished appearance, the fit is bad. It can be corrected by using Loctite 242 between the sleeve nut and the bearing.

39. [] Inspect sleeve nuts for looseness in bearing cartridges. Good? Bad?

Next, inspect the axle for bends. Roll the axle on a flat smooth surface such as a Formica counter top or a glass counter. Look under the axle as it rolls for a humping up and down that indicates the axle is bent. A bent axle is an axle in the process of breaking, and should be replaced. A bent axle can be caused by misaligned dropouts, so check the dropouts. Axles can also bend from severe impact to the wheel or high pedaling loads.

40. [] Inspect axle for bends. Good? Bad?

Threads can be damaged on the axle from getting nicked, or from excess torque on a locknut, which results in stripped threads. If the threads are nicked from impact, they can be repaired with the thread file. Threads stripped from an over-tightened locknut cannot be repaired. Replace the axle.

41. [] Inspect axle for damaged threads.

Good? Bad?

42. [] Inspect locknuts for damaged threads, cracks, warpage, and rounded off flats.

Good? Bad?

ASSEMBLY

If installing a new axle, the length does not have to match exactly. For quick-release axles, the minimum axle protrusion per side should be no less than one-half the dropout thickness, and the maximum should be no more than the dropout thickness. For non-quick-release axles, the minimum length should be no less than the sum of the dropout thickness, plus the thickness of the washers under the axle nuts, plus the thickness of the axle nuts.

NOTE: *If not replacing axle with a new one of different length skip to step 46.*

Calculate new axle protrusion

43. [] Measure difference between axle lengths.

Difference is: _____ mm

Divide by two: _____ ÷ 2

1/2 difference is: _____ = _____ mm

44. [] Repeat original average axle protrusion here (from step 11): _____ mm

45. [] If new axle is shorter, subtract (or if longer, add) the difference from/to old protrusion.

NEW AVG. PROTRUSION IS: _____ = _____ mm

46. [] Replace bad parts on bundles with good parts.

Freehub-body installation

If the freehub body was removed in step #35, it is time to install it. Be sure it is dry and oiled inside. Techniques for cleaning, drying, oiling, and installation are all covered in the **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** chapter (page 25-??).

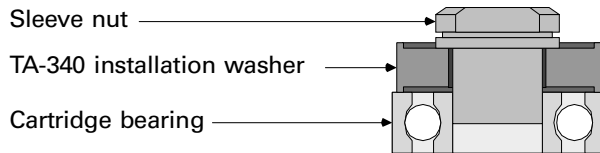
47. [] Install freehub body if it was removed in step 35.

NOTE: *Hubs with bearing cartridges already installed skip to step 56.*

Installation of the cartridge bearings

Bearing cartridges sometimes have the same seal on both faces, and sometimes the seals are different. In general, the black rubber seal should face out when the bearing cartridge is installed. In the next step, the sleeve nuts, axle, and the black washers from the TA-340 tool set combine to form a bearing-cartridge installation tool. If used properly, the set-up guarantees that cartridges go in straight and do not bind. The key to this is having the sleeve nut *inside* the bearing cartridge during installation.

48. [] Secure vise on flats of sleeve nut, with sleeve pointing up.
49. [] Thread axle into sleeve nut.
50. [] Slip TA-340 washer and then bearing cartridge over sleeve. Install bearing-spacer washer (if any) on top of bearing. It may be necessary to use a little force to get bearing cartridge onto sleeve nut.



13.11 Assemble the TA-340 installation washer and the bearing cartridge to the sleeve nut.

51. [] Place hub on axle, resting on bearing.
52. [] Install other bearing-spacer washer (if any) into hub shell.
53. [] Slip other TA-340 washer and then other bearing cartridge over other sleeve nut. It may be necessary to use a little force to get bearing cartridge onto sleeve nut.
54. [] Thread sleeve-nut/washer/bearing assembly onto axle and use wrench on sleeve nut to press bearing cartridges fully into hub.
55. [] Unthread sleeve nuts from axle and return sleeve nuts to parts bundles.

Set right-side axle protrusion

56. [] Grease axle threads.
57. [] Install axle in axle-vise or soft jaws with right end up. (Right end is longer-threaded end if right parts bundle is bigger bundle, or shorter-threaded end if right parts bundle is smaller bundle.)

When disassembling an axle set, the assumption is that all parts are in the correct orientation. If the parts are not in correct orientation, or if the bundle came apart during cleaning and the parts orientation is uncertain, make sure the outer locknuts go on correctly. If one side of the locknut is flat and smooth and the other side is not, then the non-smooth side faces out, so as to grip the inside face of the dropout and hold the wheel more securely in the bike.

58. [] Transfer all parts from right-side bundle (two ties) to axle.
59. [] Position top locknut so axle protrusion equals average axle protrusion plus .2mm.
60. [] Hold top locknut stationary with wrench and tighten parts below it snugly up against locknut.
61. [] Measure axle protrusion and adjust if necessary.

62. [] Loosen axle-vise (or vise) slightly, so that axle is free to turn.
63. [] Hold sleeve nut with cone wrench and torque locknut to 120–180in-lbs (30–45lbs@4").

Install axle in hub

64. [] Turn axle over.
65. [] Drop hub (right-side down) onto axle assembly.
66. [] Transfer left-side parts bundle to axle. It may be necessary to press hub down onto lower sleeve nut to have enough room to install left-side parts.

FINAL SETTING

The final setting is different if the hub has a quick-release axle, than it is if the hub has a solid axle (wheel held on by axle nuts). The reason for this difference is that the force of closing down a quick-release lever compresses the axle, making any out-of-the-bike adjustment of the hub that is perfectly adjusted over-tight once the wheel is in the bike. There are two procedures for the final setting; whether the hub has a quick-release axle or a solid axle determines which procedure to follow.

If axle is non-quick release

NOTE: If axle is quick release type skip to step 70.

67. [] Turn sleeve nut in clockwise until both sleeve nuts bottom against bearings.
68. [] Back sleeve nut out counterclockwise 45° (one-eighth turn).
69. [] Holding sleeve nut stationary with cone wrench, secure locknut to 120–180in-lbs (30–45lbs@4").

If axle is quick release

NOTE: Skip to step 73 for non-quick-release axles.

70. [] Turn sleeve nut in clockwise until both sleeve nuts bottom against bearings.
71. [] Back sleeve nut out counterclockwise 90° (one-quarter turn).
72. [] Holding sleeve nut stationary with cone wrench, secure locknut to 120–180in-lbs (30–45lbs@4").

Completion

73. [] Remove wheel from vise, install freewheel or frehub cogs (if any), install wheel normally.

NUKE PROOF AND SIMILAR HUBS

This section is written primarily about Nuke Proof hubs, but applies as well to other varieties that are similar, including Suzue, Bullseye, American Classic.

TOOL CHOICES

The design of the Nuke Proof hub requires only a 3/64" size Allen wrench. The Bullseye hub requires a 5/64" Allen wrench. A drift punch is also needed to remove one of the bearings.

In addition, a plastic mallet and a variety of other common tools are used.

TIME AND DIFFICULTY RATING

Overhauling a Nuke Proof style hub, including freewheel removal and bearing replacement, is a 10–15 minute job of little difficulty.

COMPONENT REMOVAL AND PRE-DISASSEMBLY INSPECTION

1. [] Remove wheel from bike and skewer (if any) or wheel mounting bolts from hub.
2. [] Rotate axle and feel for severe grittiness that indicates worn out parts.
3. [] Remove freewheel if overhauling hub.

DISASSEMBLY

Of the varieties of hubs that this section covers, almost all have some sort of cap or spacer: one that slips onto the end of the axle. This cap may be retained by a set screw, or it may simply slip on and be held in place by the dropouts, once the wheel is mounted in the frame.

The one exception to this approach are Suzue hubs. These have a threaded axle and a pair of locknuts (with spacers between them) that are locked together on each end of the axle just outward of the bearings. A wrench and cone wrench would be used to unlock the locknuts from each other so the axle can be made bare outward of the bearings.

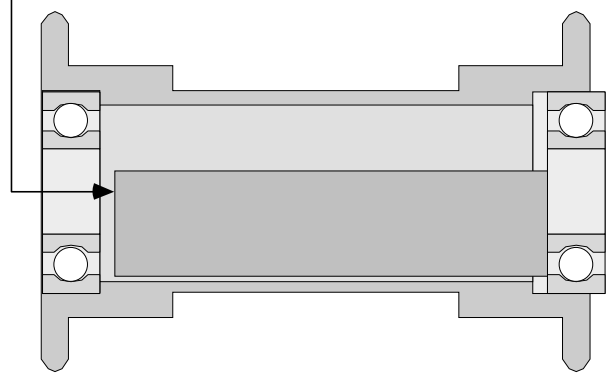
4. [] Loosen set screws on right-side spacer cap on end of axle, slip spacer cap off axle, and slip off any spacer washers. Bundle all these parts together on a tie.
5. [] Repeat step 4 for left side.

6. [] Tap on either end of axle to drive out axle and one bearing. A shoulder on the axle bears against the bearing to drive it out.

The Bullseye hub is an exception to the above step. There are no shoulders on the axle, so when it is tapped out the bearings remain in place. A spacer sleeve that goes around the axle and between the bearings will drop to one side when the axle is removed. A drift punch can be used through one bearing against the end of the spacer sleeve in order to drive the first bearing out. A punch or the CalVan 28 can be used to drive the remaining bearing out.

7. [] Turn inner race on each cartridge bearing to inspect bearing condition.

Apply force to end of spacer sleeve to drive out bearing



13.12 Bullseye bearing unit removal.

NOTE: Skip to step 11 for all hubs except Bullseye.

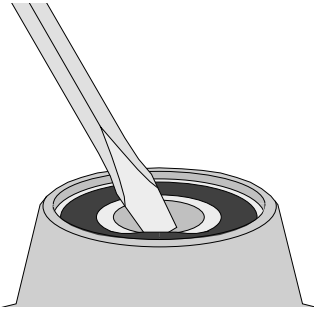
Regreasing Bullseye bearing cartridges

If the bearings feel rough, there is an option of cleaning and regreasing them, or replacing them. Impact is required to remove the bearings, so once they are removed, they must be replaced. If cleaning and regreasing does not eliminate the roughness, replacement is the only option.

If the inner race of the bearings feel rough or sluggish when rotated, they may need cleaning and regreasing, or they may need replacement. If they don't feel good after cleaning and regreasing, replacement is required.

If only cleaning and regreasing the bearings, they should remain in the hub. Removing the seals is a little tricky, but it can be done. The seal looks like black rubber, but actually it is a flat metal ring pressed into the outer race and coated with rubber. At its inner perimeter, there is a rubber lip that a small screwdriver or seal pick can pass by and catch under

the metal ring in order to lift it out. The metal ring is easily bent, so pry gently and try prying at several points right next to each other if the seal does not lift right out. If it is only slightly bent, it can be flattened and reused.



13.13 Removing the seal from the bearing.

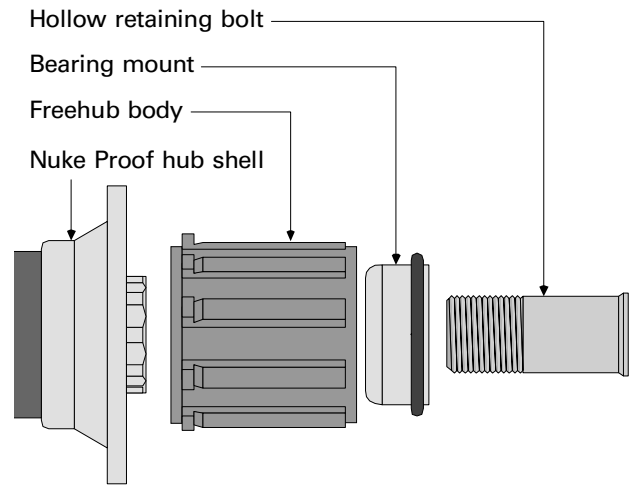
8. [] **Gently** insert tip of a 1/8" slotted screwdriver or seal pick under soft lip at inner perimeter of black rubber seal on face of bearing and lift out seal.
9. [] Clean grease out of bearing area with solvent and a toothbrush and dry thoroughly.
10. [] Pack bearings with grease and press seals back in.

Removing other bearing cartridge

Removing bearings may damage them beyond reuse, so do not remove them unless prepared to replace them. There should be a four digit number on the bearing seals that is the identification number for the bearings.

11. [] To remove bearing that was driven out with axle, support bearing on vise jaws and tap axle down out of bearing.
12. [] Insert axle in hub and drive out left-side bearing. Remove second bearing from axle.
13. [] Clean all parts, including outside of hub shell. Clean bearing mating surfaces of any corrosion, remnants of Loctite, grease, and dirt.

The Nuke Proof freehub has a bearing mount inside the freehub mechanism. There is no need to remove this for normal bearing service. It is retained by the same hollow bolt that holds the freehub to the hub shell. Use a 10mm Allen wrench to remove the bolt and the cartridge-bearing mount will come out of the freehub mechanism, and the freehub mechanism will be free to slip off the hub shell.



13.14 Freehub-body removal from a Nuke Proof hub.

ASSEMBLY

Installing the cartridge bearings and axle

14. [] Place axle (axle and spacer sleeve if Bullseye hub) inside hub shell.
15. [] Slide bearings onto each end of axle.

In the next step, load needs to be placed against the face of the bearings. Although it is possible to install them by tapping around their perimeter with a plastic mallet, this method can cause them to misalign and jam.

A better method is to devise some sort of support cylinder and driving cylinder. The perfect driving cylinder for the Nuke Proof hub is a pair of Shimano TL-FW30 freewheel removers. The diameter of the splined end of these tools closely matches the diameter of the Nuke Proof bearings and allows the pressure to be born by the outer races only. The length of these tools allows the axle to be cleared whether working on a front or rear hub.

16. [] Support one end of hub on support cylinder and use another cylinder to drive in upper bearing until both bearings are fully inserted.
17. [] Turn axle to feel if bearings are binding. If binding, tap alternately on opposite sides of axle until bearings turn smoothly.
18. [] Install caps/spacers on ends of axles.

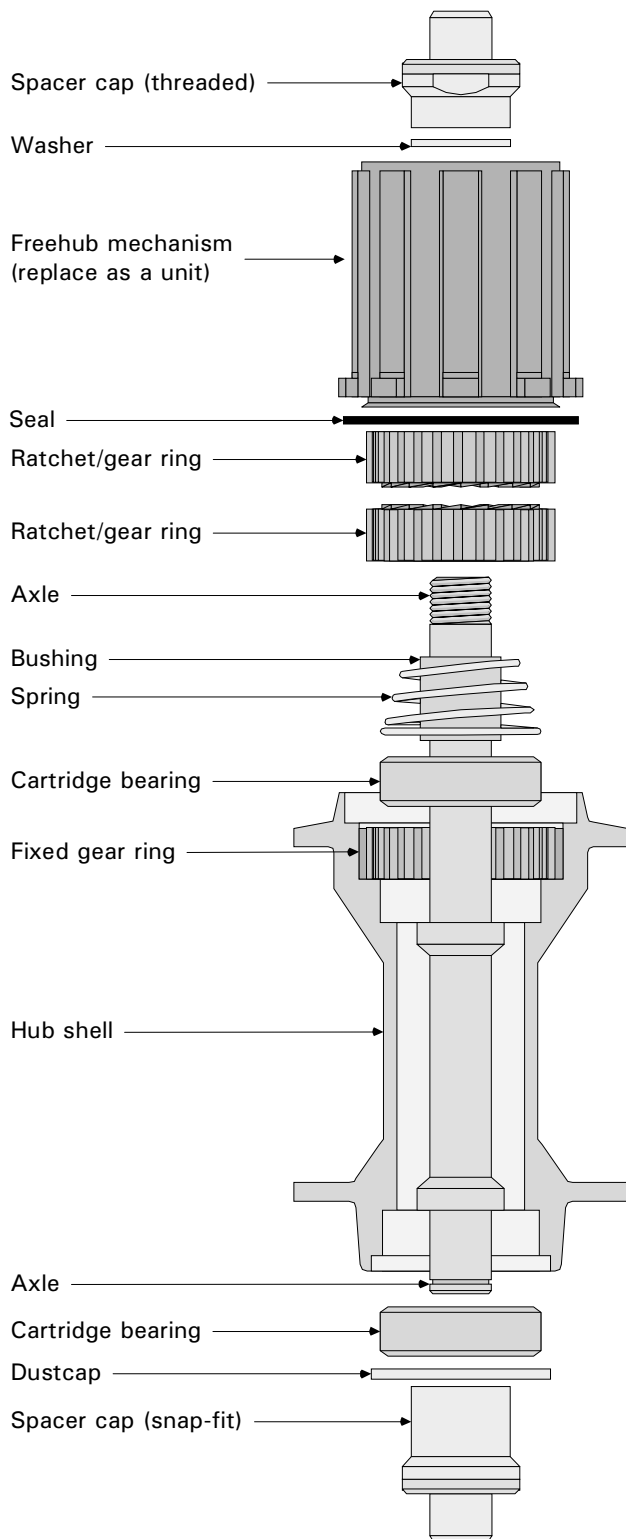
Completion

19. [] Install freewheel or freehub cogs (if any), install wheel normally.

13 – CARTRIDGE-BEARING HUBS

HÜGI FREEHUBS

This section is about Hügi freehubs. These hubs exist in several design variations, but most varieties are similar to this example.



13.15 A Hügi freehub.

TIME AND DIFFICULTY RATING

Overhauling the hub including cog removal and bearing replacement is a 15–20 minute job of little difficulty.

DISASSEMBLY

1. [] Remove cogset from hub.
2. [] Pull spacer cap off left end of axle (hold spacer cap in vise soft jaws if necessary).
3. [] Hold left end of axle in 10mm smooth jaw axle vise (fabricate larger diameter clamp blocks for other axle size).
4. [] Use 17mm cone wrench to unthread right-side spacer cap.
5. [] Pull freehub mechanism off axle.
6. [] Remove small washer from inside bearing dustcap on outboard face of freehub mechanism.
7. [] Remove ratchet/gear ring from back face of freehub mechanism.
8. [] Remove ratchet/gear ring, spring, and metal bushing from right end of axle.
9. [] Carefully remove seal from right side of hub shell.

When removing the bearing in step #10, it is important to support the hub shell in a way that will protect it. A simple support for the hub shell can be made out of a section of PVC pipe with a 1–9/16" inside diameter.

10. [] Tap right end of axle with soft hammer to drive bearing and dustcap out of left side of hub shell.
11. [] Remove bearing from left end of axle.
12. [] Insert axle back into hub shell, and drive bearing out right side of hub shell.

ASSEMBLY

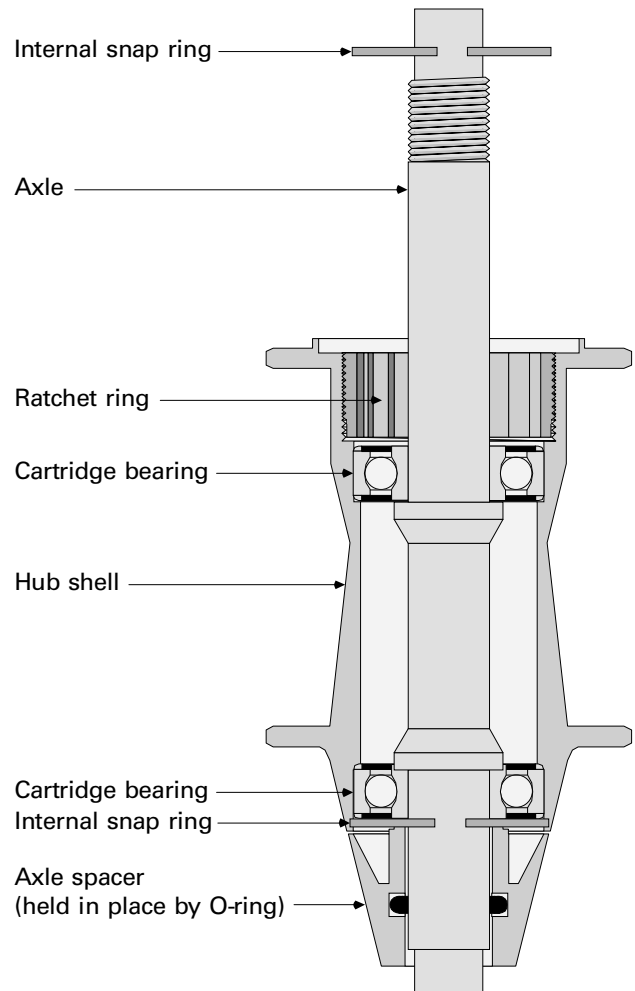
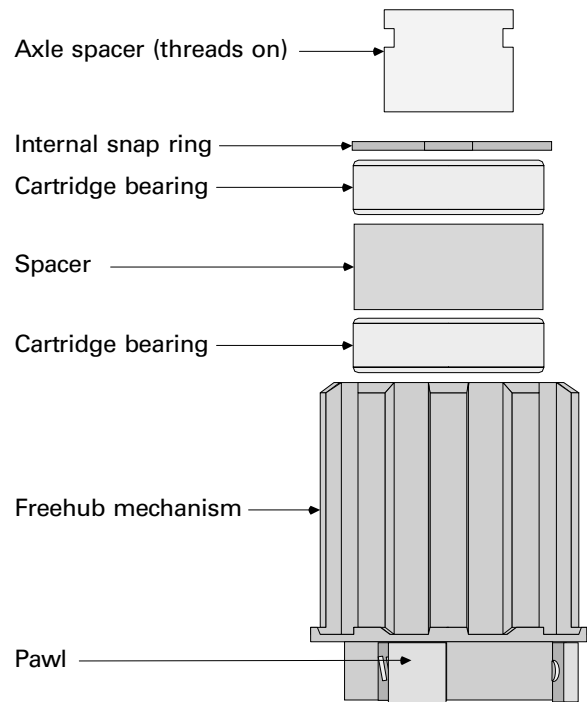
13. [] Place axle into hub shell with longer end on right.

14. [] Place bearings on each end of axle.

When removing pressing the bearings in step #15, a support cylinder (under the lower bearing) and a driving cylinder are needed. These cylinders can be fabricated from a 1" fork column, or from the center section of a handlebar that has a 1" O.D.

15. [] Place right side of hub down on top of 1" cylinder (section of fork column, or section of handlebar center).
16. [] Place second 1" cylinder on top of left-side bearing and align it carefully to bearing.
17. [] Tap on upper cylinder to simultaneously press in both bearings fully.
18. [] Mount left end of axle in axle vise.

19. [] Place seal ring over lip on inward end of freehub mechanism so that metal side of ring will face hub shell.
20. [] Grease metal bushing and place over right end of axle.
21. [] Place conical spring over metal bushing, small end facing out.
22. [] Grease one ratchet/gear ring and place in right end of hub shell with toothed-face facing out.
23. [] Grease other ratchet/gear ring and place in inside end of freehub mechanism so that toothed face faces out of freehub mechanism.
24. [] Slide freehub mechanism onto right end of axle and press firmly to seat seal inside hub shell (some rotation may be required to align teeth on ratchet/gear ring, and inner ratchet/gear ring may need to be poked with a finger to get it to center up).
25. [] Place washer over right end of axle.
26. [] Treat right-side spacer cap threads with Loctite 242, then gently secure cap on right end of axle.
27. [] Use tip of 3/16" slotted screwdriver to press seal down (accessible through each groove in freehub mechanism).
28. [] Remove hub from axle vise and support right-end down on surface.
29. [] Use 1" cylinder to gently tap left side dustcap into left end of hub shell.
30. [] Tap left-side spacer cap onto left end of axle.
31. [] Install cogs.



RINGLE FREEHUBS

TOOL CHOICES

In addition to common bicycle mechanic's tools, the following tools will be needed.

Ringle bearing tool kit including:

- a) Bubbahub bearing driver with 24mm O.D. driving surface (for front hub),
- b) Superbubba bearing driver with 27.5mm O.D. driving surface,
- c) Large Diameter Tool, which is 47 × 57mm cylinder with 1/2" hole on one side and large 35mm cavity on other side. A 2-1/4" length of 2-1/4" O.D. PVC pipe works.

Bicycle Research Sealed Bearing Remover Kit
(Substitute White Industries removers)

White Industries bearing press.

13.16 A Ringle freehub.

DISASSEMBLY

1. [] Pry under edge of left-side axle spacer to remove it.

Older models lack the snap-ring referred to in the next step, or the other snap-ring referred to adjacent to the right-side hub bearing.

2. [] Remove internal snap-ring from left end of hub shell.
3. [] Mount left end of axle in smooth radius axle-vise and secure.

Older models lack the 16mm flats for the cone wrench mentioned in the next step. Use a small adjustable pin spanner or snap-ring pliers in the pin holes in the face of the nut instead.

4. [] Use 16mm cone wrench to remove spacer nut from right end of axle.
5. [] Thread cog lockring into freehub body, put freehub body between vise jaws so that flange of lockring keeps hub from dropping, then tap on axle with plastic mallet to separate freehub body from hub shell (remove pawls and springs).
6. [] Place 2–1/4" section of 2–1/4" PVC pipe on bench, then place left side of hub into pipe.
7. [] Strike right side of axle with plastic mallet to remove left-side bearing.
8. [] If old axle will be reused, remove bearing from axle. Support bearing and tap axle with plastic mallet to remove.

Inner right-bearing removal

Older models have a smaller-diameter ratchet ring, which will not allow the bearing to pass through. This must be unthreaded before with a special Ringle tool before the right bearing can be removed.

9. [] Remove internal snap-ring from inside of right end of hub shell.
10. [] Install 15mm Bicycle Research Bearing Remover (insert from left) into right bearing, then secure with expansion ring positioned inside bearing. Alternatively, use 15mm White Industries Bearing Extractor, installed from right).
11. [] Support right side of hub on PVC pipe.
12. [] Tap on shaft to remove bearing.

Bearing removal from freehub body

13. [] Remove internal snap-ring in right end of body using snap-ring pliers.
14. [] Insert 12mm Bicycle Research Bearing Remover into outward bearing (insert from inward end), then secure tool. Alternatively, use 12mm White Industries Bearing Extractor inserted from outer end.

15. [] Place old splined cassette cog on freehub body and place body with right-side down in vise using soft jaws to gently hold body.
16. [] Tap on shaft to drive bearing downward.
17. [] Insert 15mm Bicycle Research Bearing Remover into remaining bearing from inner end of freehub body, then secure tool. Alternatively, use CalVan 28 tool to extract bearing (White Industries tool will not fit).
18. [] With freehub body supported in vise (resting on cog), tap on tool to remove bearing and spacer sleeve.
19. [] Loosen tool bolts and remove bearing from tool (it may be necessary to tap tool out of bearing).

ASSEMBLY

Install bearings in freehub body

20. [] Secure White Bearing Installer in vise, threaded end up.
21. [] Place large spacer, freehub body (open-end up), 28 × 15mm (O.D. × I.D.) bearing, aluminum sleeve, and then 28 × 12mm bearing onto tool shaft.
22. [] Place large spacer and handle/bearing assembly onto tool, then tighten until bearings are fully pressed into freehub body.
23. [] Unthread tool handle and remove freehub body from tool shaft.
24. [] Put internal snap-ring into end of freehub body.

Install right-side hub bearing

25. [] Place large spacer and hub shell (left side first) onto tool shaft.
26. [] Place 32 × 15mm bearing into right side of hub shell.
27. [] Place large spacer on tool, then thread on handle/bearing assembly and tighten handle until bearing is fully seated.
28. [] Unthread handle and remove hub from tool and tool from vise.
29. [] Install large internal snap-ring in hub just past ratchet ring.

Install axle and left-side bearing

30. [] Place right side of hub on top of PVC tube.
31. [] Insert right end of axle (threaded) down into hub shell and tap axle gently with mallet until axle shoulder for left bearing is even with bearing shoulder in left end of hub.
32. [] Place new left-side bearing over axle, then use Ringle bearing driver to install left-side bearing. Alternatively, use a hollow cylinder with an O.D. of 26–27.8mm.
33. [] Install internal snap-ring in left end of hub shell.

Install freehub body, axle spacers, and nuts

34. [] Hold left side of axle using smooth radius jaw axle-vise.

35. [] Lubricate pawls of freehub with light oil and install pawls and springs.

In the next step, a hard-to-find tool by Campagnolo is recommended to hold the pawls compressed during freehub-body installation. Alternatively use a rubber band with a thickness 1/8" or less, and a length of 2–3". Wrap the rubber band once around the pawls, give it a single twist, then wrap all the slack around the splined body.

36. [] Use Campy clip (or rubber band) to hold pawls compressed.

37. [] Install freehub onto right side of axle. Turn freehub counterclockwise to engage pawls into ratchet ring, then withdraw Campy clip (or rubber band).

38. [] Lubricate threads of spacer nut and install on right side of axle.

39. [] Secure spacer nut to equivalent of 60in-lbs (10lbs@6").

40. [] Install left-side axle spacer.

PHIL WOOD FSA HUBS

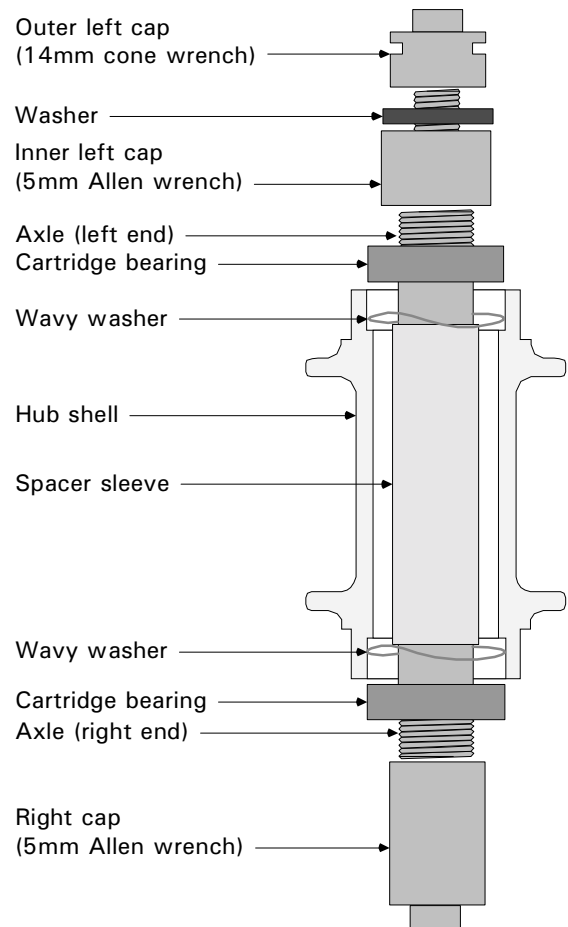
Phil Wood FSA hubs are unique in that the axle and bearings can be removed with nothing more than a 14mm cone wrench and a 5mm Allen wrench. No impact or pressure is supposed to be required to get the bearings or the axle in or out.

This ease of disassembly relies on the assumption that all the parts are adequately lubricated to prevent corrosion. Once corrosion sets in, disassembly can be very difficult, if not impossible. It would be worthwhile to disassemble and grease everything on a new hub.

DISASSEMBLY

In the next step, a cap is removed from one end of the axle. If the hub is a rear hub, there will be a double cap on the left end. The two left caps may remain locked together, in which case the right cap will unthread. The following procedure assumes that the two left caps will remain locked together, and it is the right cap that will come off.

Another possibility is that the outer left cap will break loose from the inner left cap, in which case the axle will still be trapped in the hub. The inner left cap has a 5mm Allen fitting in the end. This allows the use of two 5mm Allen wrenches to remove either of the caps from the axle.



13.17 Representative Phil Wood FSA hub. Number and thickness of spacers may vary. Front hubs are symmetrical both sides and configured like right side of illustrated hub.

1. [] Holding left end of axle with 14mm cone wrench (rear) or 5mm Allen (front), use a 5mm Allen wrench to loosen right-side axle cap.
2. [] Unthread cap from right end of axle.
3. [] Pull axle assembly out left end of hub.
4. [] Use axle to poke bearing out of right end of hub shell.
5. [] Find wavy washers that were between bearings and hub shell (on both sides) and remove.
6. [] Slide spacing sleeve off axle.
7. [] Slide left-side bearing off axle.

ASSEMBLY

8. [] Clean and grease bearings, or replace.
9. [] Check axle for bends and replace if necessary.
10. [] If replacing axle, insert long 5mm Allen from right end of axle and use 14mm cone wrench to break loose outer cap, then unthread inner cap. (If inner cap is secure to axle, there is no choice except to grasp axle in vise to unthread inner cap.)

13 – CARTRIDGE-BEARING HUBS

11. [] *If axle was replaced*, thread cap(s) onto new axle.
12. [] Grease axle thoroughly.
13. [] Grease inner and outer cylindrical surfaces of both bearings.
14. [] Grease bearing-mounting surface inside shell.
15. [] Place wavy washers in each end of shell.
16. [] Slide bearing and spacing sleeve onto axle.
17. [] Slide axle assembly into left end of shell.
18. [] Slide bearing onto right end of axle.
19. [] Thread right-side cap onto axle.
20. [] Holding axle with 14mm cone wrench (rear) or 5mm Allen (front), use 5mm Allen wrench to gently secure right-side axle cap.

WHITE INDUSTRIES TI CASSETTE HUB

This hub is one of several made by White Industries. The other models are simpler (front or rear for thread-on freewheel). By ignoring steps and illustrations that are specific to the freewheel mechanism (called “driver” by the manufacturer), the following procedure can be used as a guide to service any White Industries hub.

DISASSEMBLY

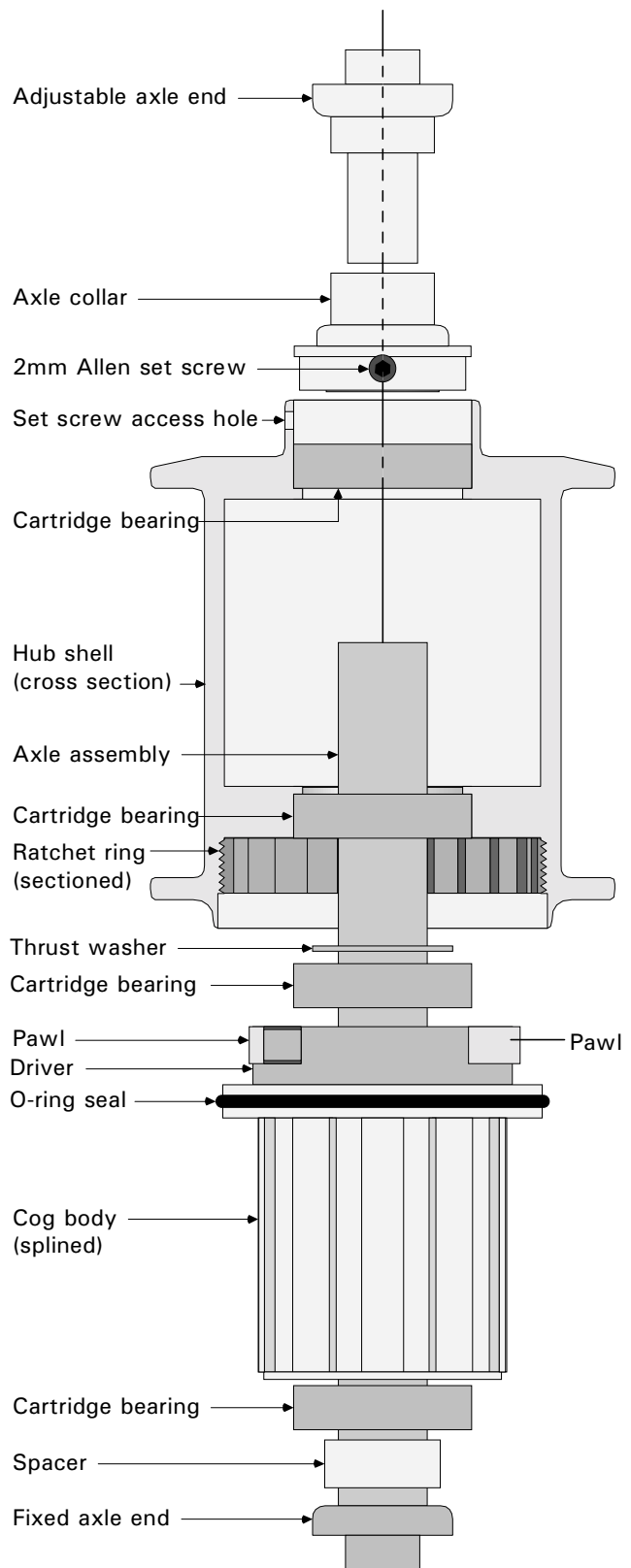
1. [] **Remove cogset from hub (same as Shimano freehubs).**

In step #2, three 2mm Allen set screws are loosened. If loosened too little, the parts will still remain together. If loosened too much, the set screws will interfere with the inside of the hub shell, and it will not be possible to rotate the axle collar relative to the hub shell, or to pull it out of the hub shell. Loosen all three 2mm Allen set screws one full turn. This amount should be ideal.

2. [] **With 2mm Allen wrench, loosen 3 set screws accessible through hole in lip in left end of hub shell 1 full turn each.**

In the next step, the adjustable axle-end is pulled out of the left end of the axle. It is supposed to pull out easily after loosening the set screws (in the previous step). Corrosion could make axle-end removal difficult. There is a 6 × 1mm thread inside the axle-end piece. If it is difficult to remove the axle-end, thread in a long bolt of the correct thread. Grasp the bolt head firmly in the vise and pull the wheel away from the vise.

3. [] **Pull adjustable axle-end out of left axle end.**



13.18 The White Industries TI Cassette hub.

The axle collar can be difficult to pull out because one (or all) of the set screws has been loosened too much, or because the axle is corroded. With the left-side down, press the wheel against the bench top to get the axle to move. If this does not work, try inserting a conventional axle inside the White Industries axle, then tap on the conventional axle. The drive-side axle-end is a press fit augmented with Loctite. It may pop out before the axle releases. If this happens, it will need to be tapped back in with fresh Loctite.

4. [] Pull axle collar out of left side of hub shell.
5. [] Pull axle and driver together out right side of hub shell.
6. [] Remove thrust washer (which may be stuck to inside face of driver or outside face of bearing in right side of hub shell).
7. [] Pull driver off of axle.

CLEANING AND RE-GREASING

8. [] Use seal pick or small pointed device to gently lift seals out of both bearings in hub shell and both bearings in driver.
9. [] Scrub, flush, and dry all exposed bearings, hub shell, driver assembly, and axle parts.
10. [] Pack all bearings with grease.
11. [] Replace seals in bearings with lettered-sides facing out.

BEARING REPLACEMENT

Hub-shell bearing-cartridge removal

See page 13-22 for up-to-date information on tools for bearing removal and installation.

12. [] Insert lip end of White 15mm bearing remover into left-side bearing, then support left side of hub shell on top end of any race installer that can be used on a 1-1/8" fork.
13. [] Use small White drift to tap out bearing.
14. [] Insert lip end of White 15mm bearing remover into right-side bearing, then support right side of hub shell on top end of any race installer that can be used on a 1-1/8" fork.
15. [] Use small White drift to tap out bearing.

Driver bearing-cartridge removal

16. [] Insert bearing remover into outer bearing, place any used Shimano freehub cog on driver, then place driver upside-down in vise with cog resting on top of vise and vise jaws *not* clamping on driver.
17. [] Use small White drift to tap out bearing.

18. [] Insert bearing remover into inner bearing(s), then support inward end of driver on top end of any race installer that can be used on a 1-1/8" fork.

19. [] Use small White drift to tap out bearing.

Installing bearing cartridges in hub shell

20. [] Slide large spacer and right-side hub bearing onto shaft of White Bearing Installer.
21. [] Put tool shaft into hub shell from right side.
22. [] Place left-side bearing over end of tool shaft.
23. [] Put large spacer over tool shaft, then thread on handle/bearing assembly.
24. [] Place fixed end of tool in soft jaws in vise.
25. [] Tighten tool handle until both bearings are fully seated.
26. [] Unthread handle, then remove hub from tool.

Installing bearing cartridges in driver

27. [] Place large spacer, then small spacer, then outer bearing over tool shaft.
28. [] Place driver outer-end down over tool shaft, then inner bearing(s), then both spacers, then thread on handle/bearing assembly.
29. [] Tighten handle until all bearings are seated.
30. [] Unthread handle, remove driver from tool, and remove tool from vise.

ASSEMBLY

31. [] Grease outside of axle shaft and grease outside of inserted portion of left-side adjustable axle-end.
32. [] Use light oil on pawl springs, pawls, and O-ring seal on driver.
33. [] Slide spacer onto axle, followed by driver and thrust washer.
34. [] Insert axle/driver assembly into right side of hub shell.
35. [] Rotate driver counterclockwise while maintaining slight inward pressure to get pawls to seat inside ratchet ring.
36. [] With right end of axle supported on bench, press down firmly on wheel to make sure everything is seated.
37. [] Install axle collar on left end of axle.
38. [] Install adjustable axle-end in left end of axle.
39. [] Rotate axle or axle collar to align set screws with access hole in lip on left side of hub shell and secure each set screw.
40. [] Install and secure cogset.

CHRIS KING FREEHUBS

This section applies specifically to the Chris King MTB, road, and DiscGo-Tech rear hubs. Although not specifically for the BMX hub, once you are familiar with the hubs covered here, the BMX hub should not be a challenge to service.

There are two levels of service possible. The basic service includes cleaning or replacement of drive mechanisms and greasing of bearings. The full service adds to this bearing replacement and drive mechanism parts replacement. The basic service requires one inexpensive special tool, Hub Cone Adjusting Tool #77301. The full service requires a complete Chris King Hub Service Kit (number unavailable). Additionally, a 2-1/4" section of 2-1/4" I.D. PVC pipe and ordinary shop tools are needed.

TOOL TERMINOLOGY

The following tools are all part of the Chris King Hub Service Kit.

Cog spline wrench: A large-diameter ring with splines on the inner perimeter. It is labeled "cog spline wrench."

Cone washer: A steel washer with a conical face on one side.

Driveshell bushing: A long cylinder with a larger diameter at one end. It is labeled "driveshell bushing."

Extension shaft: A threaded shaft with two thread diameters, ending in a knurled shaft at one end.

Hub cone adjusting tool: A medium-length cylinder with four steel pins in a recess in one end. It is labeled "hub cone adjusting tool."

Knurled ring: A ring with several steps of various diameters on each face, with a knurled texture at the outermost perimeter. It is labeled "knurled ring."

Spline driver: A short cylinder with a square hole in one face and a splined configuration in the opposite face. It is labeled "spline driver."

Split rings: Two rings (large and small) split in half and held together by means of an O-ring in the groove in the outer perimeter of the ring. They are labeled "lg split ring" and "sm split ring."

T-handle: A large stepped cylinder with a threaded shaft at one end and a handle inserted through a ball at the other end of the cylinder. It is labeled "T-handle."

PART TERMINOLOGY

Adjusting cone: A ring with four holes in its face that resembles a dust cap that is used to adjust the bearing preload.

Axle end: A cap that threads onto the left end of the axle.

Capture plate: A simple metal washer that keeps the needle-bearing cage from moving out of the needle-bearing race.

Capture sleeve: A metal cylinder with one flat face that keeps the needle bearing cage from moving the other way out of the needle-bearing race.

Drive ring: A ring that has teeth on one face and helical splines on the inner perimeter.

Drive side of hub shell: The side of the hub shell with the larger-diameter hole.

Drive spring: A large-diameter spring that moves the drive ring.

Driven ring: A ring that has teeth on one face and splines on the outer perimeter.

Driveshell: A complexly-shaped cylinder to which the cogs attach. When installed, it resembles a freehub body on a conventional freehub.

Needle bearing: A bearing that is a cylinder instead of a ball.

Needle-bearing cage: A plastic cage of cylindrical shape that holds the needle bearings.

Needle-bearing race: A steel bearing surface in the shape of a simple cylinder on which the needle bearings roll.

Non-drive side of hub shell: The side of the hub shell with the smaller-diameter hole.

Plastic seal (small and large): A thin washer-like seal made of plastic that resembles a shim washer.

RingDrive: The Chris King name for the free-wheeling design that is used in these hubs instead of a conventional pawl and ratchet-ring design.

Seal ring: A ring that is threaded on the outside, splined on the inside, and has a blue rubber seal installed in one face.

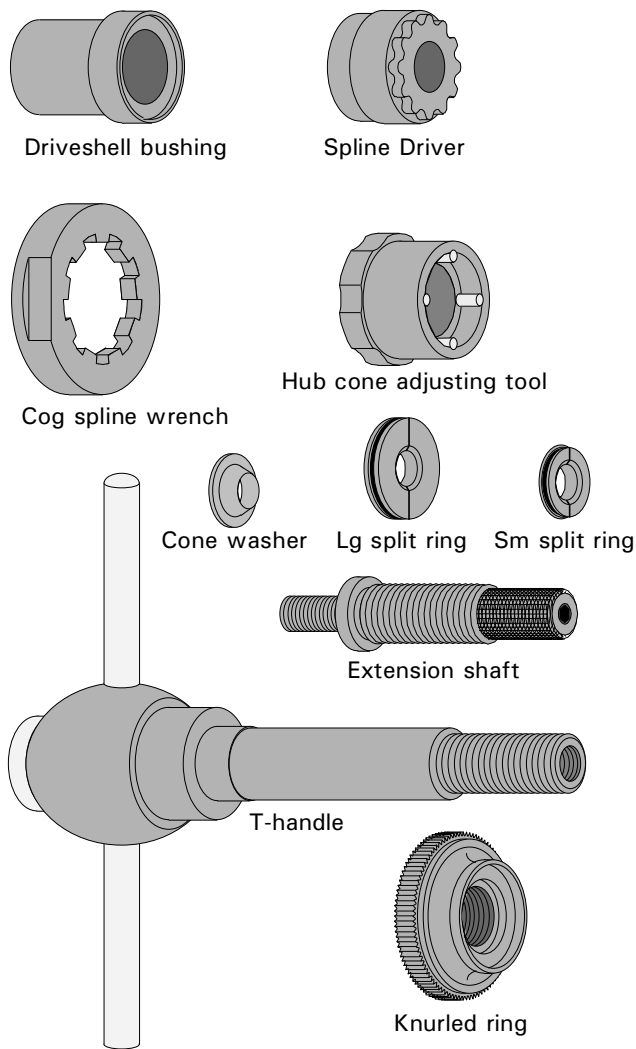
Spring retainer: A flat metal ring that has a slight taper to one face and a clear step-down in diameter on the other face that supports the drive spring.

FULL HUB SERVICE

Axle and bearing-seal removal

1. [] Remove cogs.
2. [] Insert a 5mm Allen wrench in each end of axle, then unthread left-side axle-end/adjusting-cone assembly.
3. [] Pull driveshell and axle out drive side of hub with firm counterclockwise twisting motion.

NOTE: Skip to step 7 if replacing bearings.



13.19 The Chris King hub tool set.

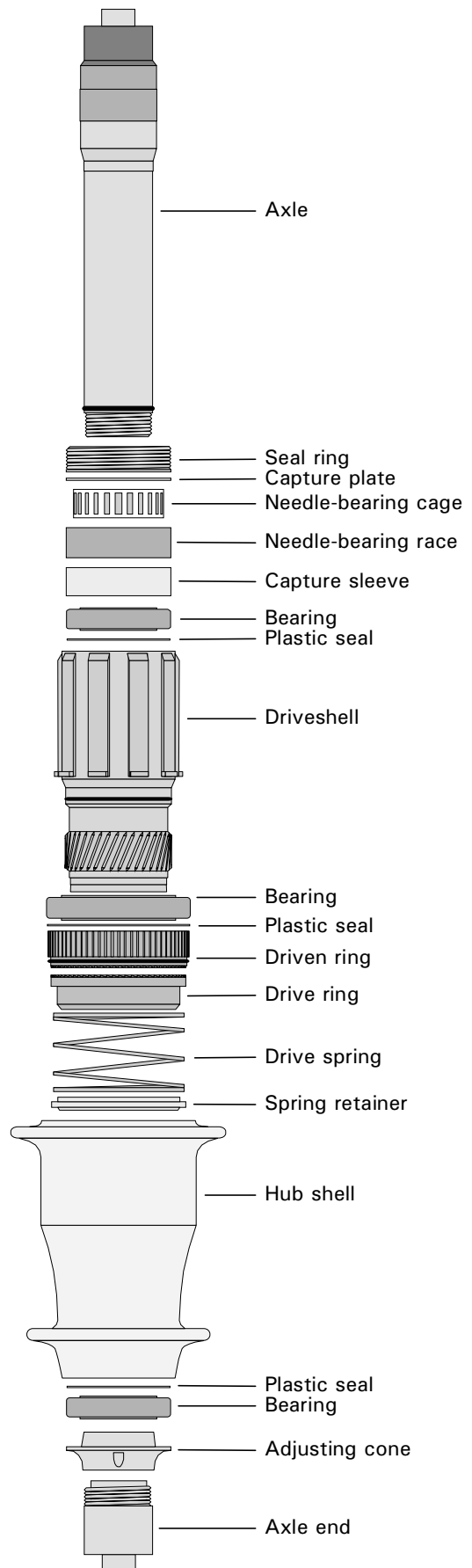
4. [] Insert tip of razor knife in diagonal split of metal snap ring in face of drive-side hub-shell bearing to lift one end of ring, then pull snap ring out of bearing. Repeat on non-drive side.
5. [] Use seal pick to lift soft rubber seal out of face of each bearing.

Chris King recommends use of a light spray lubricant instead of solvent when cleaning parts and bearings to avoid any possibility of damaging plastic and rubber parts with solvent.

6. [] Flush exposed bearings with light spray lubricant and dry with compressed air. Use light lubricant on brush to carefully clean helical splines on driveshell and inside drive end of hub shell.

In the next step, removing the O-ring makes it easier to pull the axle out, but it is not necessary. If you remove it, take care not to lose it and to remember to replace it.

7. [] Remove small O-ring from non-drive end of axle, then push axle out large end of driveshell.



13.20 The Chris King cassette hub.

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NOTE: Skip to step 35 if not replacing bearings.

Non-drive side bearing removal

In the next step, the split ring, extension shaft, and cone washer are assembled to the T-handle. If the extension shaft is threaded in too much, the split ring is expanded and will not pass through the bearing. The small split ring is not symmetrical, so observe which face of the ring is a larger diameter.

8. [] **Place small split ring (large-diameter-face first) on small end of extension shaft, place cone washer (cone-side first) against split ring, then thread extension shaft fully into end of T-handle without expanding split ring.**

9. [] **Insert T-handle through drive side of hub.**

The knurled ring is a complexly-shaped tool with several steps or shoulders of various diameters on each of its faces. The purpose of the configuration is to insure, if properly oriented, that the knurled ring acts somewhat like a pilot to align the bearing and the T-handle. Another function of the knurled ring, achieved by threading it on the recommended amount, is to set the depth of the split ring so that when the split ring is expanded it is in the correct position relative to the bearing. If the wrong end of the knurled ring is threaded on first, then the number of turns will not work to correctly position the split ring.

10. [] **Thread knurled ring, big-end first, fully onto extension shaft, then back off exactly seven full turns.**

A sure sign in the next step that the knurled ring has been threaded on the wrong amount is that the T-handle gets tight in a fraction of a turn when tightening it to expand the split ring. If this happens, loosen the T-handle and unthread the knurled ring about one turn, then try again.

11. [] **Pull tool assembly out drive side of hub until knurled ring seats against hub, then hold extension shaft stationary and turn T-handle clockwise until split ring is fully expanded.**

12. [] **Turn knurled ring fully clockwise.**

13. [] **Tap on T-handle tool with plastic mallet to drive bearing out non-drive side of hub.**

14. [] **Unthread knurled ring, then remove in order non-drive-side bearing and small plastic seal.**

15. [] **Unthread extension shaft and remove tools from hub.**

Drive-side bearing removal

16. [] **Place large split ring on small end of extension shaft, place cone washer (cone-side first) against split ring, then thread extension shaft fully into end of T-handle without expanding split ring.**

17. [] **Insert T-handle into non-drive side of hub.**

18. [] **Thread knurled ring (big-end first) onto extension shaft exactly three full turns.**

19. [] **Pull tool assembly out non-drive side of hub until knurled ring seats against hub, then hold extension shaft stationary and turn T-handle clockwise until split ring is fully expanded.**

20. [] **Turn knurled ring fully clockwise.**

In the next two steps, as the bearing is pressed out there are a number of other parts that will come out at the same time. The set up of the tool is designed to insure that all the parts come out together, trapped on the tool in the order they are installed in the hub shell. By following the directions closely, it is possible to then take these numerous parts off the tool in order, so as to become familiar with the sequence and orientations of the parts.

21. [] **With drive side of hub supported on PVC pipe, tap on T-handle tool with plastic mallet to drive bearing out drive side of hub.**

22. [] **Unthread knurled ring, then remove in order drive-side bearing, large plastic seal, driven ring (externally splined), drive ring (internally splined), drive spring, and spring retainer.**

23. [] **Unthread extension shaft and remove tools from hub.**

Driveshell disassembly

In the next step, the driveshell is inserted in the cog spline wrench, and both are grasped in the vise. There is no need for high force when closing the vise, and the tools and parts could easily be damaged by excess force. Consider the side of the tool with writing to be the front face, and the blank side to be the back face.

24. [] **Insert driveshell into back face of cog spline wrench, then gently secure flats of wrench in vise.**

25. [] **Place spline driver on 3/8" drive wrench, then use spline driver to unthread seal ring from driveshell.**

26. [] **Remove capture plate then needle-bearing cage from driveshell with your fingers (needle-bearing race and capture sleeve remain in driveshell).**

The previous step says that the needle-bearing race and capture sleeve remain in the driveshell. In some cases, in the next step they may be loose and prone to falling out without encouragement. If this is the case, it is fine to let them come out at this time.

27. [] **Remove cog spline wrench from vise, remove driveshell from cog spline wrench, then reinsert driveshell into front face of cog spline wrench.**

28. [] Place small split ring (large-diameter-end first) on small end of extension shaft, place cone washer (cone-side first) against split ring, then thread extension shaft fully into end of T-handle without expanding split ring.
29. [] Insert T-handle through small end of driveshell.
30. [] Thread knurled ring (small-end first) onto extension shaft exactly 2–1/2 turns, then pull tool through drive shell until large shoulder on face of knurled ring seats inside end of driveshell.
31. [] Holding extension shaft stationary, turn T-handle clockwise until split ring is fully expanded, then turn knurled ring fully clockwise.
32. [] Grasp flats of cog spline wrench in vise, then tap on T-handle with plastic mallet to drive bearing parts out bottom of driveshell.
33. [] Remove cog spline wrench from vise, unthread knurled ring from extension shaft, then remove in order needle-bearing race, capture sleeve, bearing, and small plastic seal.
34. [] Unthread extension shaft and remove all tools from driveshell.

Bearing and RingDrive lubrication

Chris King makes special grease for use in the Chris King hubs. Although deviation from the recommended grease may not be as critical inside the ball bearings, the wrong lubricant can make the RingDrive non-functional. The recommended grease is very light, and in its absence Chris King recommends a high-quality 10W oil, never another grease! When greasing the bearings, it is critical to use a moderate amount. Too much grease will make it impossible to seat the rubber seal and snap ring.

NOTE: Skip to step 39 if replacing bearings.

35. [] Place small bead of Chris King grease one-half to two-thirds of way around inside of hub-shell bearings.
36. [] Place rubber seals over grease and carefully seat between inner and outer races.
37. [] Engage one end of split ring in groove between inner and outer races, then work all the way around, seating split ring into bearing. Repeat for other bearing.
38. [] Use finger to separate drive rings and put bead of Chris King grease in gap between drive rings. Release ring, then smear excess grease over helical splines.

NOTE: Skip to step 56 if not replacing bearings.

Non-drive-side bearing installation

All three of the bearing cartridges are non-symmetrical. Upon examining the hole in each of the three bearing cartridges, it can be seen that one end of the

hole is tapered inside. When each bearing is installed, be sure to note which way this “internally-tapered end” should face. Failure to orient the bearings correctly will make it impossible to complete the hub assembly, and also makes it extremely difficult to remove the bearing without damaging the plastic seal that sits behind each bearing. In all three cases, the correct bearing orientation is such that the tapered end of the hole ends up facing out from the center of the hub.

39. [] Holding T-handle threaded-end up, place small bearing (internally-tapered end first) onto T-handle, then place small plastic seal on top of bearing.

In the following bearing installation, as well as all the other bearing installations, the correct orientation of the knurled ring is critical in two respects. First, the knurled ring must face the correct way so that the intended surface on the hub shell or driveshell supports the high load of pressing in the bearings and so that the knurled ring serves its purpose of aligning everything. Second, the knurled ring needs to be correctly seated against the supporting surface. If these cautions are not observed, the supporting surface and the bearing counterbore can easily be damaged while pressing the bearings.

40. [] With T-handle tool held threaded-end up, place hub shell (non-drive-side first) over tool, then thread knurled ring (large-end first) onto T-handle.

By Chris King’s recommendation, a seemingly redundant process is used when seating each bearing. The company’s position is that this process insures proper bearing alignment. This is why the next step includes tightening the T-handle twice.

41. [] Tighten T-handle until bearing seats fully, loosen T-handle, rotate knurled ring 180° either way, then secure T-handle again. Remove tools.

Drive-side bearing and RingDrive installation

42. [] Check that O-ring is in place inside inner perimeter of spring retainer, then install spring retainer in drive side of hub so that stepped face faces out drive side of hub.
43. [] Insert drive spring in drive side of hub.
44. [] Use Chris King grease to lubricate toothed face and helical spline of drive ring (internally splined), then insert ring so teeth face out drive side of hub.
45. [] Insert driven ring (externally splined) tooth-face first into hub so splines engage hub shell splines.
46. [] Place large plastic seal over driven ring, then insert large bearing so internally-tapered end

13 – CARTRIDGE-BEARING HUBS

faces out of hub.

- 47. [] Insert T-handle through non-drive side of hub, then thread knurled ring (large-end first) onto T-handle and against face of bearing.
- 48. [] Tighten T-handle until bearing seats fully, loosen T-handle, rotate knurled ring 180° either way, then secure T-handle again. Remove tools.

Driveshell assembly

- 49. [] Holding T-handle threaded-end up, place onto threaded end in order driveshell bushing (small-end first), small bearing (internally-tapered end first), small plastic seal, and driveshell (large-end first).
- 50. [] Thread on knurled ring (large-end first) until it seats over end of driveshell.
- 51. [] Tighten T-handle until bearing seats fully, loosen T-handle, rotate knurled ring 180° either way, then secure T-handle again. Remove tools.

If the needle-bearing race did not fall out while disassembling the driveshell assembly, then the following step will be needed in full to install the capture sleeve and needle-bearing race. If they did fall out during disassembly, the two parts should simply slip into place during the next step, and then it will be unnecessary to use the seal ring as an installation press for these parts.

- 52. [] Place capture sleeve (flat face facing out) and needle-bearing race into large end of driveshell. If necessary, use spline driver and seal ring to seat needle-bearing race fully, then remove seal ring.
- 53. [] Insert driveshell into back face of cog spline wrench, then gently secure cog spline wrench in vise.
- 54. [] Grease needle-bearing cage with Chris King grease, then insert needle-bearing cage and capture plate into driveshell.
- 55. [] Thread seal ring into driveshell, then secure to 100in-lbs. Remove driveshell from tools.

Axle assembly and adjustment

- 56. [] Insert axle into large end of driveshell until it seats with a “pop,” then put small O-ring back onto threaded end of axle.
- 57. [] Insert axle/driveshell assembly into drive side of hub with a clockwise rotation and a forceful push, until it seats with a “pop.”
- 58. [] Put 5mm Allen wrench in vise, end pointing up, then place right end of axle onto Allen wrench.
- 59. [] Thread adjusting cone fully onto axle end, then thread assembly onto left end of axle (do not secure).

Like all other hubs that utilize quick-release retention, the axle of a Chris King hub compresses when the wheel is installed in the dropouts and the quick release is properly secured. Unlike conventional hubs, it is not possible to simulate this compressive load at the same time as making the adjustment, so it is necessary to use a trial and error process of adjustment, starting with an adjustment that is clearly too loose, then making fine adjustments until the looseness just disappears once the wheel is correctly installed in the bike.

- 60. [] Holding axle end stationary, rotate adjusting cone clockwise until contact is felt, then counterclockwise 1/4 turn. Stabilize adjusting cone while gently securing axle end.
- 61. [] Place wheel in frame and correctly secure quick release, then check for knock by jerking laterally on rim. (If no knock is felt the first time this step is attempted, redo step 60 with a slightly looser starting adjustment.)
- 62. [] If knock is felt, remove wheel and put right end of axle back on Allen wrench in vise.
- 63. [] While stabilizing adjusting cone, loosen axle end, then turn adjusting cone a few degrees clockwise and secure axle end. Repeat check in step 61, and stop if knock is eliminated.

CARTRIDGE-BEARING TOOLS

There are several tools recently available or currently available that are in the category of “universal” cartridge bearing removers and installers.

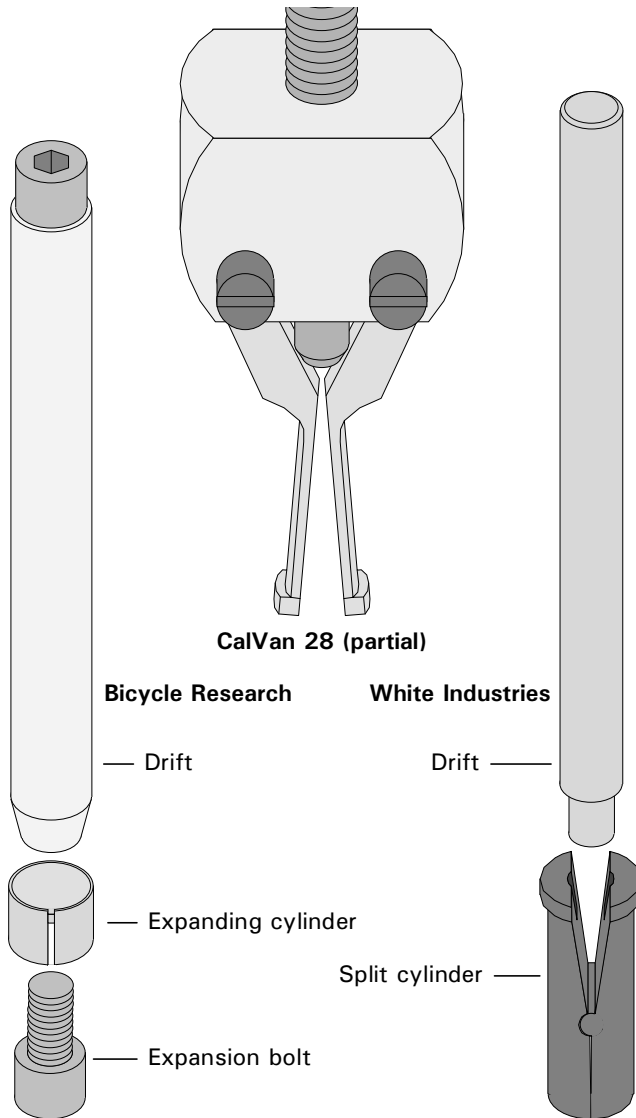
Due to the variety of hub designs, no tool can be truly universal, but with a good assortment of tools and a little ingenuity, virtually any hub can be serviced.

REMOVAL TOOLS

There are three choices of removal tools. These are the Bicycle Research Sealed Bearing Remover Kit (#SBR-K), the White Industries Bearing Extractors, and the CalVan #28.

The Bicycle Research SBR-K is the most universal tool. It works on the principle of an expanding cylinder that grips the inside bore of the bearing by means of friction. This design eliminates the need for access to the back face of the bearing, which is not always accessible. This tool kit includes five sizes of removers: 10mm, 12mm, 1 1/2", 15mm, and 17mm. The limitation of the tool is that bearings that have a large I.D./O.D. difference, are heavily secured with Loctite, or are corroded in place may have more friction holding

them in place then the tool can generate between the tool and the bearing. If this is the case, the tool will keep slipping out before the bearing is moved.



13.21 Bearing removal tools.

Proper care and use of the SBR-K is important. The expanding cylinders are easily destroyed if they are expanded when not contained by a bearing they are designed to fit, so never tighten the bolts unless the expanding cylinder is inside a bearing that it is intended to fit. With the expansion cylinder inside the bearing, simply tighten the bolts at each end of the tool to the typical limit of the Allen wrench, then tap on the end of the tool to drive the bearing out. Using a high-strength, zero-residue solvent such as acetone or alcohol on the mating surfaces of the tool and bearing will increase the maximum friction and effective-

ness of the tool. Once removal has been accomplished, it can be somewhat awkward to remove the bearing from the tool. This problem can be reduced by greasing the inside of the expansion cylinders.

White Industries sells tools that work on the principle of a lip that catches on the back side of the bearing. The early version of their tool consisted of three sizes of these split cylinders with lips (12mm, 15mm and 17mm). To use the tool, the lip-end of the remover was compressed in order for the lip to be able to pass through the bearing, then held in an expanded state by means of a special shaft that was used both to hold the split cylinder open and to drive against the cylinder in order to press out the bearing. The current version is much less expensive, but not nearly as strong. It, too, uses a split cylinder with lips that catch the bearing, but relies on a screwdriver as the means to spread the cylinder and drive against the cylinder. The advantage of these lip-type tools is that they never slip out. The disadvantage is that if there is not adequate clearance on the back side of the bearing, the tool will not fit.

The CalVan #28 is a single tool with lipped prongs that spread apart as the tool handle is tightened. The lips are somewhat thinner than the White Industries tool, so the CalVan #28 will fit some bearings that the White Industries tool will not. Since it is not size specific like the other removers, it is more universal. However, the fit is not precise and the tool is much more awkward to use.

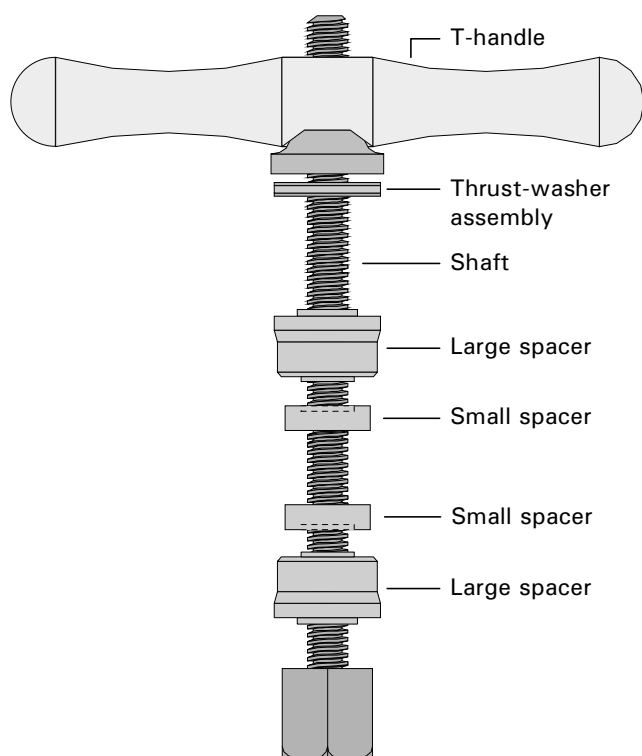
For the complex area of bearing removal, the well-equipped mechanic would want each of these tools.

INSTALLATION TOOLS

There are two varieties of universal bearing installers. These are the Bicycle Research Sealed Bearing Installation Kit (#SBI-K) and the White Industries Bearing Press (#Bearing-PR). Both work on the principle that various diameters of spacers mate against the face of the bearing, with a threaded shaft that inserts through the bearings and spacers to draw the whole assembly together when tightened. The difference between the tools is primarily in the number and configuration of spacers.

The White Industries tool has spacers that match the bearing O.D. of 24mm, 28mm and 30mm, and some of these spacers have lips that fit in 15mm and 17mm holes. The shaft itself fits a bearing with a 12mm I.D.

13 – CARTRIDGE-BEARING HUBS



13.22 *White Industries bearing-installation tool.*

The Bicycle Research tool has spacers that match the O.D. of 24mm, 26mm, 28mm, 30mm, 32mm and 35mm bearings. Additional spacers match the bearing I.D. of 12mm, 15mm and 17mm. The shaft itself fits a bearing with a 10mm I.D.

Despite these differences in spacers and shaft diameters, both tools will fit all the popular hub designs. The I.D. spacers on the Bicycle Research tool tend to get lost in the hub unless the entire installation process is done with the tool precisely horizontal. The White Industries tool has an edge in ease of use because its I.D. spacers cannot slip out of position.

14 – ADJUSTABLE-CONE/CUP PEDALS

ABOUT THIS CHAPTER

This chapter is about pedals with conventional bearings. Conventional bearing systems have loose balls, cones, and cups. Most pedals use an adjustable cone threaded on the end of the pedal axle. These closely resemble hubs in principle. Another variety uses an adjustable cup threaded into the pedal body. These closely resemble adjustable-cup bottom brackets in principle. This chapter has separate procedures for service of these two types, which are called “Adjustable-cone” pedals and “Adjustable-cup” pedals. A troubleshooting chart that covers both of these pedal types follows at the end of the chapter.

GENERAL INFORMATION

TERMINOLOGY

Pedal body: The main structure of the pedal. The pedal body includes the housing for the bearings and can also include a *pedal cage* or a *retention mechanism*.

Pedal cage: The one-piece or two-piece plate of metal that is on the front and back, or just the back, of the pedal. The pedal cage supports the shoe and may be the point to which a toe clip mounts.

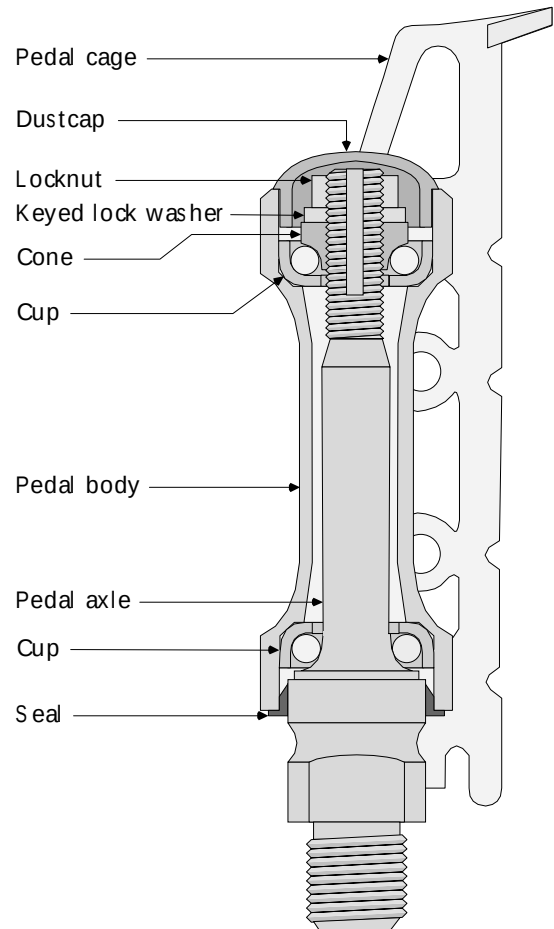
Retention mechanism: This mechanism is similar to a ski binding. Usually by means of springs, the retention mechanism engages some sort of clip to the cleat that is attached to the rider’s shoe.

Pedal axle: The shaft that threads into the crank arm and about which the pedal rotates.

Cone: A surface that bearings roll on that is positioned inside the circle of balls. A pedal cone may be a built-in feature on an axle, or it may thread onto an axle.

Cup: A surface that bearings roll on that is positioned outside the circle of balls. A cup may be pressed permanently into the pedal body or it may be threaded into the pedal body.

Locknut. A nut that threads onto an axle against a threaded-on cone, to lock the position of the cone relative to the axle, or it may thread onto a threaded-in cup against the pedal body, to lock the position of the cup relative to the pedal body.



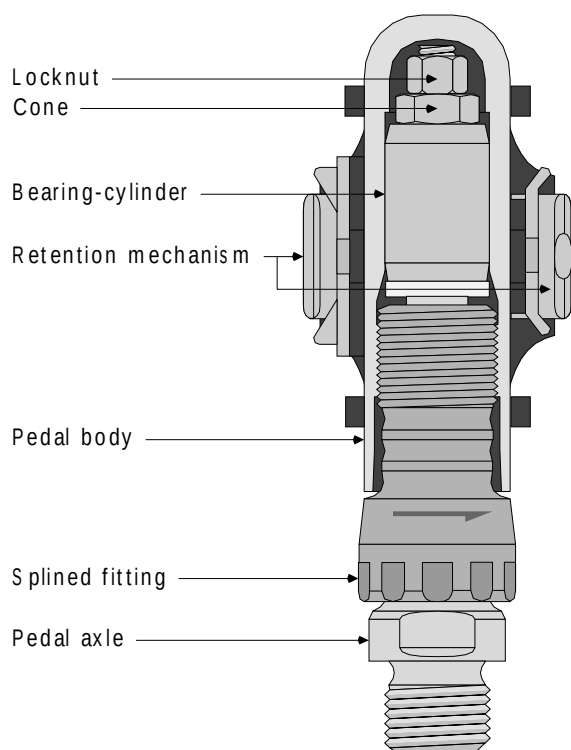
14.1 Diagram of a common adjustable-cone pedal.

Dustcap: A piece of plastic, metal, or rubber that threads or presses onto the outer end of the pedal body to cover the hole through which the bearings are accessed.

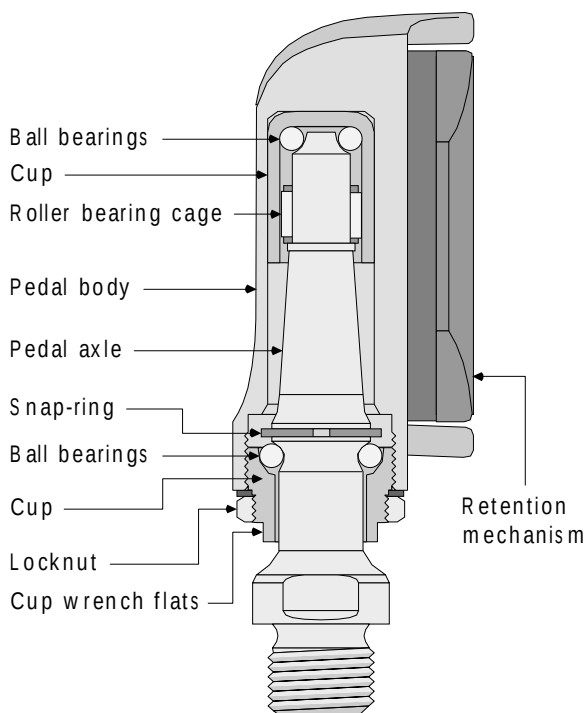
Spline: A cylindrical fitting that has alternating ribs and grooves on its surface that are parallel to the axis of the cylinder. Splines are usually engaged by a tool with the opposite spline pattern. A spline is used as an alternative to a standard six- or eight-sided wrench fitting.

Bearing-cylinder: A complete bearing-system housing that is cylindrical-shaped and includes two cup races. When the bearing-cylinder is assembled to the axle with cones and bearings, it is a complete bearing unit that can be inserted and removed from the pedal body with the bearings intact.

14 – ADJUSTABLE-CONE/CUP PEDALS



14.2 Diagram of a adjustable-cone pedal with bearing unit removable from pedal body.



14.3 Diagram of an adjustable-cup pedal.

LIMITATIONS

The design of pedals varies more than conventional hub, bottom bracket, and headset bearings. For this reason, the procedural steps are somewhat more generalized, and may not apply directly to the make and model of pedal being serviced.

This chapter does not cover pedal installation or bearing service on cartridge-bearing pedals. See **PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION** (page 24-1), or **CARTRIDGE-BEARING PEDALS** (page 15-1).

PREREQUISITES

Pedal removal and installation

It is optional, but strongly recommended, to remove the pedals from the crank arm to service the bearings. The procedures are written as though the pedals are removed from the crank arms. It is strongly recommended to overhaul only one pedal at a time, so as not to mix parts between pedals.

Other prerequisites

It is optional, but recommended, to be familiar with servicing hubs and/or bottom brackets. Due to the greater variation in design of pedals, the following instructions are generalized to a greater degree than other bearing service information in this book. If already familiar with servicing other bearings, then apply that sense of knowledge about the other bearings to the variations that might be encountered with pedals. This keeps the more generalized instructions for pedals from being a handicap.

INDICATIONS

There are several reasons pedals require an overhaul, and several reasons they require adjustment. An overhaul should be done as part of a regular maintenance cycle, the duration of which will change depending on the type of riding, the amount of riding, and the type of equipment. Adjustments should be done on the basis of need.

MAINTENANCE CYCLES

If starting out with the pedal(s) known to be in good condition with good quality grease, they should be able to be ridden thousands of miles without needing an overhaul. If the equipment sees little wet-weather riding, then an appropriate maintenance cycle would be 2000–3000 miles in most cases. If a lot of wet-condition riding is done, then the maintenance

cycle might need to be as often as every 750–1000 miles. Parts rust whether being ridden or not, so another factor is how long the bike may be sitting before it will be used again; for example, if the bike is ridden 200 miles in the rain in the fall, then put away four months for the winter, it would be a good idea to overhaul the pedal(s) before putting the bike away.

Some other factors affecting pedal maintenance cycles are whether there is grease injection and whether there are seal mechanisms. *Grease-injection systems do not eliminate the need for overhaul.* Grease injection only increases the acceptable time between overhauls. Grease-injection systems are only as good as the customer is consistent and thorough about pumping in new grease. Seal mechanisms (conventional bearings with rubber seals between the cone and dustcaps) *are not effective water-tight seals.* Their effectiveness varies with the brand and model. At best, they can lengthen the acceptable time between overhauls. With seal mechanisms or grease-injection systems, the best policy is to initially overhaul the pedal(s) on a normal-length maintenance cycle, and if the grease is found to be in good condition, then extend the cycle the next time.

Symptoms indicating need of overhaul

What symptom would lead to feeling that the pedal(s) should be overhauled? One is that when performing an adjustment, the looseness (free-play) in the bearings cannot be eliminated without the bearing becoming excessively tight (does not turn smoothly). The lack of smoothness could be caused by dry grease, contaminated grease, or worn parts. Another symptom indicating a need for overhaul is that when re-

moving the pedal and rotating the axle, the end of the axle oscillates, indicating a bent axle (which should always be replaced).

Symptoms indicating need of adjustment

The primary symptom that will be experienced indicating that pedal(s) needs adjustment is looseness in the bearings. This can be detected by grasping the pedal and jerking it side-to-side while feeling for a knocking sensation. Inspect for loose bearings and loose locknuts every 300–500 miles. The only way to check for a loose locknut is to put a tool on the locknut and see if it is secure. Another possible symptom indicating need to adjust the pedal(s) is that the pedals simply feel tight when removed and the axle is turned. If tightness is felt when rotating the pedal body on its axle while the pedal is attached to the crank arm, the bearing is extremely tight.

One other case in which pedal-bearing adjustment is recommended is on any new bike. Most retail outlets assume the factory has done the job correctly, and don't check the adjustment. Factory adjustments are not very reliable. Hubs may be completely worn out after as little as 1000 miles of use, due to poor factory setup.

TOOL CHOICES

The design or brand of pedal(s) will determine the tools needed. The following list covers tools for adjustable cone/cup pedals only.

In addition to these specialized tools, a variety of spanners used on brakes, hubs, and bottom brackets are needed for the cones and adjustable cups. These include the Park HCW-3, Park OBW-1, Park OBW-2, and 14–17mm cone wrenches.

ADJUSTABLE-CONE/CUP-PEDAL BEARING TOOLS(table 14-1)

Tool	Fits and considerations
Campagnolo 7130025	Campy adjustable-cup "Three-bearing" models called TBS, SGR, Record, and Croce deAune
Campagnolo 7130034	Campagnolo QR pedals with removable bearing unit
Campagnolo 710	Dustcap spanner for classic Campagnolo Nuovo Record and Super Record road quill-style pedals
Shimano TL-SH-PD73	Socket-in-socket tool required for Shimano adjustable-cone pedals with no lock washer between locknut and cone including: Deore XT PD-M735, Deore DX PD-M650, PD-M525, Ultegra PD-6402, PD-A525
Shimano TL-SH-PD40	Bearing-unit-removal tool for accessing bearings on following models: Dura-Ace PD-7410, Ultegra PD-6400, Ultegra PD-6401, Ultegra PD-6402, 105SC PD-1055, 105SC PD-1056, PD-M737, PD-M525, PD-A525, and any other models w/20.7mm diameter 10-tooth spline just outward of the mounting-wrench flats
Shimano TL-SH-PD30	Lockring tool for adjustable-cup models including Dura-Ace PD-7400 and Dura-Ace PD 7401, or any other model with a 8-face locknut with concave faces
Park HCW3	25mm bottom-bracket adjustable-cup spanner for Shimano adjustable-cup models with 25mm locknut including: Ultegra PD-6400, 105 PD-1050, Exage PD-A450, PD-A550

TIME AND DIFFICULTY RATING

Overhauling a pedal including pedal removal, disassembly, cleaning, assembly and bearing adjustment is a 20–30 minute job of moderate difficulty. Double this for two pedals. Adjusting the pedal alone is a 5–8 minute job of moderate difficulty.

COMPLICATIONS

Limited parts availability

Many pedals have limited parts availability or no parts availability. This is because the value of the labor required to service the pedal often exceeds the replacement value of the pedal. Before beginning service of a pedal, make sure there is a source for parts.

Damaged body parts

Pedals are extremely exposed to damage. If the main structure of the pedal is damaged, there is usually no point in overhauling the pedal. If body parts are loose and cannot be tightened, it will interfere with checking whether the bearing adjustment is loose.

Mixing left and right pedal parts

Parts are often similar, but not interchangeable, between left and right pedals. Even experienced mechanics do not overhaul pedals frequently, so it is a good idea to have only one pedal apart at a time, to eliminate any possibility of mixing parts between the left and right pedals.

Trial-and-error adjustments

Unlike bottom brackets, headsets, and hubs, there is no convenient way to mark and calibrate the increments of adjustment when adjusting a pedal bearing; furthermore, there is usually no way to hold the cone while securing the locknut, making the adjustment a frustrating trial-and-error process.

ABOUT THE REST OF THIS CHAPTER

There are three sections to the rest of this chapter: the first section is **ADJUSTABLE-CONE PEDALS**, which starts with a description of the type of pedals this section covers, some common models and styles, what to look for if uncertain about the type of pedals being serviced, and a list of some particular styles this section does not cover; the second section is **ADJUSTABLE-CUP PEDALS**, which begins with a description of the type of pedals it covers, some common models and styles, what to look for if uncertain about the type of

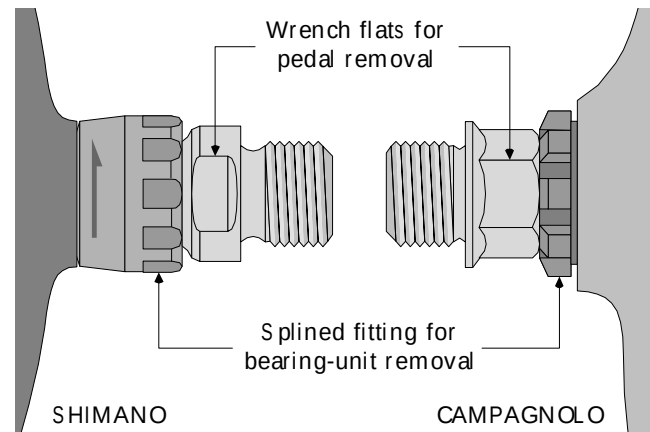
pedals being serviced, and a list of some particular styles it does not cover; the third section is the **ADJUSTABLE-CONE/CUP-PEDALS TROUBLESHOOTING** table that applies to both styles of pedals.

ADJUSTABLE-CONE PEDALS

PEDALS THAT THIS SECTION COVERS

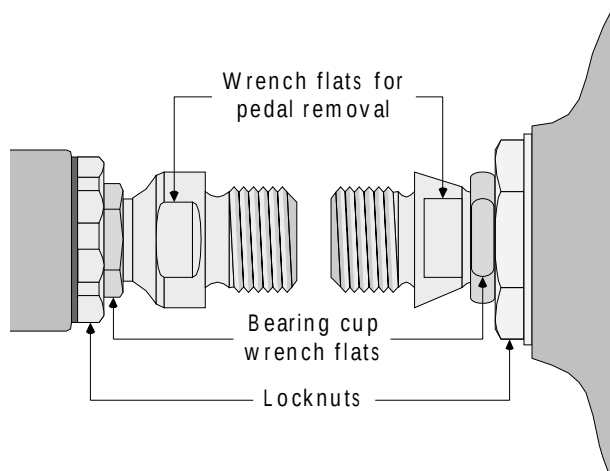
The most common type of pedal has an adjustable cone. This adjustable cone is located at the outside end of the axle. All traditional pedals have a dustcap that can be removed at the outside end of the pedal. If there is such a dustcap, then it is certain that the pedal is an adjustable-cone type.

Shimano and Campagnolo make pedals that have adjustable cones but no dustcap on the outside end of the pedal. This includes all Shimano “SPD” type pedals, and all “Look-retention-system compatible” models except Dura-Ace. Specific Shimano models include Dura-Ace model PD-7410; Ultegra models PD-6400, PD-6401, and PD-6402; 105SC models PD-1055 and PD-1056; model PD-A525; and off-road models PD-M737 and PD-M525. The distinguishing characteristic of these above-listed Shimano models and any unlisted Shimano models is that on the inside face of the pedal body there is a 10-spline, 20.6mm cylinder. This spline rotates with the pedal body. The Campagnolo pedals of this type are the “Look-retention-system compatible” QR models including Record. The distinguishing Campagnolo feature is an octagonal-splined fitting on the inside face of the pedal body measuring 21mm across the flats. This octagonal fitting rotates with the pedal body.



14.4 Shimano and Campagnolo adjustable-cone pedals that have removable bearing cylinders.

Shimano and Campagnolo both make pedals that have no dustcap on the outside end that *are not* the adjustable-cone type. The distinguishing feature in each case is that there are places to put two different spanners on the inside face of the pedal body. These two fittings both rotate with the pedal body, and are in addition to the wrench fitting that is on the pedal axle that is used to install and remove the pedal from the crank arm. All of these have an adjustable cup that fits a 15mm or 17mm cone wrench and a locknut of a much larger size threaded onto the cup.



14.5 Shimano and Campagnolo adjustable-cup pedals.

Look makes a pedal that is similar in appearance and external configuration to the Shimano and Campagnolo models that has no dustcap on the outside end of the pedal, but once the pedal-axle assembly is extracted from the pedal body, it will be found to have cartridge bearings instead of adjustable-cone/cup bearings.

NOTE: If just adjusting pedal bearings and not overhauling them, skip to step 33.

PEDAL REMOVAL AND PRELIMINARY INSPECTION

1. [] Do steps 1–6 of **PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION** procedure (page 24-3).
2. [] Spin pedal axles and observe whether there is any oscillation in the end of the pedal axles, indicating that they are bent.

ACCESS PEDAL BEARING

It is strongly recommend from this point on that only one pedal is disassembled at a time. There are parts that are unique to each pedal. If both pedals are disassembled at the same time and parts get mixed from right

to left, each overhaul will have to be done all over again (at best); at worst, getting the parts mixed up between left and right pedals will damage some parts.

If there is access to the adjustable cone through a dustcap on the outside end, then the cups will be pressed directly into the pedal body. If the pedal is the type that has bearings accessed by threading an assembly out of the pedal body, then the cups will be at either end of a cylinder that rotates on the pedal axle. This “bearing-cylinder” will not be evident until the bearings have been accessed. After accessing the bearings, there is no great difference in how to treat each system. The only difference will be the terminology used to refer to the piece that includes the bearing cups and either the pedal body or the bearing-cylinder. From this point on, the portion including the bearing cups will be called the “pedal-body/bearing-cylinder.”

There is one optional difference about how to treat the pedals with a bearing-cylinder design. Instead of overhauling this type of pedal to clean and grease the bearings, it is possible to pump fresh grease into the bearings without any further disassembly. In order to do this, a grease gun and a piece of flexible hose that fits snugly over the bearing-cylinder are needed. Attach the hose to the grease gun and to the outer end of the bearing-cylinder, then pump grease through the bearing-cylinder until nothing but clean grease comes out the other end. The only disadvantage to this shortcut is that the ball bearings cannot be replaced; usually the other parts that could be accessed by full disassembly are not available.

3. [] **If pedal has dustcap on outside end unthread or pry out dustcap.**
4. [] **If pedal has no dustcap on outside end, and is a Shimano, use TL-PD40 to remove bearing assembly from pedal body. Use large adjustable wrench to turn TL-PD40 counterclockwise on left-side pedals or clockwise on right-side pedals.**
5. [] **If pedal has no dustcap on outside end and is a Campagnolo, use Campagnolo 7130034 to remove bearing assembly from pedal body. Turn tool counterclockwise on left-side pedals or clockwise on right-side pedals.**

DISASSEMBLE BEARING

The pedal axle must be held securely from rotating while removing the locknut/cone, and when adjusting the bearing later.

6. [] **Clamp threaded portion of pedal axle in vise, using soft jaws to protect threads from steel jaws of vise.**

14 – ADJUSTABLE-CONE/CUP PEDALS

Step #7 measures the offset (if any) between the end of the pedal spindle and the face of the locknut. If bearing size is lost track of, or a guess must be made about bearing size, or if the pedal gets assembled with bearings out of position it will show up as a change in this number after putting the pedal back together.

7. [] **Use depth gauge of caliper to measure offset between upper end of pedal axle and face of locknut and record here: _____ mm.**
8. [] **Hold cone stationary with cone wrench or special tool while breaking loose locknut with adjustable wrench or fit wrench.**
9. [] **Thread parts off pedal axle and onto bundling tie while maintaining order and orientation.**

There are no standards for bearing quantities and sizes in pedals. There are usually different quantities in each cup, and there may be different sizes. Step #10 keeps track of the first set of balls encountered, so that there is no need to rely on trial-and-error when assembling. Step #11 records similar information for the second set of bearings encountered.

10. [] **Use magnet to remove bearings from outer bearing cup. Count and measure ball-bearing size and record here:
Outer-bearing quantity _____
Outer-bearing size _____ mm.**
11. [] **Lift pedal-body/bearing-cylinder off axle, cupping hand below pedal to catch interior ball bearings. Count and measure ball-bearing size and record here:
Inner-bearing quantity _____
Inner-bearing size _____ mm.**

Rubber seals on pedal bodies or axle cones may rotate relative to the part they are attached to. Seal effectiveness can be improved and seal drag reduced by lubricating between the seal and what it is attached to, so they will be removed at this time to enable greasing later. Seals can possibly be re-installed backwards, so note their orientation if removing them from a dustcap, or simply leave them on the bundle if removing them from a cone.

12. [] **Remove rubber seals, if any, from pedal body (note orientation) or axle cone.**
13. [] **Pry dustcaps out of inside face of pedal body unless damage is likely. Were dustcaps very loose? Yes? No? (circle one)**
14. [] **Clean all parts, including outside of pedal.**

INSPECTION

Pedal-body damage that will affect the bearings is rare. Some inexpensive pedal bodies made of multiple parts joined together can fail at the joints. Since the pedal body must grasped and jiggled vigorously to

check for whether the bearing adjustment is too loose, it is important that there be no looseness in the structure of the pedal.

15. [] **Inspect pedal body for unrepairable looseness. Good? Bad?**

The bearing cups are supposed to be permanently pressed into the pedal body (except bearing-cylinder types). Occasionally, they work loose. If not inspected for, this might cause considerable trouble later when trying to eliminate play when making the adjustment. Firmly press a finger into a cup and try to force it to rotate. If it does rotate, it must be fixed. Drip Loctite 290 around the edge of the cup to fix a loose cup. It is designed to penetrate and flow behind the cup and then cure to lock the part securely in place.

16. [] **Inspect pressed-in cups for looseness. See if they rotate or jiggle. Good? Bad?**

By design, bearing cups wear out long after the cones have worn out. This is good because they cannot be replaced. A new pedal or axle assembly is needed. Check for cup wear by looking in the cups for the wear line left by the balls. Trace this wear line with the tip of a ball point pen. If it snags on anything, the cup is shot.

17. [] **Trace ball path in cups with a ball point pen to check for pits. Good? Bad?**

If the cups were worn out, the cones are virtually certain to be. If not, be sure to check the cones carefully so that a worn-out one will not damage a cup, leading to a pedal replacement. One cone is threaded off the outside end of the pedal axle. The other cone is built into the pedal axle and is only replaceable if the pedal axle is replaceable. Cones wear out by developing pits (galling). Find the shiny wear line left by the balls on the conical portion of the cone. Trace this wear line with the tip of a ball point pen to check for pits.

18. [] **Trace ball path on cones with a ball point pen to check for pits. Good? Bad?**

Next, inspect the axle for bends. This inspection was already done in step #2, but this is another way of looking at the axle and is worth doing. Roll the axle on a flat smooth surface such as a Formica counter top or a glass counter top. Look under the axle as it rolls for a humping up and down that indicates it is bent. A bent axle is an axle in the process of breaking, and should be replaced.

19. [] **Inspect for a bent axle. Good? Bad?**

Some axles have slots along their length. A tab on the lock washer engages the slot. The function of the tab is to enable adjusting the pedal without a cone wrench, a necessity in some cases; however, the

washer often rotates around the axle and the tab damages the threads as well as itself. If a tab is damaged, the washer is sure to rotate again. Replace washers with damaged tabs.

20. [] **Inspect keyed lock washers for damaged keys. Good? Bad?**

Inspect the locknuts for damage, usually resulting from being over-tightened, or from poor wrench fit or use. Locknuts have to match the original thread and thickness. If the new nut is thicker, it may interfere with the dustcap.

21. [] **Inspect locknuts for damaged threads, cracks, warpage, and rounded off flats. Good? Bad?**

Inspect the dustcaps for looseness and damage. If they were loose (determined during removal), then re-install them with Loctite 242. If they are bent, try to straighten them out. Bends in dustcaps are only critical if the dustcaps are deformed to the point that the rub on the part of the axle that they overlap.

22. [] **Inspect dustcaps for looseness (done) and damage. Good? Bad?**

ASSEMBLY

Preparation of pedal-body/bearing-cylinder for assembly

Put a light coating of grease in each bearing cup and put the balls into the grease. If unsure of the ball quantity, fill the cups with balls without forcing any in. Cover the balls with a light coating of grease.

Some pedals have dustcaps pressed into the inside end of the body. The most important thing about dustcap installation is to make sure that they end up level rather than tipped. Tap the dustcap in with a rubber or plastic mallet. Level the dustcap as well as possible at this point; when the pedal is completely re-assembled, give it a spin and check whether the dustcaps wobble as they spin. Straighten them as necessary.

23. [] **Lightly grease bearing cups.**

24. [] **Place correct quantity and size of ball bearings in each cup.**

25. [] **Cover balls with a light coating of grease.**

26. [] **Press dustcap (if any) into inside end of pedal body.**

27. [] **Grease seals, if any, and install on pedal body or pedal axle.**

Assemble bearings

28. [] **Clamp threaded portion of pedal axle in vise, using soft jaws to protect threads from steel jaws of vise.**

29. [] **Drop pedal-body/bearing-cylinder (inside-end down) onto pedal axle.**

30. [] **Thread on cone until it presses against bearings, slip on lock washer (if any), and thread locknut down fully.**

31. [] **Measure offset between end of pedal axle and face of locknut and record: _____ mm.**

32. **Compare measurement in step 7 to measurement in step 31 and check *one* of following choices.**

[] **If step 7 and step 31 are equal or different by less than .5mm, then balls are in correct position and are correct size and quantity.**

[] **If step 31 is less than step 7, balls are out of position in cup(s), balls are too large, or too many balls installed.**

[] **If step 7 is less than step 31, balls are too small.**

PRELIMINARY ADJUSTMENT

NOTE: If just adjusting pedal only, do steps 1–8.

33. [] **Position cone so that it gently contacts balls then turn it counterclockwise 90°.**

FINAL ADJUSTMENT

Adjusting a pedal can be challenging. The first challenge of adjusting a cone is that adjustment calibrations like the ones used with other bearings cannot be used. This is made further challenging by the fact that some cones need to be turned only a fraction of the distance that a hub cone is turned, which is a small adjustment to start with. If that were not enough, there is sometimes no access to the cone with a wrench while tightening the locknut. The tabbed washer between the cone and locknut must be relied on entirely on to keep the cone from turning while securing the locknut. Since the washer almost always has some rotational free-play, this can become very frustrating. Unfortunately, there are no tricks. A lot of patience and hand control is needed. If relying on the tabbed washer to maintain the cone position, then allow for rotation of the cone when setting its position.

34. [] **Hold cone stationary (if accessible) and tighten locknut to it to 60–70in-lbs (20–25lbs@3").**

35. [] **Jiggle the pedal-body/bearing-cylinder side-to-side and check for *obvious* knocking. If the adjustment is not adequately loose, go back to step 33 and start even looser.**

In the next step, hold the cone stationary while breaking loose the locknut. If the cone and locknut both turn counterclockwise simultaneously, the axle

14 – ADJUSTABLE-CONE/CUP PEDALS

will turn with them. This will cause the frame of reference for the cone to be lost so there will be no idea if a small or large adjustment has been made. Avoid this if possible by *keeping the cone absolutely stationary while breaking loose the locknut.*

36. [] Holding cone absolutely stationary, loosen locknut.

37. [] Adjust cone 10° tighter, hold cone absolutely stationary and secure locknut to 60–70in-lbs (20–25lbs@3").

The next step is to jiggle the pedal-body/bearing-cylinder and feel if there is knocking that indicates the adjustment is too loose, then reset the cone additional 10° clockwise. This adjustment needs to be very precise. If the mark is under- or over-shot, try again. The adjustment needs to repeated over and over again until the knocking is eliminated.

38. [] Jiggle the pedal-body/bearing-cylinder side-to-side and check for knocking.

39. Check one of two following choices depending on result of step 38.

[] No knocking is felt, adjustment is done.

[] Knocking is felt, repeat steps 36–39.

40. [] Install dustcap or insert pedal-axle assembly into pedal body.

INSTALL PEDAL

41. [] Do steps 14–23 of *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-4).

ADJUSTABLE-CUP PEDALS

PEDALS THAT THIS SECTION COVERS

Non-cartridge-bearing pedals that do not have an adjustable cone have an adjustable cup. This adjustable cup is located at the inside face of the pedal body. This type of pedal never has a dustcap on the outside end of the pedal body and always has two fittings on the inside face of the pedal body where spanners can attach. These two fittings rotate with the pedal, and should not be confused with a third fitting on the pedal axle that the pedal-mounting wrench mates to.

Shimano and Campagnolo make pedals that have adjustable cups. Specific Shimano models include: Dura-Ace models PD-7400 and PD 7401; 105 model PD-1051; and Exage models PD-A450 and A550. The distinguishing characteristic of these above-listed Shimano models and any unlisted Shimano models is

that on the inside face of the pedal body there is a octagonal locknut that fits a 25mm spanner (except Dura-Ace, which has an octagonal locknut with concave faces). The Campagnolo pedals of this type are the TBS models including Record, SGR, and Croce deAune. The distinguishing Campagnolo feature is an octagonal fitting on the inside face of the pedal body measuring 23mm across the flats.

Shimano and Campagnolo both make pedals that have no dustcap on the outside end that *are not* the adjustable-cup type. The distinguishing feature in each case is that there is a *single* spanner fitting on the inside face of the pedal body that rotates with the pedal.

NOTE: If only adjusting pedal bearings and not overhauling them, skip to step 29.

PEDAL REMOVAL AND PRELIMINARY INSPECTION

1. [] Do steps 1–6 of *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-3).
2. [] Spin pedal axle and observe whether there is any oscillation in the end of the pedal axle, indicating that it is bent.

DISASSEMBLE BEARING

3. [] Clamp pedal body in vise, using soft jaws to protect pedal from steel jaws of vise.
4. [] Use depth gauge of caliper to measure offset from face of locknut to face of adjustable cup and record here: _____ mm.
5. [] Use 15mm or 17mm cone wrench to hold adjustable cup stationary while using special spanner to turn locknut counterclockwise to break it loose.
6. [] Thread locknut off of adjustable cup.
7. [] Thread adjustable cup counterclockwise until it is out of pedal body, but do not lift axle assembly out of pedal body.
8. [] Lift adjustable-cup/pedal-axle assembly out of pedal body by pulling up on pedal axle and carefully lay assembly down on rag to collect any loose bearings that may drop out of the cup.
9. [] *Dura-Ace models only*, examine pedal shaft and inside pedal body for caged cylindrical roller bearing and remove.
10. [] *Dura-Ace models only*, use snap-ring plier to remove external snap-ring from pedal axle.
11. [] Remove loose balls from adjustable cup and record quantity and size here:
Inside-end-bearing quantity: _____
Inside-end-bearing size: _____ mm.

12. [] **Remove outside-end ball bearings from depth of pedal body and record quantity and size here:**

Outside-end-bearing quantity: _____

Outside-end-bearing size: _____ mm.

13. [] **Clean all parts, including pedal body.**

INSPECTION

One bearing cup is supposed to be permanently pressed into the pedal body at the deep end of the hole in the pedal body. The bearing cup's inaccessible location makes it virtually un-inspectable for looseness, unless it is so loose that it falls out.

14. [] **Inspect pressed-in cup for looseness. See if it falls out. Good? Bad?**

By design, bearing cups wear out long after the cones have worn out. This is good because they cannot be replaced, and a new pedal or axle assembly is needed. Check for cup wear by looking in the cups for a wear line left by the balls. The cup fixed in the pedal body can only be inspected visually. The adjustable cup can be inspected normally; trace the wear line in the cup with the tip of a ball point pen. If it snags on anything, the cup is shot.

15. [] **Visually inspect fixed cup inside pedal body, and trace ball path in adjustable cup with a ball point pen to check for pits. Good? Bad?**

If the cups are worn out, the cones are virtually certain to be. If not, be sure to check the cones carefully so that a worn-out one will not damage a cup, leading to pedal replacement. One cone is at the outer end of the pedal axle. The other cone is built into the pedal axle towards the inner end and is only replaceable if the pedal axle is replaceable. Cones wear out by developing pits (galling). Find the shiny wear line left by the balls on the conical portion of the cone. Trace this wear line with the tip of a ball point pen to check for pits.

16. [] **Trace ball path on cones with a ball point pen to check for pits. Good? Bad?**

Campagnolo and Dura-Ace models have a cylindrical bearing surface on the pedal axle between the inner and outer cone. If this bearing surface is worn, it will appear scored. In this case, the pedal axle needs to be replaced.

17. [] **Campagnolo and Dura-Ace only, inspect cylindrical bearing surface on pedal axle. Good? Bad?**

Next, inspect the axle for bends. It was already inspected in step #2, but this is another way of looking at the axle and is worth doing. Roll the axle on a flat smooth surface such as a Formica counter top or

a glass counter top. Look under the axle as it rolls for a humping up and down that indicates it is bent. Bent axles are axles in the process of breaking, and should be replaced.

18. [] **Inspect axle for bends. Good? Bad?**

Inspect the locknuts for damage, usually resulting from being over-tightened, or from poor wrench fit or use. Locknuts have to match the original thread and thickness. If the new one is thicker, it may interfere with the dustcap.

19. [] **Inspect locknuts for damaged threads, cracks, warpage, and rounded off flats. Good? Bad?**

ASSEMBLY

Preparation of pedal-body cup and adjustable cup for assembly

Put a light coating of grease in each bearing cup and put the balls into the grease. If unsure of the ball quantity, fill the cups with balls without forcing any in. Cover the balls with a light coating of grease. The balls can be difficult to position down in the pedal body. The pedal axle can be used to seat the balls correctly before covering them with grease.

20. [] **Lightly grease cups and slide adjustable cup onto pedal axle.**

21. [] **Fill cups with appropriate size and quantity of ball bearings, then coat with grease.**

22. [] **If Campagnolo pedal with roller bearing pressed inside pedal body, coat roller bearings with grease.**

Preparation of axle assembly for installation into pedal

Depending on the brand and model of pedal, some or all of the following steps will need to be done.

23. [] **Lightly grease adjustable-cup threads.**

24. [] **Install locknut onto adjustable cup (unless not removed) and position at end of cup with spanner fitting.**

25. [] **Shimano Dura-Ace pedals, install adjustable-cup retainer snap-ring in slot in pedal axle.**

26. [] **Shimano Dura-Ace pedals, slip roller bearing cage onto end of pedal axle.**

Installation of pedal-axle assembly into pedal body

27. [] **Put pedal body in vise, open-end of bearing hole facing up.**

28. [] **Maintaining upward pressure on pedal axle (to keep balls trapped in adjustable cup), insert pedal-axle assembly in pedal body and thread adjustable cup fully into pedal.**

BEARING ADJUSTMENT

This bearing system adjusts like a bottom bracket. Tightening the locknut that is threaded onto the cup actually draws the cup slightly out of the pedal body. When a cup is set right up against the bearings so that rotating the axle might feel a little tight, the act of securing the locknut loosens the adjustment, even if the cup does not turn. There is no point to feeling the axle to check the adjustment except when the locknut is secure.

- 29. [] With locknut loose, adjust cup until it is gently pressing against bearings.
- 30. [] With felt-tip pen, put matching marks on adjustable-cup face and pedal body.
- 31. [] Use spanner to hold adjustable cup stationary and secure locknut.
- 32. [] Use depth gauge of caliper to measure offset from face of locknut to face of adjustable cup.
- 33. Compare measurement in step 4 to measurement in step 32 and check *one* of following choices.
 - [] *If step 4 and step 32 are equal or different by <.5mm*, then balls are in correct position and are correct size and quantity.
 - [] *If step 32 is less than step 4*, balls are out of position in cup(s), balls are too large, or too many balls installed.
 - [] *If step 4 is less than step 32*, balls are too small.
- 34. [] Jerk on end of pedal axle to check for knocking.

In the last step, either knocking in the bearings was felt, or it was not. If knocking is felt, then the adjustment is too loose. When knocking is not felt, it does not mean that the adjustment is correct. Step #29 is designed to create an initial adjustment that has knocking. If knocking is not felt, the adjustment could easily be too tight. For this reason, the “*If no knocking is felt*” option in step #35 suggests redoing step #29 (setting the adjustable cup slightly more counterclockwise).

- 35. [] *If no knocking is felt*: Redo step 29 with adjustable cup left in a slightly more counterclockwise position.
If knocking is felt: Loosen locknut and position adjustable cup 10° (1–2mm) further clockwise, remark, then secure adjustment.
- 36. [] Repeat step 35 repeatedly until knock is not felt.
- 37. [] Do steps 14–23 of *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-4).

ADJUSTABLE-CONE/CUP-PEDAL TROUBLESHOOTING_(table 14-2)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>The axle feels tight or rough when play is first eliminated.</i>	
Last adjustment was too many degrees.	Try to find an in-between adjustment.
Mis-installed dustcap rubbing on axle.	Observe whether dustcap turns true as the pedal turns and reset if needed.
Bent axle causing a portion of the axle set to rub dustcap.	Inspect for bent axle and replace.
Dry grease.	Disassemble, inspect, overhaul.
Cones and/or cups galled.	Disassemble, inspect, replace parts.
Seal mechanism drag.	Check that seal mechanisms are not incorrectly positioned and/or lubricate seals.
Wrong size balls.	Disassemble, measure balls.
SYMPTOM: <i>Play cannot be eliminated without severely over-tightening the adjustment.</i>	
Cups and/or cones galled.	Disassemble, inspect and replace.
Loose cups in pedal body.	Disassemble, inspect and repair with appropriate Loctite.
SYMPTOM: <i>Properly adjusted bearings feel sluggish but not rough when rotating the axle.</i>	
Seal mechanism drag.	Grease seal mechanisms.
Dry grease.	Disassemble, inspect, overhaul.
Plastic dustcap rubbing.	Align dustcap.
SYMPTOM: <i>When adjusting or inspecting the pedal, an erratic looseness or tightness is detected that comes and goes and changes location.</i>	
Too many balls in the cup(s), or a ball has dropped into the pedal-body core.	Disassemble and check ball quantity and for out-of-place ball(s).
SYMPTOM: <i>When rotating the axle, a pattern is detected of a consistent tight spot and a consistent loose spot.</i>	
Bent axle.	Inspect for bent axle and replace.
Low-precision parts.	None.
SYMPTOM: <i>When inspecting the cone, a wear pattern is detected that is high on the cone profile on one-half of the cone and is low on the cone profile 180° away.</i>	
Bent or broken axle.	Inspect and replace.
SYMPTOM: <i>When riding the bike, a clicking sound is heard from a pedal, but the axle feels normal when inspected.</i>	
Loose parts in the pedal body	Tighten cage bolts or other pedal-body hardware.
Loose or worn shoe cleat	Inspect and secure or replace cleat.
SYMPTOM: <i>When inspecting the cone, the wear pattern is very high or very low on the cone profile. Wear life has probably been very short.</i>	
Wrong size balls.	Measure balls.

15 – CARTRIDGE-BEARING PEDALS

ABOUT THIS CHAPTER

This chapter is about pedals with cartridge bearings. The design of this kind of pedal can vary tremendously, with almost every manufacturer designing pedals a different way. About the only factor these manufacturers have in common is that they all use a cartridge bearing (Hadley and Conrad are names that are sometimes used for the bearing) that is pressed into the pedal body. This chapter addresses the Look pedal (which is the same as the Mavic), the Time pedal, and the onZa pedal. The onZa pedal design is typical of a number of cartridge-bearing MTB pedals.

GENERAL INFORMATION

TERMINOLOGY

Pedal body: The main structure of the pedal. The pedal body includes the housing for the bearings and can also include a *pedal cage* or a *retention mechanism*.

Pedal cage: A one-piece or two-piece plate of metal that is on the front and back, or just the back, of the pedal. The pedal cage supports the shoe and may be the point to which a toe clip mounts.

Retention mechanism: This mechanism is similar to a ski binding. Usually by means of springs, the retention mechanism engages some sort of clip to the cleat that is attached to the rider's shoe.

Pedal axle: The shaft that threads into the crank arm and about which the pedal rotates.

Cartridge bearing: A fully self-contained bearing unit that cannot be disassembled. The bearing cartridge includes ball bearings and an inner and outer race. The bearings are usually hidden behind seals. The entire assembly is shaped like a short cylinder with a hole through the center.

Locknut: A nut that threads onto an axle against a bearing cartridge to lock the position of the bearing relative to the axle.

Dustcap: A piece of plastic, metal, or rubber that threads or presses onto the outer end of the pedal body to cover the hole through which the bearings are accessed.

Spline: A cylindrical fitting that has alternating ribs and grooves on its surface parallel to the axis of the cylinder. Splines are usually engaged by a tool with the opposite spline pattern. A spline is used as an alternative to a standard six- or eight-sided wrench fitting.

PREREQUISITES

Pedal removal and installation

It is optional, but strongly recommended, to remove the pedals from the crank arm to service the bearings. The procedures are written as though the pedals are removed from the crank arms. It is strongly recommended to overhaul only one pedal at a time, so as not to mix parts between pedals.

INDICATIONS

There are several reasons that the pedals may need bearing replacement, and several reasons they may need adjustment. Bearing replacement should be done as part of a regular maintenance cycle, the duration of which will change depending on the type of riding, the amount of riding, and the type of equipment. Adjustment should be done on the basis of need.

Maintenance cycles

If starting out with the pedals(s) known to be in good condition with good quality grease, they should be able to be ridden thousands of miles without needing bearing replacement. If the equipment sees little wet-weather riding, then an appropriate maintenance cycle would be 2000–3000 miles in most cases. If a lot of wet-condition riding is done, then the maintenance cycle might need to be as often as every 750–1000 miles. Parts rust whether the bike is being ridden or not, so another factor is how long the bike may be sitting before it will be used again; for example, if ridden 200 miles in the rain in the fall, then put away four months, it would be a good idea to overhaul the pedal(s) before putting the bike away.

Seal mechanisms used in these pedals *are not effective water-tight seals*. Their effectiveness varies with the brand and model. At best, they can lengthen the acceptable time between overhauls. With seal mechanisms, the best policy is to initially overhaul the

15 – CARTRIDGE-BEARING PEDALS

pedal(s) on a normal length maintenance cycle (2000-3000 miles), and if the grease is found to be in good condition, then extend the cycle the next time.

Symptoms indicating need of bearing replacement

What symptom would lead to feeling the pedal(s) should have the bearings replaced? One is that when performing an “adjustment,” the looseness (free-play) in the bearings cannot be eliminated. Another is that when removing the pedal and rotating the axle, the end of the axle oscillates, indicating a bent axle (which should always be replaced).

Symptoms indicating need of “adjustment”

Cartridge bearings cannot be “adjusted,” but if the retaining mechanism that holds the pedal parts together is loose, it may seem like a loose bearing. When the retaining mechanisms are secured, the looseness may go away. If securing the retention mechanism does not eliminate the sensation of looseness, parts are probably worn out and need to be replaced. With Look, Mavic, and Onza pedals the retaining mechanism is the dustcap.

The primary symptom that will be experienced indicating the pedal(s) needs “adjustment” is looseness in the bearings. This can be detected by grasping the pedal and jerking it side-to-side while feeling for a knocking sensation. Inspect for loose bearings and loose locknuts every 300–500 miles. The only way to check for a loose locknut is to put a tool on the locknut and see if it is secure.

TOOL CHOICES

Each type of pedal requires some different special tools that will be needed; therefore, there is no tool list. Reading the complete procedure is recommended before preparing to service the pedal. It is also a good idea to know what tools will be needed before starting.

TIME AND DIFFICULTY RATING

Overhauling a pedal (including pedal removal, disassembly, cleaning, assembly, and bearing adjustment) is a 10–15 minute job of little difficulty. Double this time for two pedals. Adjusting the pedal alone is a 1–2 minute job of little difficulty.

COMPLICATIONS

Limited parts availability

Some pedals have limited parts availability or no parts availability. This is because the value of the labor required to service the pedal exceeds the replacement value of the pedal. Before beginning service of a pedal, make sure there is a source for parts.

Damaged body parts

Pedals are extremely exposed to damage. If the main structure of the pedal is damaged, there is usually no point in overhauling the pedal. If body parts are loose and cannot be tightened, it will interfere with checking whether the bearing adjustment is loose.

Mixing left and right pedal parts

Parts are often similar, but not interchangeable, between left and right pedals. Even experienced mechanics do not overhaul pedals frequently, so it is a good idea to have only one pedal apart at a time, to eliminate any possibility of mixing parts between the left and right pedals.

ABOUT THE REST OF THIS CHAPTER

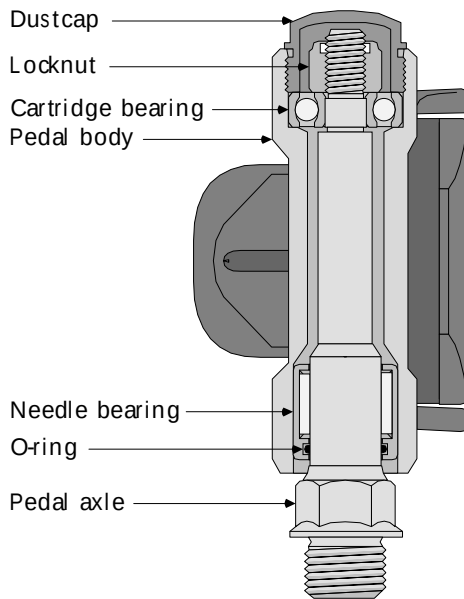
There are three sections to the rest of this chapter: the first section is **LOOK/MAVIC PEDALS**; the second section is **TIME PEDALS**; the third section is **ONZA PEDALS**.

LOOK/MAVIC PEDALS

PEDALS THIS SECTION COVERS

This section covers almost all Look pedals and Mavic pedals that are the “Look-clipless” style, as well as some models that use toe-clips. All the models covered have a dustcap in the outside end of the pedal. If the pedal has no dustcap, this section does not cover it, with one exception.

Look makes a pedal that is similar in appearance and external configuration to the Shimano and Campagnolo “Look-style” models that have no outside-end dustcap (see figure 14.2 on page 14-2), but once the pedal-axle assembly is extracted from the pedal body, you will find that it has cartridge bearings instead of adjustable-cone/cup bearings.



15.1 A Look/Mavic pedal.

PEDAL REMOVAL AND PRELIMINARY INSPECTION

1. [] Do steps 1–6 of **PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION** procedure (page 24-3).

In the next step, inspect the end of the axle for oscillation, which indicates it is bent. A bent axle is an axle in the process of breaking and should be replaced.

2. [] **Spin pedal axle and observe whether there is any oscillation in the end of the pedal axle, indicating that it is bent.**

ACCESS PEDAL BEARING

It is strongly recommend that only one pedal is disassembled at a time. There are parts that are unique to each pedal. If both pedals are disassembled at the same time and parts get mixed from right to left, each overhaul will have to be done all over again (at best); at worst, getting the parts mixed up between left and right pedals will damage some parts.

In step #3, the dustcap is removed. Older models had a plastic dustcap with a hex-nut on its face. The dustcap should be tight and the plastic is soft, so it is important to use a 6-point socket on this dustcap to prevent rounding the corners. More recent models have a dustcap with multiple pin holes. A bottom-bracket pin spanner can be used to remove these.

3. [] **Remove pedal dustcap from outside end of pedal.**

DISASSEMBLE BEARING

The pedal axle must be held securely from rotating while removing the locknut. Soft jaws made of copper, aluminum, or plastic are recommended to protect the threads of the pedal axle from damage while clamped firmly in the vise.

4. [] **Clamp threaded portion of pedal axle in vise, using soft jaws to protect threads from steel jaws of vise.**

In step #5, remove a locknut, which could be a right-hand or left-hand thread, depending on whether the pedal is from the left or right side of the bike. Be sure to pay attention to the clockwise/counter-clockwise notations in this step. Older Mavic quill pedals that use toe clips have right-hand thread on both left and right pedal locknuts.

5. [] **Hold axle from turning with a pedal wrench while breaking loose locknut with an 11mm socket wrench (counterclockwise for right pedal, clockwise for left pedal).**
6. [] **Support pedal body on vise so that axle is free to drop down between jaws. Use punch to drive end of axle down through outer bearing.**
7. [] **Turn pedal body over so outer bearing cartridge will drop out of pedal body.**

At this point, a cylindrical cage of needle bearings is still inside the pedal body. Although Mavic instructions indicate that this cylindrical cage is removable, and the replacement part is available, removal is not recommended. Using the tools and methods Mavic describes has proven unreliable and the installation tool is difficult, if not impossible, to find.

8. [] **Clean all parts, including outside of pedal.**

INSPECTION

9. [] **Rotate outer bearing cartridge to check for rough feeling, indicating need of replacement.**

In step #10, inspect the polished cylindrical surface that is the inner race for the needle bearing, which is still inside the pedal body. If this surface on the axle is gouged or pitted, then the bearing is probably bad as well. Because the bearing cannot be replaced, replacing only the axle will provide a very short-term benefit, and would be a waste of money. Suggest to the customer that they ride with a bad pedal bearing until it becomes intolerable, or suggest replacing the pedals now.

10. [] **Inspect polished cylindrical surface on axle that rolls inside of needle bearing assembly for gouges and pits.**

15 – CARTRIDGE-BEARING PEDALS

Next, inspect the axle for bends. This was already inspected for in step #2, but this is another way of looking at it, and is worth doing. Roll the axle on a flat smooth surface such as a Formica counter top or a glass counter top. Look under the axle as it rolls for a humping up and down that indicates it is bent. A bent axle is an axle in the process of breaking and should be replaced.

11. [] Inspect axle for bends. Good? Bad?

ASSEMBLY

12. [] Grease needle bearings in inside-end of pedal body.

13. [] Grease bearings of outside-end cartridge bearing.

14. [] Insert axle into pedal.

15. [] Grasp fat threaded end of axle in soft jaws in vise.

16. [] Slip outside-end cartridge bearing onto end of axle.

To remove the outside-end bearing from the axle, impact is needed. Instead of using impact to install a new bearing, the locknut on the end of the axle can be used as a press to drive the bearing onto the axle. Do not be surprised by the high resistance encountered when threading the locknut down.

Once again, note that left and right pedals differ in regards to whether this locknut is a left-hand or right-hand thread. Pay attention to the clockwise/counterclockwise notations.

17. [] Holding axle from turning with pedal wrench, use 11mm wrench to secure locknut (counterclockwise for left pedal, clockwise for right pedal). Tightening locknut presses bearing onto spindle.

ADJUSTMENT

A surprising feature of this pedal is that the dustcap fixes the location of the axle/bearing assembly in the pedal body. When the dustcap is not in place, or not tight, then the pedal body will move in and out on the axle by several millimeters.

18. [] Install and secure dustcap.

INSTALL PEDAL

19. [] Do steps 14–23 of *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-4).

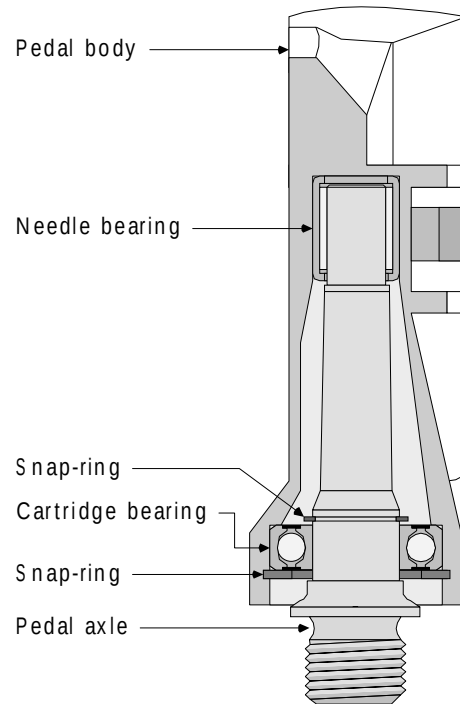
TIME PEDALS

PEDALS THIS SECTION COVERS

This section covers the original Time pedals, which feature a large-diameter cartridge bearing in the inside end of the pedal, which is retained by a circlip, and a small-diameter needle bearing permanently fixed in the outside end of pedal.

BEARING ADJUSTMENT ONLY

There is no bearing adjustment. Excess play or tightness means the bearings are damaged or worn out.



15.2 A Time pedal.

PEDAL REMOVAL AND PRELIMINARY INSPECTION

- 1. [] Do steps 1–6 of *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-3).**
- 2. [] Spin pedal axle and observe whether there is any oscillation in the end of the pedal axle, indicating that it is bent.**

ACCESS PEDAL BEARING

- 3. [] Use internal snap-ring plier to remove snap-ring from inside face of pedal body.**

The pedal axle must be held securely from rotating while removing the locknut. Soft jaws made of copper, aluminum, or plastic are recommended to protect the threads of the pedal axle from damage while clamped firmly in the vise.

4. [] **Clamp threaded portion of pedal axle in vise, using soft jaws to protect threads from steel jaws of vise.**
5. [] **Pull up sharply on pedal body to remove it from axle assembly.**
6. [] **Use external snap-ring plier to remove snap-ring (just outside of cartridge bearing) from axle.**

In the next step, use impact to remove the cartridge bearing from the axle. This impact can damage the bearing, so do not remove the bearing unless prepared to replace it.

7. [] **Remove axle from vise and support outer perimeter of bearing on jaws of vise with threaded end of axle down and use ball peen hammer to gently tap axle out of bearing.**

At this point, all the parts that can be removed have been removed. There is a needle bearing still in the pedal at the outside end of the pedal that cannot be removed.

8. [] **Clean all parts, including outside of pedal.**

INSPECTION

9. [] **Rotate bearing cartridge to check for rough feeling, indicating need of replacement.**

Inspect the polished cylindrical surface that is the inner race for the needle bearing, which is still inside the pedal body. If this surface on the axle is gouged or pitted, then the bearing is probably bad as well. The axle can be replaced with the bad bearing still in the pedal; however, it would probably be a waste. Either suggest riding with the bad axle until it becomes intolerable, or replace the pedals.

10. [] **Inspect polished cylindrical surface on outside end of axle for gouges and pits.**

Next, inspect the axle for bends. This was already inspected for in step #2, but this is another way of looking at it and is worth doing. Roll the axle on a flat smooth surface such as a Formica counter top or a glass counter top. Look under the axle as it rolls for a humping up and down that indicates it is bent. Bent axles are axles in the process of breaking and should be replaced.

11. [] **Inspect axle for bends. Good? Bad?**

ASSEMBLY

12. [] **Grease bearings in inner-end of pedal body.**

13. [] **Slip inward-side cartridge bearing onto end of axle. Support bearing on vise jaws and tap axle in with plastic hammer if necessary.**
14. [] **Use external snap-ring plier to install small snap-ring on axle.**
15. [] **Insert axle into pedal.**
16. [] **Use internal snap-ring plier to install large snap-ring into inside face of pedal.**

INSTALL PEDAL

17. [] **Do steps 14–23 of *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-4).**

ONZA PEDALS

PEDALS THIS SECTION COVERS

This section covers original onZa pedals, which have a cartridge bearing in the outer end of the hole through the pedal body, and a brass bushing in the inner end of the hole through the pedal body.

BEARING ADJUSTMENT ONLY

There is no bearing adjustment. If the dustcap or locknut on the axle is loose, it will allow the pedal body to float laterally on the axle assembly. If there is excess play or tightness once the dustcap has been checked, it means the bearings are bad.

PEDAL REMOVAL AND PRELIMINARY INSPECTION

1. [] **Do steps 1–6 of *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-3).**
2. [] **Spin pedal axle and observe whether there is any oscillation in the end of the pedal axle, indicating that it is bent.**

ACCESS PEDAL BEARING

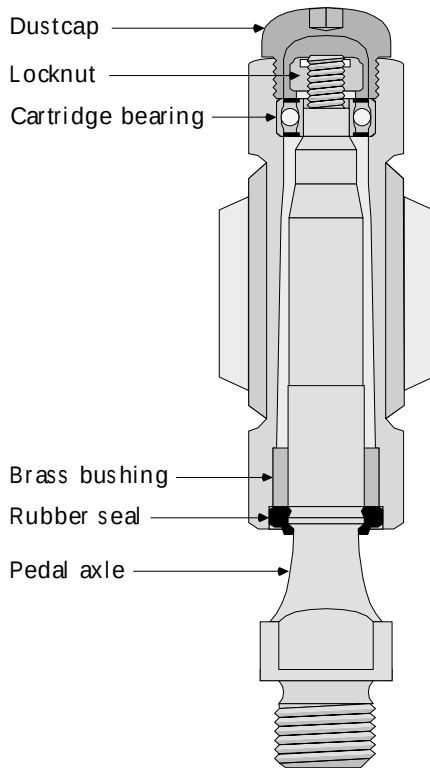
It is strongly recommend that only one pedal is disassembled at a time. There are parts that are unique to each pedal. If both pedals are disassembled at the same time and parts get mixed from right to left, each overhaul will have to be done all over again (at best); at worst, getting the parts mixed up between left and right pedals will damage some parts.

3. [] **With 6mm Allen wrench, remove pedal dustcap from outside end of pedal.**

15 – CARTRIDGE-BEARING PEDALS

DISASSEMBLE BEARING

The pedal axle must be held securely from rotating while removing the locknut. Soft jaws made of copper, aluminum, or plastic are recommended to protect the threads of the pedal axle from damage while clamped firmly in the vise.



15.3 An Onza pedal.

4. [] Clamp threaded portion of pedal axle in vise, using soft jaws to protect threads from steel jaws of vise.
5. [] Hold axle from turning with a pedal wrench while breaking loose locknut with 8mm socket.
6. [] Pull pedal body off of axle.
7. [] Turn pedal body over so outer bearing cartridge will drop out of pedal body. If it will not drop out, drive it out with a 10mm diameter drift punch or same-size pipe.
8. [] Use small-tip screwdriver to pry rubber seal out of inside-end of pedal body.
9. [] Use 10.5–11.1mm diameter drift punch or same-size pipe (a long 10mm Allen wrench also works) to drive brass bushing out of inside-end of pedal body.

INSPECTION

10. [] Rotate outer bearing cartridge to check for rough feeling, indicating need of replacement.
11. [] Inspect polished cylindrical surface on axle that rolls on inside of bushing for gouges and pits.
12. [] Inspect inside of brass bushing for gouges and pits.

Next, inspect the axle for bends. This was already inspected for in step #2, but this is another way of looking at it and is worth doing. Roll the axle on a flat smooth surface such as a Formica counter top or a glass counter top. Look under the axle as it rolls for a humping up and down that indicates it is bent. Bent axles are axles in the process of breaking and should be replaced.

13. [] Inspect axle for bends. Good? Bad?

ASSEMBLY

14. [] Using same tool used for brass bushing removal, drive brass bushing back into hole (unthreaded) in inside-end of pedal.
15. [] Press rubber seal into hole in inside-end of pedal body (with inner-perimeter lip facing out of pedal body).
16. [] Oil or grease cylindrical bearing surface on inner end of axle and insert axle into pedal.
17. [] Insert bearing cartridge into hole (threaded) in outside-end of pedal body.
18. [] Thread locknut onto end of axle.
19. [] While holding axle from turning with pedal wrench, use 8mm socket to secure locknut. Torque to 10–15in-lbs (3.5–5.0lbs@3").

ADJUSTMENT

A surprising feature of this pedal is that the dustcap fixes the location of the axle/bearing assembly in the pedal body. When the dustcap is not in place or not tight, then the pedal body will move in and out on the axle by several millimeters.

20. [] Lube threads, install and secure dustcap to torque of 24in-lbs (4lbs@6").

INSTALL PEDAL

21. [] Do steps 14–23 of *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-4).

16 – WHEEL BUILDING AND RIM REPLACEMENT

ABOUT THIS CHAPTER

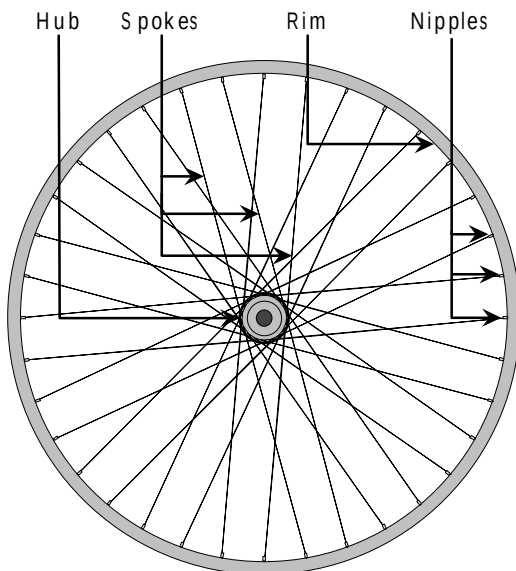
This chapter is about rebuilding wheels. It covers designing the wheel, determining the spoke length, assembling the spokes to the hub and rim (lacing the wheel), and getting the wheel ready for truing. Additional information is included about replacing rims and re-using old spokes. This chapter does not include anything about truing the wheels, but refers to the **WHEEL TRUING AND REPAIR** chapter (page 17-6) for that purpose.

The information in this chapter can be used for rebuilding a damaged wheel (saving the hub and using a new rim), or building a new wheel with all new components; however, it is written as though a wheel is being rebuilt. If building a new wheel with new components, merely substitute the word “build” for the word “rebuild.”

GENERAL INFORMATION

TERMINOLOGY

Wheel: The structure consisting of the hub, spokes, nipples, and rim.



16.1 Parts of a wheel.

Rim: The metal hoop at the outer end of the spokes that the rubber tire attaches to. The word *rim* is sometimes misused to apply to the wheel.

Spoke hole: The hole in the rim where the nipple comes out, although it would be better called the “nipple hole.” In regard to the hub, the term refers to the hole in the hub flange that the spoke goes through.

Eyelet: A separate metal reinforcement that goes in the spoke-nipple hole in the rim.

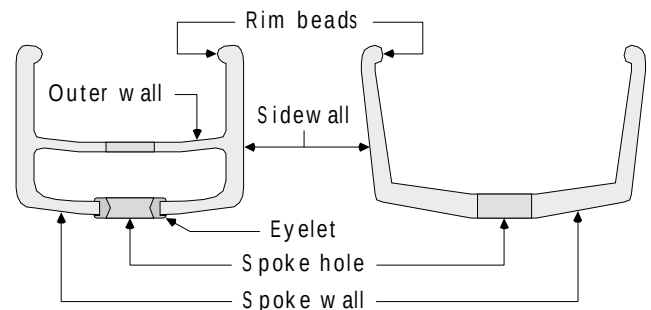
Valve hole: The hole in the rim that the tire-inflation valve inserts through.

Spoke wall: The wall of the rim that the spokes attach to.

Outer wall: The wall of the rim that faces the tube and tire. This wall only exists on modular-style clincher rims and tubular rims.

Sidewall: The vertical face of the rim where brake pads contact. There are rim sidewalls and tire sidewalls; in regard to a tire, *sidewall* refers to the portions of the tire between the rim bead and the tire tread.

Rim bead: The edge of the rim where the tire attaches.



16.2 Parts of a rim.

Hub: The mechanism at the center of the wheel that an axle rotates inside of and the spokes attach to.

Hub flange: The disc on either end of the hub that the spokes attach to.

Spokes: The wires that go from the hub to the rim.

Spoke elbow: The end of a spoke that makes a 90° bend where the spoke goes through the hole in the hub flange.

Spoke head: The flattened disc at the end of the spoke elbow that keeps the spoke from pulling through the holes in the hub flange.

Nipple: The elongated nut that threads onto the end of the spoke and attaches the spoke to the rim.

Nipple head: The fat portion at one end of the nipple (usually round).

Nipple slot: A slot in the nipple head that fits a slotted screwdriver.

Cross pattern: The pattern created by two sets of spokes in a hub flange that radiate in opposite directions as the spokes go out to the rim. If a clockwise-radiating spoke crosses three counterclockwise-radiating spokes from the same hub flange, then the wheel is said to be a “three-cross pattern.” Cross patterns are described symbolically. A three-cross pattern is usually just written “3X.”

Interlace: When a spoke leaves the hub, it crosses over other spokes; if it switches to crossing under at the last spoke it crosses on way to the rim, then this pattern is called an interlace.

Dish: The centering of the rim to the hub locknuts. Because the flanges of a rear hub may not be equidistant from the locknuts, a rim centered to the locknuts is not necessarily centered to the hub flanges. Viewed from the wheel’s edge, this makes the wheel appear like a dish viewed from its edge.

PREREQUISITES

Wheel removal and installation

Before rebuilding a wheel, the wheel must be removed from the bike. See the **WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION** chapter (page 18-6) if unsure about wheel removal and installation.

Tire removal and installation

Before rebuilding a wheel, the tire must be removed from the wheel. See the **TIRES AND TUBES** chapter (page 19-3) if unsure about tire removal and installation.

Freewheel removal and installation

To rebuild a wheel, it is necessary to remove the freewheel or freehub cogs. See the chapter **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** for freewheel removal (page 25-9) and freehub-cog removal (page 25-16).

Hub adjustment

Before building a wheel, the hub must be adjusted to have no free play when out of the bike. See the appropriate chapter on hub adjustment.

INDICATIONS

Symptoms indicating the need for rim replacement or wheel rebuilding

During wheel repair, or even before, symptoms may be experienced that indicate wheel replacement or wheel rebuilding is desired. These symptoms are:

Multiple broken spokes, either all at once or one at a time, over the last few hundred miles.

Multiple corroded nipples that won’t turn.

Multiple damaged nipples (rounded-off wrench flats).

Dents or bends in the rim that cannot be adequately straightened by normal spoke adjustment and unbending techniques.

Cracks in the rim.

Severe rim-sidewall wear, evidenced by a concave rim sidewall, or by rim beads that have become wider apart than they were originally.

Whenever these symptoms are specific to the spokes and nipples, decide whether to keep the rim or replace it. The dilemma is that if the problem with the spokes or nipples is bad enough to prevent truing the wheel, then there is no good way to tell if the rim is in good shape. If the rim is reused, the damage may not be discovered until most of the work of truing has been done. As a rule, replace the rim when the set of spokes needs to be replaced.

TOOL CHOICES

The most important tool for building a wheel is the spoke-length system that will be used to determine the correct spoke length. There are many systems on the market, and all will determine the length correctly most of the time; however, there is no ideal system. Each has its own compromise. Short reviews of several of the systems are included. In the section of this chapter on determining spoke length, there are tips for some of these systems and complete instructions for a few of them. The systems are basically sound, but the instructions that come with them are over-simplified, making each system appear simple and easy-to-use. Because the systems come with over-simplified instructions, this chapter includes very detailed instructions that will enable you to get better results out of any of these systems than you would get by just using the manufacturer’s over-simplified instructions.

The spoke-length-calculation systems are either manual, or electronic. The electronic ones require a computer or a special scientific calculator. The manual

ones require the use of written tables for looking up factors, and leave the math up to the user. Most systems provide hub and rim data for existing equipment to simplify calculations, but inevitably wheels need to be built with components that are not listed. Consequently, the system's provisions for dealing with unlisted equipment are more critical than the lists of existing equipment.

Sutherland's Handbook for Bicycle Mechanics. This book covers much more than spoke length, but its spoke-length system is one of its most important features. The database on existing rims and hubs is good when an edition is first published, but becomes seriously out of date between editions. The book provides a system for determining data for rims not listed, but the instructions for measuring and calculating rim data are vague. This manual includes instructions for *Sutherland's* fifth and sixth editions for no other reason than these editions are the one most widely used at the time of this writing.

Spoke Calc by DT. This is a wall poster full of data tables and measuring devices for hubs and rims. The data tables are based on dimensions, rather than models, so they never go out of date. On the other hand, no model information means that every rim and hub needs to be measured, instead of just looked up. The built-in measuring systems are primitive and a likely source of error. In this chapter, full instructions for use of *Spoke Calc* (with more accurate methods for measuring components) are provided.

Wheelsmith Spoke Length Calculator. This scientific calculator, programmed specifically for spoke-length calculation, is simple and quick. The accompanying book has a reasonable range of existing component data, and the system comes with a good device for measuring rims. The system for measuring hubs is less precise, but this chapter provides more accurate hub-measurement techniques.

Blue Pig Industries Wheel Calculator. This PC-based computer program is accurate, has a comprehensive database, allows adding and editing data, and has many extra features. It requires hub and rim measurements for unlisted equipment. Procedures for making these measurements are included in this chapter.

SpokeMaster (BOD). SpokeMaster is a component of the BOD bicycle-product database. This program (based on the *Sutherland's* book) is easy to use but is severely limited by the complete lack of any way to deal with rims or hubs that are not listed in its database. It is difficult to confirm whether a hub or rim matches a listing due to lack of dimensional and descriptive information about the hubs and rims. *This program is not recommended!*

SpokeMaster for Windows by Two-Bit Software. This is a completely different program than SpokeMaster (BOD). The name is likely to change because of trademark infringement, so look for a spoke-length program for Windows by Two-Bit Software. It has a database, and allows custom entries for hubs and rims. The descriptions of how to measure hubs and rims are inadequate, so use procedures recommended later in this chapter. The program is inexpensive and easy to use, but forces the user to complete the process for both sides of rear wheels, resulting in inconsistent differentials between the left and right sides (inconsistent differential values are the result of the program's use of a simple geometrical model of the wheel, rather than a more realistic one based on physics). Use the recommended left-side length and calculate the right-side length differential by methods recommended later in this chapter.

Tool choices and useful supplies are listed in table 16-1 (page 16-4). The preferred tools or supplies in table 16-1 are shown in **bold** face. If there are several tools for the same purpose that are shown in **bold** type, the choice is strictly a matter of personal preference or price.

TIME AND DIFFICULTY RATING

Lacing new spokes into a wheel is a 8–12 minute job of little difficulty. This time is based on starting with a bare hub. This does not include calculating spoke length (which varies from 2–10 minutes depending on the system used), or truing.

COMPLICATIONS

Removing spokes before removing the freewheel from hub

On the freehub-type rear hubs that are most common today, it is not a big concern if the cogs are not removed from the hub before the spokes are cut or unthreaded. Making this mistake on a traditional hub with thread-on freewheel can be disastrous because the rim is an indispensable part of the freewheel-removal procedure, and because the freewheel blocks access to the spoke holes in most cases. See the chapter **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** (page 25-13)

for methods for removing freewheels once the rim has been detached. Usually, a choice must be made between sacrificing the freewheel or sacrificing the hub.

Knowing whether to reuse a rim

When spokes start breaking repeatedly, then it makes more sense to replace them all at once, rather than one at a time. It might also be desirable to replace a set of spokes because of corroded nipples, rounded nipple-wrench flats, or spokes mangled from a chain over-shift. For reasons of economy, a decision is often made to reuse the rim.

If the problems with the spokes make it impossible or impractical to true the wheel precisely before rebuilding it, then there is no way to know whether the rebuilt wheel will end up true with good uniform spoke tension. It can turn out to be very false economy to reuse a rim. Unless it is possible to true the wheel and evaluate spoke-tension uniformity before unbuilding the wheel, it is recommended to use a new rim when the spokes need to be replaced.

WHEEL-LACING AND BUILDING TOOLS (table 16-1)

Tool	Fits and considerations
Blue Pig Wheel Calculator	PC computer program. See preceding review of spoke-length systems.
DT Spoke Calc	Wall chart or PC computer program. See preceding review of spoke-length systems.
SpokeMaster (BOD)	Not recommended — see preceding review of spoke-length systems.
SpokeMaster for Windows by Two-Bit Software	Name for this is likely to change due to trademark conflict. Make sure program is by Two-Bit Software. See preceding review of spoke-length systems.
Sutherland's Handbook	Book, includes spoke-length system. See preceding review of spoke length systems.
Wheelsmith Spoke Length Calculator	Programmed scientific calculator. See preceding review of spoke-length systems.
Bicycle Research ND-1	Offset screwdriver for speed-threading of nipples.
VAR 265	Special nipple driver for electric drills. Only useful for production runs of identical wheels.
Hozan C915	Relatively inexpensive spoke-threading machine, impractical for more than 2–3 spokes at a time. Valuable for creating replacement spokes in unusual sizes for wheels that just need a few spokes replaced.
Phil Wood Spoke Threading Machine	Cuts and threads spokes, difficult to cost-justify, difficult to create consistent length of threading (makes truing more difficult).
DT Spoke Ruler	Inexpensive spoke ruler, aluminum gauge-notches loose accuracy quickly.
Park SBC-1	Inexpensive spoke ruler, no gauge-notches
Phil Wood Spoke Length Gauge	Expensive, precise, and durable. Superior variety of gauge-notches that retain accuracy.
Wheelsmith Spoke Ruler	Precise and durable. Limited variety of gauge-notches.
Eldi 2620	Heavy duty spoke cutter for cutting out old spokes.
DT Spoke Freeze	Thread preparation compound reduces corrosion and vibration loosening.
Wheelsmith Spoke Prep	Thread preparation compound reduces corrosion and vibration loosening.
Sanford Sharpie Fine Point permanent marker	Used for marking on hub and rim to keep track of where spokes will go.
1/2" masking tape	Used for tagging a spoke in order to keep track of it.

Knowing whether to reuse the spokes

When a rim is damaged, it may seem to make sense to replace the rim, but reuse the spokes. This can be another false economy. There is no way to tell what life is left in old spokes. They may all be on the verge of fatigue failure. It is strongly recommended to always use new spokes when installing a new rim.

Calculating inaccurate spoke lengths

Determining the correct spoke length can depend on taking numerous measurements precisely, looking up numbers accurately from complex tables without error, and performing a number of mathematical procedures without error. Manual systems have all these potential problems. Electronic systems can reduce some of them, but usually not all. Until a mechanic has calculated spoke length for a large number of wheels without error, it is a mistake not to double-check all spoke-length calculations — recalculation is far less time-consuming than building a wheel twice.

Correct spoke length(s) unavailable

It is not unusual to calculate the correct spoke length, only to find that it is not on hand or readily available from a supplier. For most wheels there is an ideal length, and a range of acceptable lengths of at least plus or minus 1mm from the ideal.

If deviating slightly from the ideal does not solve the problem, then consider switching to another gauge or another cross pattern. Most wheels are built as a three-cross, but a four-cross pattern is practically identical in function. On front wheels only, a two-cross pattern might be an option.

Wrong spokes in box

One of the most common situations in a bike shop is for spokes in a container to be mixed, or all the spokes different from the label on the box (due to lids getting switched). Another problem is that gauges of spokes or nipples are wrong or mixed.

It is always easier to measure length and gauge of the spokes before lacing the wheel, than it is to unlace a wheel and start over again. Measuring every time is the *only* way to prevent this common problem.

Building with wrong-length spokes

For each wheel there is a range of spoke lengths that will not cause problems. Beyond this range, there are lengths that are too long or too short, but can be lived with. Spokes that are too long or too short cannot be used.

When spokes are too long, they protrude past the nipple into the tire area. If the nipple is in a recessed socket and the protrusion 1mm or less, this is not a problem. If the nipple is not in a socket, the protruding spokes will need filing, which is time-consuming and awkward.

When spokes are too short, they will show thread outside the nipple. Up to 1mm of exposed thread is nothing more than a cosmetic flaw. More than this raises concerns that there may be inadequate thread engagement between the nipple and the spoke.

Poor fit of spokes to hub flange

Spokes may seem to be too tight or too loose in the spoke holes.

Some high performance hubs are made with 1.8mm spokes in mind. The 2.0mm size usually fits, but is difficult to install and causes the spokes to come out of the flange at an awkward angle. The lacing procedure recommended here effectively deals with the problem of the tight spokes coming out of the flanges awkwardly.

Sometimes a flange seems too thin for the elbow of the spoke. Traditionally, it has been recommended to use washers between the spoke head and hub flange in this case, however these washers are virtually impossible to find. Structurally it makes little difference.

Light gauge spokes, such as 1.8mm, sometimes seem loose inside the spoke hole in the hub flange. As long as the spoke is a harder metal than the hub flange, then the spoke under load will always create its own ideal bed of support in the hub flange.

Special hub configurations

There are numerous special hub configurations, and between the time this manual is being written and the time that a new edition comes out, there will undoubtedly be more.

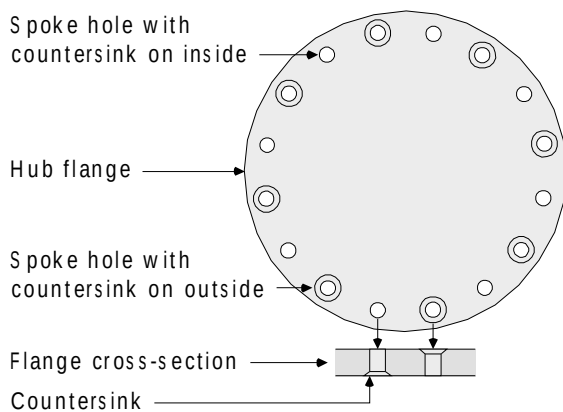
The rage at the time of this writing is “direct pull” hubs that use spokes that have no elbow. The only certain thing is that this rage will be replaced by another before this edition of the manual gets old.

This chapter only applies to the tried-and-true drilled-flange hubs and elbowed-spoke designs.

Even with this traditional design there are variations that create complications. The simplest variation is one in which every other spoke hole is countersunk on the outer face of the flange, and all the other holes are countersunk in the inside face of the flange. The countersinks are designed to accommodate the elbow of the spoke (highly debatable — see ***Countersunk or chamfered spoke holes*** on page 16-9), so

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dealing with this design is simply a matter of choosing the first hole correctly so that the head of the spoke ends up on the opposite side of the flange from the countersink.



16.3 *Cross-section of a hub flange with alternately-countersunk spoke holes.*

Some hubs are designed so that all the spokes have their heads on the inside of the flange. To accomplish this, there are usually two “levels” to the outer face of the flange. The “upper level” is the normal outer face of the flange. The “lower level” is usually a “V-shaped” notch in the outer face of the flange that allows a spoke to come out of the hole (in the notch) and pass under the spokes in the “upper level.” This design causes two problems: 1) when selecting the spoke length, it is important to know if the V-notches limit the cross pattern (3-cross or less is typical) so that you may select a pattern and the appropriate length accordingly; 2) when lacing, it is necessary to feed all spokes into the flange from the inside, and install the spokes (to the rim) in the “lower level” before attaching any spokes from the “upper level.”

Special rim configurations

Special rim configurations present several types of challenges.

Not all rims have the same spoke-drilling style. There are three drilling styles; furthermore, the manufacturers and distributors tend to ignore the issue entirely, so it is up to the mechanic to determine the drilling style. There are no commonly accepted terms for different styles, so the following terms are unique to this book. Depending on how the rim is oriented when being examined, a drilling style can appear two exactly opposite ways.

Hold the rim horizontal with the valve hole on the opposite side of the wheel from your body. Look at the two spoke holes to the *right* of the valve hole to see which of the following styles a rim matches:

Staggered down/up: This is the most common pattern, and the first hole to the right of the valve hole is staggered down.

Staggered up/down: This is a less common pattern, and the first hole to the right of the valve hole is staggered up.

Unstaggered: This pattern is usually found on aerodynamic-profile rims, and all spoke holes are directly in line with each other.

Deep cross-section rims have awkward access when putting a nipple down into its hole. Although tools have been made for this process, nothing works better than putting the nipple on a square-shaft toothpick.

Some aerodynamic-rim designs keep the nipple entirely inside the rim. Special tools may be required to install and adjust the nipples.

Different cross patterns on each side of the wheel

The rules change on how to lace a wheel when the lacing pattern is not the same on both sides of the wheel. Be sure to read about the special technique required whenever building something like a wheel with 3-cross on one side and 2-cross on the other side.

Lacing errors

The complexity of lacing a wheel makes it inevitable that errors will occur. The lacing method in this chapter is designed to reduce error, but more importantly it includes periodic checks as the wheel develops stage-by-stage, so that the errors will be discovered early. *Always perform the checks!*

Scratching the rim while lacing the wheel

Rims can be very expensive, and maintaining the cosmetic finish in good condition is an important part of building a wheel. Don't hesitate to bow spokes when installing them in order to get the tips to clear the rim — just avoid kinking them.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into four parts. The first part is about wheel design. This section helps determine which hub, rim, spoke, and lacing pattern will be best for any particular reason. The second section is about how to determine spoke length. The third section is about how to lace the spokes into the hub

and rim from scratch. The fourth section is about replacing a damaged rim while reusing the spokes and keeping them in place. This should only be done when a new wheel is damaged and it is known that the spokes are not damaged and have not yet begun to fatigue.

WHEEL DESIGN

When designing a wheel, the designer should keep in mind the three types of load that the wheel experiences, and the performance and reliability criteria that suit the user.

Wheels experience three types of load; radial load, lateral load, and torsional load.

Radial load is the load that is experienced in a straight line between the hub and the rim. Radial loads result from the weight on the wheel, and from hitting bumps and dips in the riding surface.

Lateral load is load experienced at the rim that is at right angles to the plane of the wheel. Normal lateral loads are relatively slight, and occur when the wheel is leaning over, but the rider is not (for example, when rocking the bike side to side while climbing out of the saddle). Extreme lateral loads are experienced when control is lost and the wheel receives impact from the side.

Torsional load is experienced on all rear wheels, and on any wheel that has a hub-mounted brake (disc brakes, drum brakes, and coaster brakes). Torsional load is experienced when drive forces cause the hub to rotate, which then causes the rim to rotate by means of the spokes. Hub brakes cause torsional load because the momentum of the vehicle is causing the rim to rotate, and the brake at the hub is resisting the rotation. Rim brakes do not cause torsional load on the wheel structure because the resistance to the rim's rotation is at the rim, not at the hub.

In addition to designing a wheel to withstand these loads, the wheel designer must consider the performance expectations of the user. Wheel weight and aerodynamic resistance are the primary considerations that affect performance. In regard to wheel weight, rim weight is most important, spoke weight is less important, and hub weight is the least important. These differences are because of the relative speed of rotation of each wheel component. The faster the speed of rotation is, the more significant a weight difference will be. Rim shape and spoke shape are the most significant factors affecting aerodynamics.

The reliability of the wheel is one more consideration in the design of a wheel. A wheel that will withstand high radial load is more reliable for the type of user that will subject the wheel to extreme levels of off-road use. Heavier riders are also concerned with a wheel's ability to withstand high radial loads. Rim weight and shape would be important considerations for this user. A wheel that will last many thousands of miles without spoke breakage is more reliable for the type of user that rides many miles of smooth road. For this user, spoke gauge and spoke number choices might be most significant.

The rest of this section on wheel design discusses the specifics of how rim shape, rim weight, rim materials, lacing patterns, spoke gauges, spoke quantity, and hub choices affect how a wheel will hold up, and meet the user's expectations of performance and reliability.

RIM CHOICES

Materials

Materials used for rims include steel, aluminum, carbon fiber, and titanium. Steel is economical, but otherwise undesirable. Aluminum has a superior strength-to-weight ratio and superior braking performance and is the only choice for most applications. Titanium rims of a reasonably low weight have extremely thin wall thickness, so their use is limited to the track. Carbon-fiber rims can either be full carbon fiber, or a carbon-fiber "fairing" on the inner diameter of an aluminum rim. A full carbon-fiber rim is prone to catastrophic failure and provides an inferior surface for braking. Aluminum/carbon-fiber combinations have neither of the disadvantage of plain carbon fiber.

Because of its combination of desirable properties, aluminum remains the material of choice for most bicycle rims.

Shapes

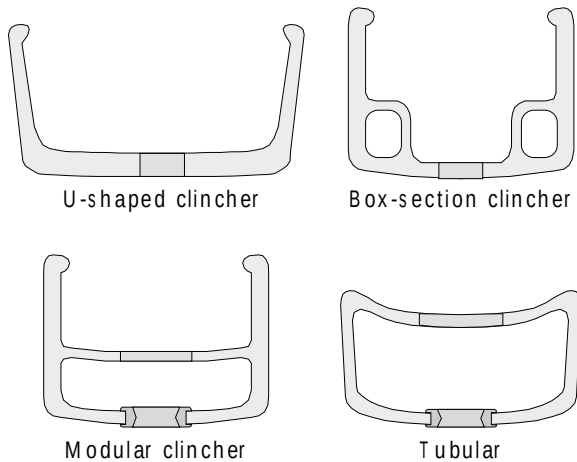
The cross-sectional shape of a rim and the thickness of its walls are the primary things affecting rim strength. Rims are of either of two categories, tubular (tires are glued on) or clincher (conventional tires).

Tubular rims have a cross-section shaped like a modified tube. This is the best shape for strength-to-weight ratio, but only sew-up tires that are glued onto a rim can be mounted on these rims, so tubular rims are therefore impractical for the average cyclist.

Clincher rims are either U-shaped, box section, or modular. U-shaped rims for clincher tires have no hollow to their cross-section and have the least strength for their weight. Box-section rims have a hollow box

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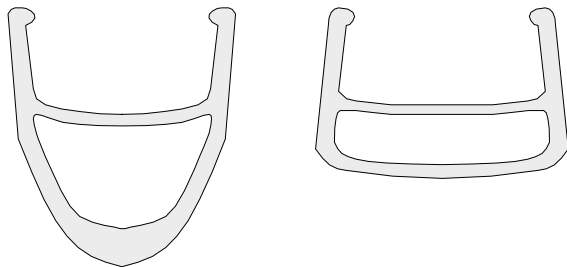
section at each corner of the rim cross-section and have an improved strength-to-weight ratio. Modular rims have a tubular cross-section with rim flanges attached for mounting a clincher tire. This design features the best strength-to-weight ratio for clincher rims.



16.4 Common rim cross-sections.

Aerodynamic rims can be tubular or clinchers with box or modular cross-section. They are generally heavier than their non-aerodynamic counterparts, weaker laterally and stronger radially. Aerodynamic rim shapes are compatible with sidepull brakes, but are not very suitable for cantilever brakes (touring and mountain bikes).

The best shape for a rim to be used with cantilever brakes is sort of a reverse-aerodynamic shape, narrower at the outer perimeter than at the inner perimeter of the sidewall. Straight-wall (no slope) rims are almost as suitable for use with cantilever brakes. Any rim that is wider at the point where it meets the tire is a poor choice for use with cantilever brakes, or brakes that mount on cantilever braze-ons.



16.5 The 'aero' rim type on the left is unsuitable for use with cantilever brakes; the rim on the right has the ideal slope to the sidewalls for use with cantilever brakes.

In conclusion, shape is important because it determines whether a rim gets the most out of the amount of material that is used.

Eyelets (hole reinforcements)

Rims may be eyeleted to reinforce the rim at the spoke hole. Single eyelets reinforce the rim only at the spoke wall. Double eyelets form a socket that distributes the spoke load between the spoke wall and outer wall of a tubular or modular-clincher rim. Eyelets also reduce friction between the nipples and the rim, and are critical for this reason when using aluminum nipples.

Eyelets are a desirable, but not critical, feature.

Anodized rims

Anodized aluminum rims have been chemically treated to make the surface more corrosion resistant. The anodization could be a variety of colors including clear, gray, silver, gold, blue, red or black. This results in a rim that keeps its appearance better; however, the anodization wears off the braking surface rapidly.

Hard-anodized rims have been chemically treated to create an anodized layer that not only resists corrosion, but is more abrasion resistant than plain-anodized rims. The process incidentally improves the strength of the rim insignificantly. These rims will be dark in color, such as smoky gray, brownish gray, dark gray, dark blue-gray or black. The result is that the hard anodization remains on the braking surface longer, but it seems to detract from braking performance.

In conclusion, anodization of all types is an insignificant consideration in wheel design.

Heat-treating and work hardening

A variety of alloys and hardening processes (heat treating) are used in manufacturing rims. These alloy choices and hardening processes cannot be described as having any special significance without also considering the rim weight and design. There is a very narrow range of hardness that is suitable to a bicycle rim. Too hard and the rim is brittle and tends to crack around the spoke holes, and elsewhere. Too soft and it bends too easily. Whether a manufacturer uses "heat treating," "work hardening," or some other exotic-sounding hardening process, the end results must be very close to the same or the rim will be too brittle or too soft.

In conclusion, the use of different materials and hardening processes mean more to the rim designer than they do to the end user. Marketing people look for every little tidbit to make their products sound superior. Do not let these marketing concepts have too much influence on rim choice.

Ceramic coating

Ceramic coatings are put on rim sidewalls to improve brake performance. They have no effect on overall rim strength, other than to reduce rim wear from the brake pads (an important consideration for many mountain bikers). These ceramic coatings are effective for the purpose of improving braking.

In conclusion, ceramic coatings are an expensive plus.

Rim weight

Rim weight is a significant factor in determining wheel strength and the bicycle's acceleration and braking performance. Weight is a function of the overall dimensions of the rim, the cross-sectional design, and the wall thickness. It is most useful when comparing two rims of similar cross-section design (both modular, for example) and similar dimensions (both 19mm wide and 14mm deep, for example). If one rim weighed 10% more than the other, the likely reason would be that the heavier rim would have thicker rim walls at some point. Thicker means stronger. If the extra thickness is uniform throughout, then it means that the rim is overall stronger. If the sidewalls only are thicker, it means that the rim is stronger radially. If the spoke wall is thicker, it means that the rim is less likely to fail at the spoke holes, and it has greater lateral strength. Whether the extra thickness would be uniform throughout is unknown, unless you have access to the manufacturer's specifications or have a rim cross-section to measure.

Clincher rims of the 27" and 700C sizes range in weight from more than 800 grams to as little as 400 grams. Less than 475 grams is generally considered to be in a range where strength is significantly compromised for the advantage of low weight. Manufacturers of 26" narrow triathlon rims claim weight savings ranging from 0 to 40 grams for a 26" rim compared to the 700C size of the same model; general weight guidelines for these 26" rims should not be considered different. Tubular rims (700C) range in weight from 480 grams to as little as 280 grams. Less than 375 grams is generally considered to be in a range where strength is significantly compromised for the advantage of low weight. Mountain bike rims (26") range in weight from 750 grams to as little as 390 grams. Less than 450 grams is generally considered to be in a range where strength is significantly compromised for the advantage of low weight.

In conclusion, rim weight is a significant factor in wheel design, but rim shape determines whether two rims of comparable weight have comparable strength and stiffness.

HUB CHOICES

Small- versus large-flange hubs

Large-flange hubs were traditionally thought to increase a wheel's lateral, radial and torsional stiffness. Of these, only torsional stiffness has been scientifically verified, but the increase in torsional stiffness reduces spoke fatigue by an insignificant degree.

Small-flange hubs have been traditionally described as having less radial stiffness (making them more comfortable), less lateral stiffness (making them less stable in cornering) and less torsional stiffness, which is true, but of low significance (see above). The assumptions about comfort and lateral stiffness with either flange type are false and the difference in torsional stiffness is not significant, so flange diameter should not be a major consideration in designing a wheel. This is also true for mixed-flange designs (small flange on one side and large flange on the other side).

In conclusion, flange-diameter considerations are relatively insignificant with regard to wheel properties.

Five-, six-, seven-, or eight-speed capacity

Providing more space for a greater number of sprockets increases the offset of the right flange to the left, which in turn significantly increases the wheel's vulnerability to failure when exposed to high lateral loads (generally only experienced during crashes or other forms of losing control of the bike). In some cases, this is compensated for by adding space to the left side of the hub. A standard seven-speed hub might have 130mm overall spacing, but be available in a 135mm "dishless" (actually not dishless, just less dish) option.

In conclusion, giving up a needed gear or spreading a frame to accept a wide version of a hub to prevent wheel failure during crashes is a questionable priority choice. Build wheels with no consideration to how the number of gears affects lateral strength.

Countersunk or chamfered spoke holes

Countersinking is done to improve the mating of the spoke elbow to the flange to reduce fatigue. Aluminum flanges are softer than spokes, so the edges of non-countersunk holes will easily conform (shape) to the shape of the spoke. This "shaping" of non-countersunk spoke holes is superior to the "shaping" that occurs if the spoke holes are countersunk.

For this reason, ignore the countersinking pattern if it interferes with lacing the wheel in the way desired.

Hub-core diameter

The advent of front suspensions has led to front-suspension hubs. These hubs often have a larger diameter core, which has been reputed to increase stiffness. Research has shown that front-suspension hubs that do reduce separate fork-leg action do so because of changes in axle design. Larger hub cores alone are irrelevant to wheel strength.

Suspension-hub considerations

Special front hubs are made for use on bikes with front suspensions. These hub features may include large diameter hub cores, oversized axles, oversized skewers, and oversized locknut faces. All these features (except larger diameter hub cores) reduce independent leg action on front forks. It cannot be designed into the hub, but nothing reduces independent fork-leg action more than maximizing the security of the hub in the fork. Wheel performance is unaffected by all these factors, which work by reducing flex in the axle and motion between the axle and the fork leg.

Direct-pull flange designs

Direct-pull flange designs use a spoke that has no elbow. This is a poor design that attempts to solve a problem that does not exist. It has been reinvented and abandoned numerous times in the history of bicycles. The rationale is that since spokes break at the elbow, the elbow should be eliminated. Spokes do not break at the elbow because it is an elbow, but because it is the anchor-point of the spoke.

The dynamics of a rear wheel require that the hub rotate under torque-loads slightly before the rim responds. The traditional elbowed spoke compensates for this by allowing the spoke to rotate in the hole in the flange, which, in itself, adds no stress to the spoke. Direct-pull designs allow the hub to wind up before the rim only by flexing the spoke, which does add additional stress to the spoke.

The direct-pull design complicates determination of spoke length, reduces cross-pattern options, increases spoke inventory, reduces choice of spoke brands and gauge options, and in some cases makes it more difficult to tighten nipples because of a tendency of the spoke to spin in the flange hole.

Avoid recommending this hub type to customers, and inform those who request it of the disadvantages.

SPOKE CHOICES

Materials

Carbon-steel spokes (most common, called chrome plated, galvanized, zinc plated) are inexpensive. Stainless-steel spokes are corrosion resistant and are usually made with superior manufacturing techniques, making them a generally more reliable choice. Stainless-steel spokes can be identified by the fact that they are not magnetic, or very mildly magnetic, whereas carbon-steel spokes are fully attracted to magnets.

There are exotic material choices, as well. Both titanium and carbon-fiber spokes are available in limited lengths and gauges at extremely high prices.

Titanium spokes are only available in thicker gauges that make them no lighter than the thinnest gauge steel spokes. Thin-gauge titanium spokes are not possible because of the greater elasticity of the material.

Carbon-fiber spokes are quite thick and may be a serious aerodynamic disadvantage. Carbon-fiber spokes are very susceptible to failure due to nicks. The carbon-fiber spokes are aerodynamically shaped, but due to their great thickness, they create more drag than thin round steel spokes.

Neither carbon-fiber or titanium spokes allow use of conventional tension meters, resulting in having to guess about the most critical factor in wheel building — correct spoke tension.

Stick with stainless-steel spokes for a proven combination of reliability, low weight potential, selection, and vital compatibility with tension meters.

Gauge choices

The most common gauge is English 14g, or ISO (and Japanese) 2mm. Note that English gauge numbers increase as the spoke diameter decreases, so that a 15g spoke is thinner than a 14g spoke.

Plain-gauge spokes are spokes that are uniform gauge over their entire length (except the thread). Common plain-gauge spokes are 2mm (14g) and 1.8mm (15g). Plain-gauge spokes are economical. Plain-gauge 2mm spokes are the easiest to build with because they wind up the least as nipples are tightened. For this reason, most machine-built-wheel spokes are 2mm. If a spoke breaks, a wheel built with 2mm spokes will go out of true less than a wheel with thinner spokes, because the spokes are less elastic.

Butted spokes are spokes that are thicker at the ends than they are in the middle. Common butted spokes are 2mm/1.8mm/2mm, 2mm/1.6mm/2mm,

1.8mm/1.6mm/1.8mm, and 1.8mm/1.5mm/1.8mm. Differentials of up to 3 gauges are now being seen. Butted spokes have the advantage of resisting fatigue by virtue of their thickness at the ends where fatigue occurs, and of enhancing wheel strength by making it more elastic, allowing a wheel to flex under load without bending. Butted spokes are more difficult to build with than plain 2mm spokes because they wind up more as the nipples are tightened. Butted spokes can save several ounces of weight per wheel compared to plain 2mm spokes, and their smaller diameter creates less aerodynamic drag.

Aerodynamic spokes are spokes that do not have a round cross-section. They may be bladed (flattened), elliptical (oval), or airfoil (best aerodynamics) cross-section. These shapes reduce the frontal area exposed to the air as the wheel moves through the air. The aerodynamic benefit is clear when riding in windless conditions, or directly in line with the wind, but in cross winds even greater turbulence (and drag) may be encountered with aerodynamic spokes than would be encountered with round-section spokes. With many aerodynamic spokes, there is a potential that there will be a compatibility problem with a tension meter.

Bladed spokes are usually 2mm spokes that have been flattened. Their weight is comparable to plain 2mm spokes. If bladed spokes have conventional spoke heads, the holes in the hub flange must be slotted with a special tool, which voids any manufacturer's warranty. Spokes with an oval or airfoil cross-section are usually 1.8mm spokes and have a weight comparable to butted 1.8mm spokes. The aerodynamic shape of oval or airfoil spokes is generally superior to bladed spokes, and they usually do not require modification of the hub flange.

The best overall spoke choice is a butted 2mm, and the best overall choice when performance is a greater priority than durability is a butted 1.8mm spoke. In addition, extra-light rims should always be built with light-gauge spokes.

NUMBER OF SPOKES

Conventional full-size wheels almost always use 36 or 32 spokes per wheel. Racing wheels usually use at most 32 spokes per wheel, but sometimes are built with 28 or 24 spokes per wheel. Touring bikes and tandems usually use 40 or 48 spokes.

Spoke quantity, weight, and true tolerances

When the number of spokes is reduced, weight is saved, but more importantly, aerodynamic resistance is reduced. When the number of spokes is reduced, the wheel structure is slightly more elastic and resistant to bending. When the number of spokes is reduced, each spoke is asked to control the true of a longer section of rim, which may lead to a worsening of the lateral-true and radial-true tolerances that can be achieved, particularly with lightweight rims. This loss of control over true is particularly troublesome with light-weight rims and less than 32 spokes.

Spoke quantity and fatigue life

The fatigue life of a spoke is directly proportional to the number of spokes. Consequently, 28 spoke wheels will start breaking spokes at 78% of the life of the same wheel built with 36 spokes. This statistic is even more significant in regards to tandem wheels. It is reasonable to assume that a tandem experiences approximately twice the load per wheel as a single bike. If both bikes had the same wheels with 36 spokes each, the life of the spokes in the tandem wheel would be 50% of the life of the spokes in the single wheel. To get equal spoke life, the tandem wheel would need 72 spokes. Increasing from 36 to 48 spokes only makes a 33% improvement in the life expectancy of the spokes on a tandem.

On the other hand, extra-spoke wheels on touring bikes are probably more trouble than they are worth. If the average rider is about 160 pounds and the average touring bike is about 30 pounds, the average 45-pound load of touring gear only increases the load on the spokes by 24%. More importantly, the total vehicle load (235 pounds) is only about 4% more than what would be considered a normal but heavy rider and bike (225 pounds). Although 40-spoke wheels would have 11% greater spoke life than 36-spoke wheels, the trade off is that replacement rims and spokes are much harder to find.

Extra spokes and rim/spoke availability

At drillings above 36 holes, the selection of rims becomes very limited. Also, every bike shop in the country is likely to have 36-hole replacement rims and the appropriate length spokes, but probably less than 5% of the shops in the country have 40- or 48-hole rims, or the unusual spoke lengths sometimes needed for such wheels. Since a tourist can't carry spare rims, the trade-off is not worth it.

NIPPLE CHOICES

Nipple length

Long nipples are designed to protrude further through thicker rim walls, or to provide a greater length for the wrench to engage. Long and short nipples of the same brand usually have the same depth of thread engagement, so use of long nipples does not usually allow the use of shorter spokes.

Nipple materials

Most nipples are made of brass and are plated with chrome or a similar plating. Aluminum nipples are used to save weight, and more significantly, in conditions where the spokes may snag on obstacles, aluminum nipples are more likely to fail than pull through the rim. The weight saved is less than 1 ounce per wheel. Aluminum nipples have a high coefficient of friction on non-eyeteled aluminum rims and may be more difficult to tighten.

SPOKING PATTERNS

A cross pattern, such as three cross (3X), gets its name from the number of times a spoke radiating one direction from a flange crosses the path of spokes radiating the opposite direction from the same flange. Most wheels are either built with a 3X or 4X pattern.

Cross-pattern voodoo

The discussion of cross pattern in regard to wheel performance characteristics is the source of a great deal of “voodoo mechanics.” Countless unsubstantiated theories based on subjective experience abound. Suffice it to say that wheel builders have been experimenting with cross patterns for as long as there have been spoked wheels. Decades ago the bulk of wheel designers settled on the virtually indistinguishable 3X and 4X patterns as the reliable ones. Scientific studies have verified these patterns to be the best and roughly comparable. All other cross patterns are voodoo, not science.

Three-cross and four-cross patterns

Traditionally, 3X patterns were thought to create a wheel with greater lateral, radial and torsional stiffness, and 4X wheels were thought to have all the opposite characteristics. All of these opinions have been scientifically disproved. On the contrary, the only measurable difference in strength between 3X and 4X is that 4X patterns have an insignificantly greater torsional stiffness. In a more practical sense, 3X has an

advantage over 4X in that the hub does not need to wind up as far when installing the third set of spokes, so that 3X is less awkward to build with.

On wheels with less than 36 spokes, 4X spoking is not compatible.

Pick between these patterns on the basis of spoke-length availability, and build 3X when lengths for both are available.

Radial, one-cross, and two-cross patterns

Cross patterns with fewer crosses than 3X are best used on very small wheels (less than 20") and are used to reduce congestion of spokes at the hub.

Performance advocates sometimes suggest using 2X, 1X, or radial spoke patterns to save weight (through use of a shorter spoke) or reduce aerodynamic resistance (only in regards to radial spoking, and in this case the logic is false). Since spoke lengths get shorter when crosses get fewer and shorter lengths are more rare, using 2X, 1X, or radial patterns often means not getting your choice of spoke gauges in order to build the lesser-cross wheel. To build a radial-spoked wheel with 14g spokes would be heavier and have more aerodynamic drag than to build the same wheel 3X with butted-1.8mm spokes.

The weight loss of radial spoking compared to 3X is 4%, or as little as 7 grams per wheel. One- and two-cross patterns are an even lesser weight savings compared to 3X. Aerodynamic resistance is not a factor, because, at the top of the wheel where the spokes are moving the fastest in relation to the air mass, changing the cross pattern does not change the face the spokes present to the air. Radial spoking (and to a lesser degree 1X and 2X) does put stresses on the hub flange in directions that they are not designed to withstand, and may lead to sudden, complete wheel failure.

Radial spoking, 1X, or 2X have inadequate torsional stiffness to support the wheel under high hub torque loads from pedaling (rear wheels) or hub-mounted brakes (such as disc brakes on either wheel). For this reason, radial spoking should not be used on any rear hub, or any front hub with a disc brake.

Traditionally, radial spoking is thought to increase the radial and lateral stiffness of the wheel. These characteristics have not been proven through testing. Radial spoking does reduce the torsional stiffness of the wheel (proven), and for this reason should not be used on rear wheels, even if just on the left flange (which does do part of the job of transferring torque to the rim from the hub).

Five-cross pattern

If 4X is better than 3X (debatable) then 5X is even better, right? No. Even if 4X were better, it would be better because it achieves an ideal 90° relationship between the spoke and the radius of the hub. The 5X pattern deviates just as much above the ideal of 90° as the 3X pattern deviates below. Furthermore, the 5X pattern causes the spokes to interfere with each other in a way that cause them to become kinked or bent.

Mixing cross patterns

Mixing cross patterns on rear wheels is sometimes suggested as a way to save weight or improve aerodynamics. A typical mix might be 3X on the right side and radial on the left. The weight savings by using radial on the left would typically be about 3 grams. The aerodynamic savings would be none.

Another reason given for mixing cross patterns on the two sides of a rear wheel is to minimize the tension difference between left and right-side spokes. Think of a wheel like a tug-of-war game in which the objective is to *keep* the flag on the middle of the rope over the center line. The rim is the flag on the rope. The spokes on each flange are like the two tug-of-war teams. The balance of tension on each side of the flag *must never change* if the flag (rim) is to stay centered. The positions of each member of the team on one side of the rope can be rearranged countless ways, but it will not change the net force they must pull with to keep the flag centered. Pretty much the only way to change the average amount of force required from each team member is to change the number of team members (number of spokes).

When cross patterns are mixed on a rear wheel, the only real difference between cross patterns becomes more significant. That difference is torsional stiffness. If the right-side spokes are a higher cross pattern than the left-side spokes, then the right side will have greater torsional stiffness. This means that load on the right-side spokes will start the rim moving before the left-side of the hub will have wound up enough to generate torsional load to the rim. In other words, on a mixed-cross wheel, only the spokes on the side with the higher cross pattern will do the work of transmitting load from the hub to the rim. Because there are no significant advantages, and because fewer spokes will be supporting the torsional load, mixing cross patterns is not recommended.

Pulling spokes heads-in or heads-out

The argument has been made that pulling spokes should be installed with the heads on the inside of the flange because the spoke is better supported when installed in this fashion. Research has shown that pulling spokes (counterclockwise radiating, viewed from the bike's right side) are no more inclined to fail from fatigue than the pushing spokes. This negates the argument; furthermore, the argument is based on the assumption that the spoke touching the flange after it leaves the spoke hole somehow gives the spoke more support. Since the primary loads in the spoke are in the shear direction, there is no way that this additional contact could provide more support.

The other argument about which way the pulling-spoke heads should face has to do with what will happen when the chain over-shifts the innermost cog and goes into the spokes. When the pulling-spoke heads are inside the flange, then the chain has a greater tendency to jam in the spokes *if pedaling pressure is maintained on the chain*; in this case, the pulling spokes act like guides that catch the chain and force it closer to the center of the wheel. What is often overlooked is that when the pulling-spoke heads are outside the flange, then the chain has a greater tendency to jam in the spokes *if the rider resists the continued rotation of the chain by keeping the cranks stationary after the over-shift occurs*; in this case, the non-pulling spokes act like guides that catch the chain and force it closer to the center of the wheel. It is impossible to predict what the rider's behavior will be in this situation, so there is no real value to build one way instead of the other.

The procedure in this chapter creates a wheel that has the pulling spokes in the flanges with the heads facing out. Because no real difference exists, there are not detailed instructions on how to build a wheel the opposite way. The least confusing way to get the opposite result is to put each set of spokes into the opposite face of the flange than the instructions indicate.

Conclusion

Stick with 3X and 4X patterns for all types of wheels except those smaller than 20".

TYING AND SOLDERING SPOKES

Tying and soldering is a technique used to restrain the spokes in case they should break. Although it has been credited with increasing the strength and stiffness of the wheel, this has been scientifically disproved. Any process that alters the metallurgy of the spoke by exposing it to high heat should be avoided.

DETERMINING SPOKE LENGTH

USING THIS SECTION

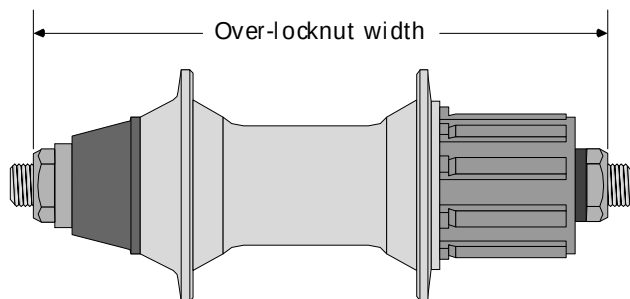
This section includes complete instructions for using *Spoke Calc* by BPP, *Wheelsmith Spoke Length Calculator*, and *Sutherland's Handbook for Bicycle Mechanics* (fifth and sixth editions). The process for several of these systems requires common measurements of the hub and rim. Before any specific system is covered, there are procedures described for making these common measurements.

In addition to complete instructions for these three systems, there are guidelines for using three computer programs. These programs are Blue Pig Wheel Calculator, PC Quick Spoke, and SpokeMaster for Windows.

COMMON HUB MEASUREMENTS AND FACTORS

Over-locknut width

As seen in the illustration below, over-locknut width is the distance from the face of one locknut to the face of the other locknut. Some cartridge-bearing hubs do not use locknuts. In this case, measure to the surfaces that butt against the inside faces of the dropouts.

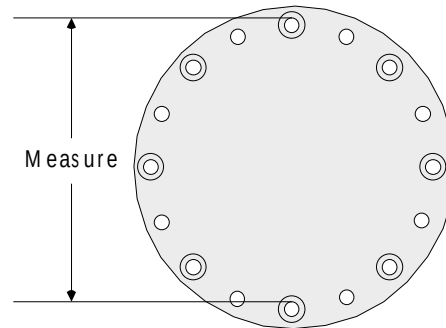


1. [] Measure Over-locknut width (_____ is O_w)

Hub-flange diameter

Hub-flange diameter is not actually a measurement of the flange diameter, but a measurement of the diameter of the circle that goes through the center of all the spoke holes in a flange. Depending on the length system being used, it will be called *hub-flange diameter*, *flange diameter*, *actual hub diameter*, *spoke-hole-*

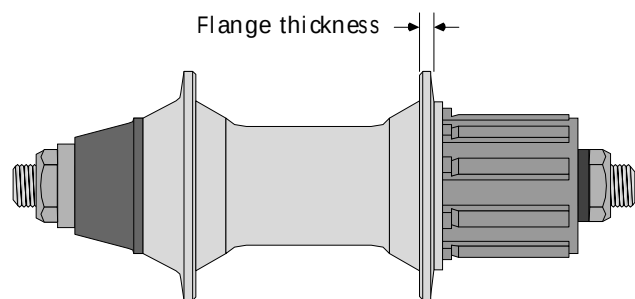
circle diameter, or *hole diameter*. It is easiest to measure from the inside edge of one hole to the outside edge of the opposite hole.



1. [] Measure Hub-Flange diameter to nearest millimeter: (_____ is H_{FD})

Center-to-flange dimension

The center-to-flange dimension is the distance from the center of a flange to the centerpoint between the two locknuts. It is easy to describe and easy to diagram, but not so easy to measure accurately because of the large offset between the edge of the flange and the face of the locknut. For this reason, a series of measurements and calculations are required.



1. [] Measure Flange thickness (_____ is F_T)
2. [] Record Over-locknut width (_____ is O_w)

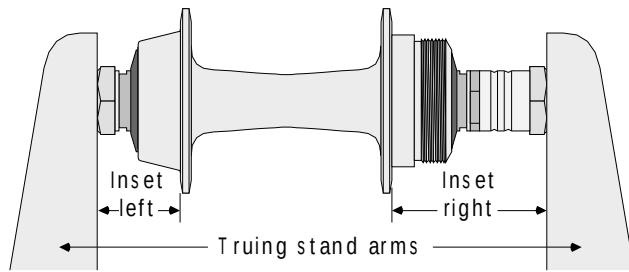
Flange thickness and over-locknut width are used in the following formula:

$$(O_w - F_T) \div 2 = C_{WF}$$

In the following steps, formulas are not written in their correct mathematical form, but as a series of calculator entries. In the blanks under each letter code, fill in the correct measurements. Then enter the values and calculator function keys as indicated, to get the result.

3. [] Center-width factor of hub (C_{WF}) Calculator entries (round result to whole millimeter):

$$O_w \quad F_T \\ \text{_____} \quad \text{_____} \quad \div \quad 2 \quad = \quad (\text{_____} \text{ is } C_{WF})$$



4. [] Measure Inset left (_____ is I_L)
5. [] Measure Inset right (skip for front hub):
(_____ is I_R)

The formula for calculating the center-to-flange (left) dimension is: $C_{WF} - I_L = CF_L$. The following step shows the calculator entries, not the mathematical formula.

6. [] Center-to-Flange left (CF_L) Calculator entries (round result to whole millimeter):

$$C_{WF} - I_L = (\quad \text{is } CF_L)$$

The formula for calculating the center-to-flange (right) dimension is: $C_{WF} - I_R = CF_R$. The following step shows the calculator entries, not the mathematical formula.

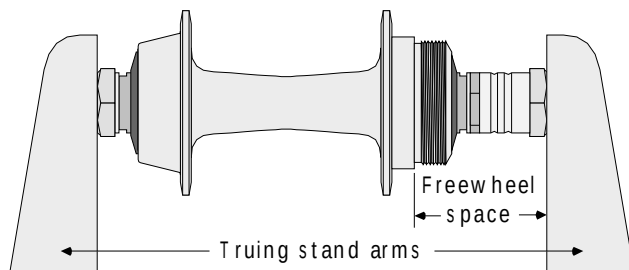
7. [] Center-to-Flange right (CF_R) Calculator entries (skip for front hub):

$$C_{WF} - I_R = (\quad \text{is } CF_R)$$

Freewheel/freehub space

NOTE: Step 1 is for conventional hubs that a freewheel threads on to.

1. [] Measure freewheel space (freewheel shoulder to locknut face): + _____ mm



16.10 Measuring freewheel space with the hub in a truing stand.

NOTE: Step 2 is for freehubs only.

2. [] Count and record the number of cogs that fit on the freehub and record here:
Number of cogs on freehub is: _____.

Rear-wheel-spoke-length differential factor

Many spoke-length-calculation systems create different lengths for the left and right sides of the rear hub by repeating all the calculations separately for both sides. Others may use a simplified mathematical calculation that determines the difference between the left and right sides. Most systems create an acceptable (but less than ideal) difference, because they rely on a simple geometrical model for determining the length differential; the simple geometrical model does not account for additional stretch that occurs on the tighter right-side spokes. The numbers in the table 16-2 are based on experience (not calculation), and should provide more consistently satisfactory length differentials than differentials that are determined by geometric calculation.

The table 16-2 shows the correct length differential for most wheel types. By looking up the intersection of the over-locknut width and the freewheel space (or number of freehub cogs), the correct differential is determined. This difference can be subtracted from the calculated left-side length to determine the correct right-side length, or it can be added to the calculated right-side length to determine the correct left-side length.

**REAR-WHEEL-SPOKE-LENGTH
DIFFERENTIAL FACTORS (table 16-2)**

	Over-locknut-width measurement in millimeters				
Freewheel space or # of freehub cogs	99- 119.5	119.6- 124.5	124.6- 128.5	128.6- 131	131.1- 136
none, or less than 29mm	0mm	N/A	N/A	N/A	N/A
29-34mm	N/A	1mm	0mm	N/A	N/A
35-38mm, or 6- or 7-speed freehub	N/A	N/A	2mm	1mm	0mm
8-speed freehub	N/A	N/A	N/A	2mm	1mm

1. [] Record over-locknut width: _____ mm.
2. [] Record freewheel space or number of freehub cogs: _____ cogs.
3. [] Look up in table 16-2 at intersection of *over-locknut width* and *freewheel-space/no.-of-freehub-cogs* value for rear-wheel-spoke-length differential factor and record here:
_____ mm (rear-wheel-spoke-length differential)

COMMON RIM MEASUREMENTS

Rim size

Rim size is often marked directly on the rim. If not, one measurement needs to be taken and then the rim size can be looked up in table 19-1 (page 19-16) in the **TIRES AND TUBES** chapter.

1. [] Use tape measure to measure outside diameter of rim.
2. [] Look up outside diameter in *Approximate rim O.D.* column of **TIRE AND RIM SIZES** table 19-1 (page 19-16) and record equivalent rim size from the *Nominal size* column here:
_____ rim size.

Making a rim-measurement tool

For most spoke-length systems, a dimension called *effective rim diameter* or *spoke end diameter* is required. To get this dimension, an accurate inside diameter of the rim is needed (except if using the Wheelsmith Spoke Length Calculator). To get the inside diameter dimension, a tool must be made. This will be called a *rim ruler*.

The tool is made by modifying two metal metric yardsticks (available at hardware stores). One of the yard sticks needs to be cut off once so that it goes from 0–350mm. The other needs to be cut twice, so that it goes from 350–700mm. Because material is lost when the ruler is cut, it is not possible to use one yardstick to get both pieces.

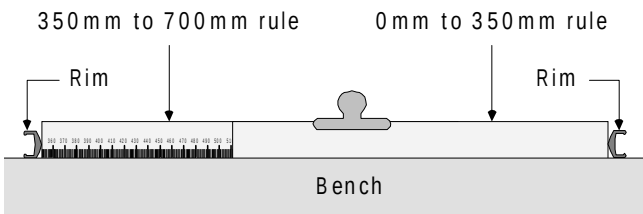
When cutting the piece that must start at 350mm, use a hacksaw to cut 1–2mm before the 350mm mark (between 348 and 349) and then use a file to carefully remove the excess to the midpoint in the thickness of the 350mm mark. Make sure that the end is square (perpendicular to the top and bottom edges of the ruler). If too much material is removed, it can be compensated for by leaving that much extra on the second piece. Cut the other end at 700mm. Precision is not important for this cut.

The second ruler must be cut so that its actual length ends up exactly equal to the starting dimension of the first ruler. If the first ruler ended up cut precisely at 350, then the second ruler needs to be 350mm long. If the first ruler ended up cut between the 350 and 351mm marks, then the second ruler needs to end up as close as possible to 350.5mm long. Make sure that all cut ends are square. *Remember, if the first piece ends up with too much cut off at the 350 millimeter mark, leave the second piece long by the amount of the error.*

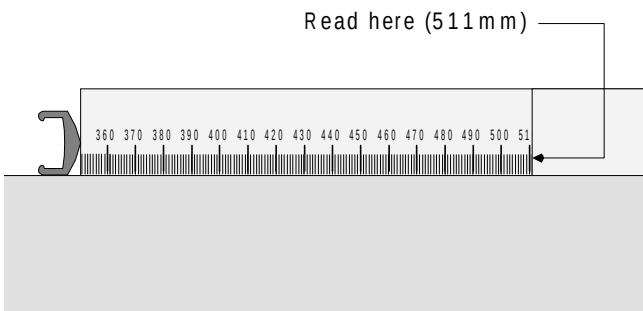
Rim diameter

Rim diameter is the diameter at the end of the spokes in the rim. It is not a measurement of the rim, but of the spokes. Other names for this are *spoke end diameter*, *actual rim diameter*, and *rim inner diameter*.

When measuring the rim, the rim should be lying on a flat surface. The rim rulers stand on their edges on the same surface, inside the rim, overlapping each other. Set the rulers up so that the 350–700mm ruler faces you with the 350mm mark on the left. The second piece will overlap in front and on the right, with the backside of the ruler facing you (no ruler markings visible). The left edge of the right piece is the point at which the reading is taken. If the end of the right piece is touching the 511mm mark, the reading is 511mm. If it clears the 511mm but does not expose the 512mm mark, then call it 511.5mm. Always read the ruler to the nearest half millimeter.



16.11 Setting up the rim rulers.



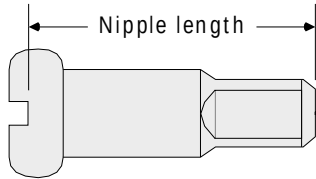
16.12 Reading the rim rulers.

To take readings, place one end of the rim-sizing rulers adjacent to the second hole past the valve hole, and the other end adjacent to the hole half the number of holes in the rim away from the second hole past the valve hole. Do not put the rulers against reinforcements of the nipple holes, but against the main body of the rim. For additional measurements, move each end of the rulers four-holes clockwise. Take four measurements and average, to account for imperfections in the rim.

1. [] Measure rim Inside Diameter at four equally-spaced points and record:

(_____ = ID₁)
 (_____ = ID₂)
 (_____ = ID₃)
 (_____ = ID₄)

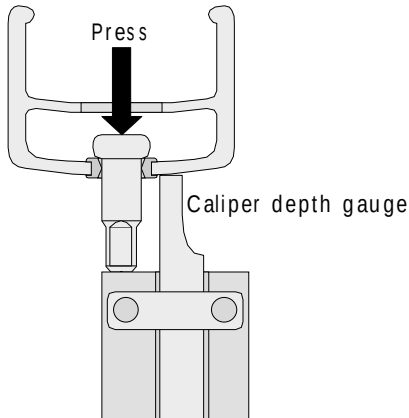
In the next step, measure the nipple length with a caliper. In this and all other steps involving caliper measurements (unless noted otherwise), read the caliper to the nearest tenth millimeter.



16.13 Measure the nipple length by putting one caliper jaw in the slot in the nipple head and the other against the other end of the nipple.

2. [] Measure and record Nipple length (N_L) from bottom of slot to tip of nipple: (_____ is N_L)

In the next step, insert the nipple in the rim, then measure the amount of nipple that protrudes from the rim. Use the depth gauge on the caliper to measure with, and make sure the nipple is held firmly in place while measuring.



16.14 Measure nipple drop by placing the butt of the caliper against a nipple and extending the depth gauge of the caliper until it meets the rim (not nipple hole eyelets).

3. [] Measure and record Nipple drop (N_D) from rim to nipple tip: (_____ is N_D)

The next step is a calculation. The step is written as a series of entries into a calculator, not as a mathematical equation. Treating it as a mathematical formula will result in error. Round all calculator results to the nearest whole millimeter. For this step the process is expressed twice. The first time shows the letter codes for the variable data that must be entered and symbols for the function keys that must be pressed in be-

tween each item of data. The second time (directly below), substitutes blanks that must be filled in; for example, in step #4 (in the blank below ID₁), fill in the value recorded for ID₁ in step #1. When all the blanks have been filled in, then enter the values and the key functions as shown. After pressing the equals key, round the answer to the nearest whole and enter this in the last blank.

Step #4 calculates something called *rim diameter*. It is not actually a measurement of the rim but of the diameter at the bottom of the slots in the nipple heads when all the nipples are in the rim. This is the point that the spoke should stop, so this calculation determines the *spoke end diameter*. By adding in the nipple length and subtracting the nipple drop, the actual distance from the inner perimeter of the rim to the bottom of the slot in the nipple head is calculated. This distance must be added at both ends of the rim inside diameter, so that is why length and drop are included twice in the calculator entries.

4. [] Rim diameter (R_D) Calculator entries (round result to whole millimeter):

ID₁ ID₂ ID₃ ID₄
 _____ + _____ + _____ + _____
 N_L N_L N_D
 ÷ 4 + _____ + _____ - _____
 N_D
 = _____ = (_____ is R_D)

If not using a calculator, the formula for this calculation is:

$$((ID_1 + ID_2 + ID_3 + ID_4) \div 4) + 2(N_L - N_D) = R_D$$

SPOKE-CALC BY DT

The Spoke-Calc system is a wall poster that has graphics on which the hub and rim are placed to determine dimensions, and tables in which numbers are looked up based on the dimensions. The table contain good data, but experimentation has shown that the method for determining rim dimensions is too subjective, with different people getting results varying by up to 4mm for the same rim.

The following information needs to be measured and looked up to use Spoke-Calc:

- Over-locknut width
- Hub-Flange diameter
- Center-to-flange dimension (left side)
- Freewheel/freehub space (rear wheels only)
- Rear-wheel-spoke-length differential

16 – WHEEL BUILDING AND RIM REPLACEMENT

Rim diameter

Differential-length factor

The following instructions use Spoke-Calc for data, but rely on the hub and rim measurement systems detailed earlier in this chapter. The data in the portions of the Spoke-Calc tables that are represented here has been altered because the tables are provided only as an illustration of how the system works. *Do not use the data in these partial tables to determine spoke length!*

Determine Table A factor

NOTE: All tables in following procedure are small simulated portions of SPOKE-CALC TABLE A from SPOKE-CALC by BPP and DT.

Steps #1, #2, and #4 require information that is common to many spoke-length-calculation systems. The instructions for measuring and calculating these pieces of information are earlier in this chapter under the headings **COMMON HUB MEASUREMENTS AND FACTORS** and **COMMON RIM MEASUREMENTS**.

1. [] Calculate Hub Center-To-Flange Dimension for left flange and record here: _____ mm.
2. [] Calculate Rim Diameter and record result here: _____ mm.

The following table is a simulated segment of Table A on the Spoke-Calc poster. The information is deliberately altered and cannot be used. It is provided to help recognize which table to use.

SPOKE-CALC TABLE A (segment)

		HUB CENTER-TO-FLANGE DIMENSION										
		18	19	20	21	22	23	24	25	26		
R	535	269	269	269	269	269	269	270	270	270	535	
I	536	270	270	270	270	270	270	270	270	270	536	
M	537	270	270	270	270	270	270	271	271	271	537	
	538	271	271	271	271	271	271	271	271	271	538	
D	539	271	271	271	271	271	271	272	272	272	539	
I	540	272	272	272	272	272	272	272	272	272	540	
A	541	272	272	272	272	272	272	273	273	273	541	
M	542	273	273	273	273	273	273	273	273	273	542	
E	543	273	273	273	273	273	273	274	274	274	543	
T	544	274	274	274	274	274	274	274	274	274	544	
E	545	274	274	274	274	274	274	275	275	275	545	
R	546	275	275	275	275	275	275	275	275	275	546	
		18	19	20	21	22	23	24	25	26		

3. [] Table A factor (TA_F). Look up in Table A for intersection of:
Rim diameter (R_D) row and
Center-to-Flange dimension (CF_L) column:
(_____ is TA_F)

Determine Table B factor

4. [] Measure and record Hub-flange Diameter here: _____ mm.
5. [] Count number of holes in one flange, double, and record here:
(_____ is holes in hub)

In the next step, a lacing pattern must be chosen. Discussion of the merits of different lacing patterns occurs earlier in this chapter under the heading **SPOKING PATTERNS**.

6. [] Decide on lacing (cross) pattern and enter here: (_____ is lacing pattern)

NOTE: SPOKE-CALC TABLE B has factors for combinations of lacing patterns and numbers of holes in the hub that can't be built (because spokes would interfere with each other). The most common of these unbuildable combinations are 4-cross lacing on hubs with 32 or fewer holes, and 3-cross lacing on hubs with 24 or fewer holes. A small portion of SPOKE-CALC TABLE B from SPOKE-CALC by BPP and DT has been reproduced here.

SPOKE-CALC TABLE B (segment)

		HUB DRILLING AND LACING PATTERN										
		32 HOLE HUBS					36 HOLE HUBS					
		0	1x	2x	3x	4x	0	1x	2x	3x		
H	41	21	19	14	8	1	21	20	16	11		
U	42	21	19	15	8	1	21	20	16	11		
B	43	22	20	15	8	1	22	20	17	11		
	44	22	20	15	8	1	22	21	17	11		
F	45	23	21	16	8	1	23	21	17	11		
L	46	23	21	16	9	1	23	22	18	12		
A	47	24	21	16	9	1	24	22	18	12		
N	48	24	22	17	9	0	24	23	19	12		
G	49	25	22	17	9	0	25	23	19	12		
E	50	25	23	17	9	0	25	24	19	13		
	51	26	23	18	9	0	26	24	19	13		
D	52	26	24	18	9	0	26	25	20	13		
I	53	26	24	18	10	0	27	25	20	13		
A	54	27	25	19	10	0	27	26	20	13		
M	55	27	25	19	10	0	28	26	21	14		
E	56	28	26	19	10	0	28	27	21	14		
T	57	28	26	20	10	0	29	27	21	14		
E	58	29	26	20	10	0	29	27	22	14		
R	59	29	27	20	11	+ 1	30	28	22	15		
		0	1x	2x	3x	4x	0	1x	2x	3x		

7. [] Table B factor (TB_F). Look up in correct # Hole Hubs column of Table B for intersection of:
HF_D row and Lacing Pattern column
(_____ is TB_F)

Determine Base-Spoke length

In step #8 Base-Spoke length is calculated. Correct front length, correct right-rear length, correct left-rear length, and correct non-differential rear length are all based on Base-Spoke length.

8. [] Base-Spoke length Calculator entries (round result to whole millimeter):

TA_F TB_F
 _____ _____ _____ is BS_L.

Front-wheel-spoke length**NOTE:** Skip to step 10 or 14 for rear wheels.9. [] Front spoke length equals BS_L .

FRONT spoke length is: _____ mm

Rear-wheel differential-spoke lengths

The dish of a typical rear wheel creates a situation where the distance from the left flange to the rim is greater than the distance from the right flange to the rim. Therefore, different spoke lengths should be used to ensure equal thread engagement on all the nipples and to reduce the likelihood of spokes protruding through nipples or leaving thread exposed at the top of the nipples.

There are drawbacks to using two spoke lengths. When two sizes are needed, it is more likely that at least one is out of stock. When lacing the wheel, it complicates things to work with two lengths and make sure that they do not get mixed up.

10. [] Record BS_L here: _____ mm

11. [] Record Differential Factor here: – _____ mm

12. [] REAR RIGHT length is: = _____ mm

13. [] Rear left length is same as BS_L (step 8)

REAR LEFT length is: _____ mm

Rear-wheel non-differential-spoke lengths

Non-differential rear length is a compromise. It usually means that the right-side spokes will be a little longer than ideal, and the left-side spokes will be a little shorter than ideal. This sometimes results in a little thread showing at the left-side nipples. Non-differential-spoke length is particularly useful when the correct lengths for differential spoking are not available. It is also useful for beginners because there is no complication of keeping track of different spokes for the right and left sides while lacing the wheel.

When using one spoke length, it is almost never acceptable to just use the Base-Spoke length for both sides. This will usually result in right-side spokes protruding all the way through the nipples. It is also unacceptable to just use the right-side length for both sides in many cases. If the correct right-side length were to be used on the left side, then it is likely that the thread engagement to the nipples would be compromised too much.

NOTE: Next step is optional and is only used for rear wheels, when needing (or preferring) to build with one spoke length.

14. [] Record BS_L (step 8) here: _____ mm
– 1mm

NON-DIFFERENTIAL REAR = _____ mm

WHEELSMITH SPOKE LENGTH CALCULATOR

In addition to the calculator and rim measuring rods that come with the system, a metric caliper is needed. Common measurements and factors needed (from the earlier section of this chapter **COMMON HUB MEASUREMENTS AND FACTORS** and **COMMON RIM DIMENSIONS**) include:

Over-locknut width

Hub-flange diameter

Center-to-Flange dimension (left side only for rear wheels)

Freewheel/Freehub space (rear wheels only)

Rear-wheel-spoke-length differential factor (rear wheels only)

Rim diameter

Differential-length factor

The following instructions assume that the Wheelsmith System, with the HP 332SII, is being used.

Preliminary measurements and calculations

1. [] Record Rim Diameter here: _____ mm.

2. [] Record Hub-flange diameter here: _____ mm.

3. [] Calculate and record left-side Center-to-Flange dimension here: _____ mm.

4. [] Count number of holes in hub and record here: _____ spokes.

5. [] Decide on a cross pattern and record cross pattern number here: _____ X.

6. [] For rear wheels only look up *Rear-wheel-spoke-length differential factor* and record here: _____ mm.**Wheelsmith calculator entries**

NOTE: "C" restarts calculation, key with back-space arrow clears entry.

7. [] Press ON key (marked "C") to turn calculator on.

8. [] Press XEQ key.

9. [] Press 9 key. R? appears.

10. [] Enter Rim Diameter on keypad and press R/S key. F? appears.

11. [] Enter Hub-flange diameter on keypad and press R/S key. C? appears.

12. [] Enter Center-to-Flange dimension on keypad and press R/S key. N? appears.

13. [] Enter number of holes in hub on keypad and press R/S key. X? appears.

14. [] Enter cross pattern number on keypad and press R/S key.

15. [] Round value on display screen to nearest whole number and record here:

Base-spoke length (BS_L) equals _____ mm.

Front-wheel-spoke length

NOTE: Skip to step 17 or 21 for rear wheels.

16. [] Front spoke length equals BS_L.

FRONT spoke length is: _____mm

Rear-wheel differential-spoke lengths

The dish of a typical rear wheel creates a situation where the distance from the left flange to the rim is greater than the distance from the right flange to the rim; therefore, different spoke lengths should be used to ensure equal thread engagement on all nipples, and to reduce the likelihood of spokes protruding through nipples or leaving thread exposed at the top of the nipples.

There are drawbacks to using two spoke lengths. When two sizes are needed, it is more likely that at least one is out of stock. When lacing the wheel, it complicates things to work with two lengths while making sure that they do not get mixed up.

17. [] Record BS_L (step 16) here: _____mm

18. [] Enter Differential Factor here: – _____mm

19. [] REAR RIGHT length is: = _____mm

20. [] Rear left length is same as BS_L (step 16).

REAR LEFT length is: _____mm

Rear-wheel non-differential-spoke lengths

Non-differential rear length is a compromise. It usually means that the right-side spokes will be a little longer than ideal, and the left-side spokes will be a little shorter than ideal. This sometimes results in a little thread showing at the left-side nipples. Non-differential-spoke length is particularly useful when the correct lengths for differential spoking are not available. It is also useful for beginners because there is no complication of keeping track of different spokes for the right and left sides.

When using one spoke length, it is almost never acceptable to just use the Base-Spoke length for both sides. This will usually result in right-side spokes protruding all the way through the nipples. It is also unacceptable to just use the right-side length for both sides in many cases. If the correct right-side length were to be used on the left side, then it is likely that the thread engagement to the nipples would be compromised too much.

NOTE: Next step is optional and is only used for rear wheels, when needing (or preferring) to build with one spoke length.

21. [] Record BS_L (step 15) here: _____mm

– 1mm

NON-DIFFERENTIAL REAR = _____mm

**SUTHERLAND'S HANDBOOK
FOR BICYCLE MECHANICS**

The following instructions can be used for determining spoke length using either the fifth or sixth edition of *Sutherland's*. Note that although the procedures are the same, tables occur on different page numbers for each edition. When the instructions refer to *Sutherland's*, there is a fifth edition page number, then a sixth edition page number.

Several of the first steps require information that is determined by procedures in the earlier sections in this chapter **COMMON HUB MEASUREMENTS AND FACTORS** and **COMMON RIM MEASUREMENTS**.

Determine hub-diameter category

1. [] Determine Hub-flange diameter and record here: _____mm.

Sutherland's groups similarly-sized hub flanges into groups called hub-diameter categories. The following procedure recommends measuring the Hub-flange diameter (previous step) and from that determining the category.

If the hub is not on hand, it may be possible to determine the hub-diameter category by looking up the brand and model in *Sutherland's* (fifth edition 11–5 through 11–13, or sixth edition 11–2 through 11–35). Look in the lists below each category heading for the make/model that corresponds to the hub in question to determine the category into which it fits.

HUB-FLANGE-DIAMETER CATEGORIES

(table 16-3)

Spoke-hole-circle-diameter range	Hub-diameter category
30–32mm	31mm
33–36mm	34mm
37–42mm	40mm
43–46mm	44.5mm
47–52mm	48mm
53–60mm	58mm
61–64mm	63mm
65–69mm	67mm
80–90mm	90mm
102.5–112mm	102.5mm

2. [] Determine hub-diameter category by finding range in table 16-3 that includes result from step 1, then look up corresponding Hub-diameter category. Hub-diameter category is: _____mm

Determine theoretical spoke length

In the next step, the rim size must be determined. Usually, this can be done by looking on the rim for size markings (such as 26×1.75). In the absence of markings, the outside diameter of the rim should be measured and the rim size looked up in the **TIRE AND RIM SIZES** table 19-1 in **TIRES AND TUBES** (page 19-16).

3. ☐ Record rim size here: _____.
4. ☐ Count number of spoke holes in hub and rim, make sure they match, and record here: _____ Number of spokes.
5. ☐ Decide on a cross pattern and record cross pattern number here: _____ X
6. ☐ Turn to correct *Sutherland's* page for rim size determined in step 3 according to table 16-4:

LOCATIONS OF SUTHERLAND'S THEORETICAL SPOKE-LENGTH TABLES

(table 16-4)

Rimsize	fifthedition	sixthedition
27" & 28" rims	11-15	11-39
700C rims	11-15	11-47
26" MTB rims	11-31	11-63
26" (other), 700D, & 650 rims	11-31	11-73
24", 22", 600 & 550 rims	11-41	11-83
20" & 500 rims	11-51	11-93
18" & 17" rims	11-58	11-99
16" & 400 rims	11-60	11-101
14" rims	11-62	11-104
12" rims	11-64	11-106
10" rims	11-65	11-107

7. ☐ On page determined in step 6, find table for hub-diameter category determined in step 2.
8. ☐ Look at intersection of *cross pattern column* and *number of spokes row* to find theoretical spoke length and record here: _____ mm.

Looking up rim-correction factors

NOTE: If exact brand and model of rim are not found in step 11, it will be necessary to measure the rim and calculate rim-correction factor starting at step 12.

9. ☐ Find correct *Sutherland's* correction-factor table. Use table 16-5 to find correct page.

LOCATIONS OF SUTHERLAND'S RIM-CORRECTION-FACTOR TABLES

(table 16-5)

Rimsize	5thedition	6thedition
28 × 1-1/2	11-16	11-40
27 × 1-1/4, 27 × 1-1/8, 27 × 1	11-16 thru 11-19	11-40 thru 11-44
700C, 28 × 1-5/8 × 1-3/8	11-20 thru 11-25	11-48 thru 11-55
700C sew-ups (Tubulars)	11-26 thru 11-29	11-56 thru 11-60
26 × 1-1/4 EA1	11-32	11-74
26 × 1-3/8 EA3 and 650A	11-33	11-75 thru 11-76
650B and 26 × 1-1/2	11-34	11-76
700D	11-34	11-76
26 × 1-3/4 and 650C	11-34	11-77
26 × 1.5, 26 × 1.75, 26 × 2.125	11-35 thru 11-38	11-64 thru 11-70
26 and 650 SEW-UPS (TUBULARS)	11-39	11-78 thru 11-79
24 × 1-1/4	11-42	11-84 thru 11-85
24 × 1.25 and 24 × 1.375	11-43	11-84
600A	11-43	11-85
24 × 1-3/8	11-44	11-86
24 × 1-3/4	11-45	11-86
24 × 1-1/8	none	11-87
24 × 1.5, 24 × 1.75, 24 × 2.125	11-46 thru 11-47	11-87 thru 11-88
22 × 1-3/8	11-48	11-90
550A	11-48	11-91
22 × 1.5, 22 × 1.75, 22 × 2.125	11-48	11-91
25", 24", 22", 600 SEW-UPS	11-49	11-89 thru 11-90
20 × 1-3/8, 20 × 1-1/4 20 × 1-1/8	11-52 thru 11-53	11-94 thru 11-95
500A	11-53	11-95
20 × 1.5, 20 × 1.75, 20 × 2.125	11-54 thru 11-55	11-96 thru 11-98
20 × 1-3/4	11-55	11-96
20 × 2 and 20" sew-ups	11-56	11-98
18" and 17"	11-59	11-100
16" and 400	11-61	11-102
14"	11-63	11-105
12"	11-64	11-106
10"	11-65	11-107

10. ☐ Starting on page determined in step 9, locate rim brand.
11. ☐ Under rim brand, locate *exact* rim model and record corresponding correction factor here. Rim-correction factor is: _____ mm (Skip this step and proceed to step 12 if exact model was not found in table.)

16 – WHEEL BUILDING AND RIM REPLACEMENT

Calculating rim-correction factors

NOTE: Steps 12–17 should be skipped if correction factor was found in tables using step 11.

12. [] Determine Sutherland's constant from following table based on rim size determined in step 3 and record constant here: _____.

SUTHERLAND'S RIM CONSTANTS

(table 16-6)

Rim size	Sutherland's rim constant
28", 27", 700C, & 700C tubulars	315
26"	300
24"	270
20"	225
18"	200
16"	175
14"	150
12"	125
10"	100

13. [] Measure and calculate Rim Diameter by method described in **COMMON RIM MEASUREMENTS** section of this chapter and record Rim Diameter here: _____ mm

14. [] Divide by 2 $\div 2$

15. [] Rim radius equals: = _____ mm

16. [] Subtract Sutherland's constant: - _____ mm

17. [] Rim-correction factor is: = _____ mm

Determine Base-Spoke length

18. [] Record theoretical spoke length from step 8 here: _____ mm

19. [] Correction factor from step 11 or step 17 + _____ mm

20. [] Base-Spoke length (BS_L) is: = _____ mm

NOTE: When adding a negative number (the rim-correction factor), simply subtract it as though it were a positive number.

Front-wheel-spoke length

NOTE: Skip to step 22 or 25 for rear wheels.

21. [] Front spoke length equals BS_L.

FRONT spoke length is: _____ mm

Rear-wheel differential-spoke lengths

The dish of a typical rear wheel creates a situation where the distance from the left flange to the rim is greater than the distance from the right flange to the rim; therefore, different spoke lengths should be used to ensure equal thread engagement on all the nipples and to reduce the likelihood of spokes protruding through nipples or leaving thread exposed at the top of the nipples.

There are drawbacks to using two spoke lengths. When two sizes are needed, it is more likely that at least one is out of stock. When lacing the wheel, it complicates things to work with two lengths, and make sure that they do not get mixed up.

22. [] Record BS_L (step 20) here: _____ mm

23. [] Enter Differential Factor here: - _____ mm

24. [] REAR RIGHT length is: = _____ mm

25. [] Rear left length is same as BS_L (step 20).

REAR LEFT length is: _____ mm

Rear-wheel non-differential-spoke lengths

Non-differential rear length is a compromise. It usually means that the right-side spokes will be a little longer than ideal, and the left-side spokes will be a little shorter than ideal. This sometimes results in a little thread showing at the left-side nipples. Non-differential-spoke length is particularly useful when the correct lengths for differential spoking are not available. It is also useful for beginners because there is no complication of keeping track of different spokes for the right and left sides.

When using one spoke length, it is almost never acceptable to just use the Base-Spoke length for both sides. This will usually result in right-side spokes protruding all the way through the nipples. It is also unacceptable to just use the right-side length for both sides in many cases. If the correct right-side length were to be used on the left side, then it is likely that the thread engagement to the nipples would be compromised too much.

NOTE: Next step is optional and is only used for rear wheels, when needing (or preferring) to build with one spoke length.

26. [] Record BS_L (step 16) here: _____ mm
- 1mm

NON-DIFFERENTIAL REAR = _____ mm

BLUE PIG WHEEL CALCULATOR

Blue Pig Wheel Calculator is a DOS program for IBM-compatible computers. Use the operator's manual to learn how to use the program. For unlisted hubs or rims, the program will require input on several hub and rim measurements that are the same as some of the common hub and rim measurements described earlier in this chapter.

Blue Pig references to "Actual Rim Diameter" or "Average Rim Diameter" are the same as Rim Diameter as described in this chapter (page 16-16).

Blue Pig references to "Hub Diameter" or "Actual Hub Diameter" are the same as Hub-flange Diameter as described in this chapter (page 16-14).

To get the value Blue Pig calls "Dish," subtract the left flange inset from the right flange inset and divide by 2.

Blue Pig references to “Lock nut- Lock nut” are the same as Over-locknut width as described in this chapter (page 16-14).

SPOKEMASTER FOR WINDOWS

SpokeMaster for Windows is a Windows-based program for IBM-compatible computers equipped with the Windows operating system. Hubs and rims may be selected from lists, or new hubs and rims can be added to the lists.

When entering a new rim, a dimension must be listed in an empty box underneath the label “inner (mm).” Use Rim Diameter as described earlier in this chapter. An empty box labeled “outer(mm)” should also be filled in with the approximate outside diameter of the rim. Although this second number is not used for calculating anything, the program will not continue the process without some value in this box that is larger than “inner (mm).”

When entering a new hub, a dialog box appears with four unlabeled empty entry boxes. The upper left one is the left-side Center-to-Flange dimension. The upper right one is the right-side Center-to-Flange dimension. The lower left one is the left Hub-flange Diameter. The lower right one is the right Hub-flange Diameter. All of these dimensions are described in the section of this chapter **COMMON HUB DIMENSIONS AND FACTORS** (page 16-14).

Although the program forces the user to calculate both sides of a rear hub, only the left-side information should be used; the right-side length information is based on a faulty geometry-only approach that fails to take spoke stretch into account. Use this chapter’s *rear-hub differential-length factor* to determine how much shorter the right side should be than the left.

LACING WHEELS

NOTE: If building a new wheel from scratch, start with step 1.

PREPARING AN EXISTING WHEEL FOR REBUILD

If re-using an old rim, there is a chance that rim damage will be discovered *after* it has been laced and partially trued. If reusing an existing rim, it is important to loosen all the spokes before cutting them out. Cutting spokes under full tension can damage the rim.

A common beginner mistake with disastrous consequences is to cut out or unthread the spokes on a rear hub *before* removing the freewheel. Since normal freewheel removal requires the presence of the rim, this will mean either sacrificing the hub or the freewheel. Once the rim has been removed, there is no guaranteed way to save and reuse both the hub and freewheel.

0a. [] Remove wheel from bike.

0b. [] Remove tire, tube, and rim strip.

0c. [] Remove thread-on freewheel or freehub cogset, if any.

0d. [] If saving rim, loosen all spokes until slack.

0e. [] Cut out all spokes.

PREPARING THE RIM AND HUB

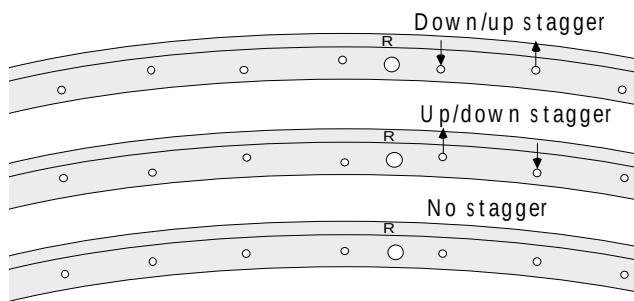
The steps in this group are the most critical to the entire process. All thinking and decisions that need to be made are made here. If these steps are done correctly, the rest of wheel lacing is little more than connect-the-dots. The general concept here is to prepare the rim by giving every spoke hole in the rim a unique name. These names will be based on names that will be given to each spoke. Like names for people, each of these names will have two parts, indicating the family the spoke belongs to and the name for the individual as well. In the case of wheels, there are always four families. The spokes are divided into two obvious groups, the left side and right side of the wheel. Look at a wheel from either side. See that on each side of the wheel there is a set of spokes that radiate out from the hub in a clockwise direction and a set of spokes that radiate counterclockwise from the hub.

Two sides with two directions on each side creates four families of spokes. The family names are A, B, C, and D. In a 36-spoke wheel there are nine spokes in each set, so each family of spokes (and corresponding holes) will be numbered A1–A9, B1–B9, C1–C9, and D1–D9. When building the wheel, the process will alternate from right side to left side, so the A and C spokes will be on the right side of the wheel and the B and D spokes will be on the left side. Once this system of marking the rim has become familiar, it will suffice to simply mark the first spoke hole for each family.

- 1. [] Lay rim on a surface, rotate in order to look directly at valve hole in inner face of rim, and observe that spoke holes are staggered so that every other hole is up and every other hole is down. There are some cases when there is no obvious stagger.**

16 – WHEEL BUILDING AND RIM REPLACEMENT

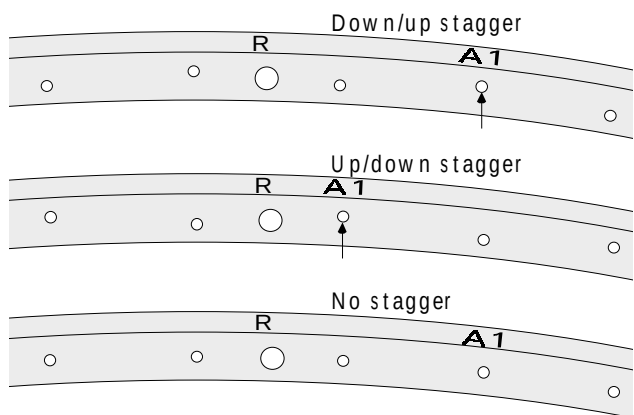
2. [] Put an “R” at valve hole on side of rim facing up with marker or tape to indicate right side of rim.



16.15 Mark an “R” on the rim at the valve hole. Note that on some rims the spoke holes are staggered so that when the rim is on its side the holes alternate up and down, on other rims the spoke holes are staggered the opposite, and that on some rims there is no spoke-hole stagger.

In the next step, the first up-hole to the right of the valve hole is marked A1. Rims are drilled three different ways (going right/clockwise from the valve hole): spoke holes staggered down/up, spoke holes staggered up/down, and without any stagger to the spoke holes. On most rims, the first up-hole clockwise from the valve hole is the second hole. On a few models, the first up-hole is also the first hole clockwise from the valve hole. With the rare rims that have no stagger to the spoke holes, the remainder of the procedure will be easier to follow if you pretend that such a rim is a staggered-hole rim of the more common variety (first up-hole is the second hole clockwise/right of the valve hole).

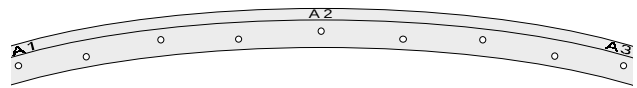
3. [] Mark first up-hole to right (clockwise) of valve hole to be A1. In cases where there is no obvious stagger, mark second hole clockwise of valve hole to be A1.



16.16 Mark the first up-hole to right of valve hole to be A1.

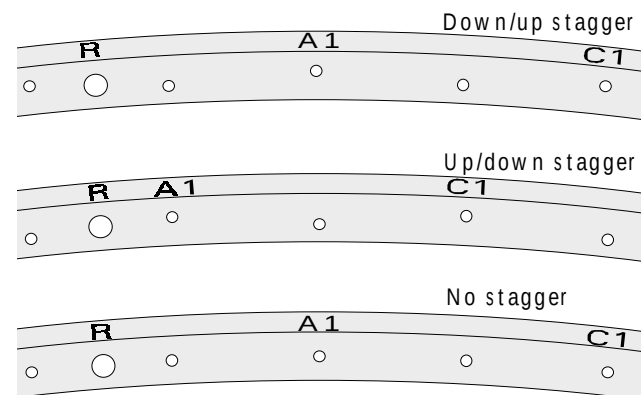
The following step #4 is useful the first few times a wheel is built, but after the lacing process becomes familiar, it is a good step to skip.

4. [] Continue clockwise around rim marking every fourth hole A2, A3, A4, etc., until back to A1. There should be three holes in-between each pair of “A” holes. The last mark should be A7 for 28-hole rims, A8 for 32-hole rims, A9 for 36-hole rims, etc.



16.17 Working to the right (clockwise) mark every fourth hole A2, A3, etc.

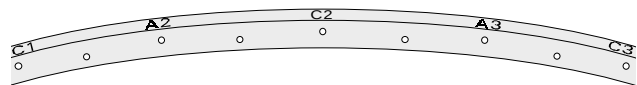
5. [] With right side of rim still up, mark hole that is two holes to right (clockwise) of A1 to be C1. This hole will always be halfway between A1 and A2.



16.18 Mark the first up-hole to right of A1 to be C1.

The following step #6 is useful the first few times a wheel is built, but after the lacing process becomes familiar, it is a good step to skip.

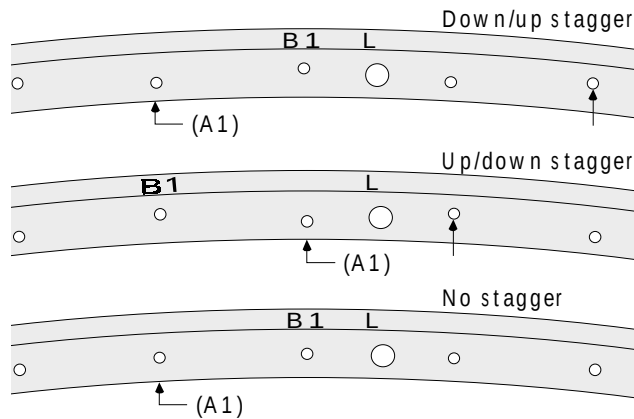
6. [] Continue clockwise around rim marking every fourth hole C2, C3, C4, etc., until back to C1. The last mark will be C7 for 28-hole rims, C8 for 32-hole rims, C9 for 36-hole rims, etc.



16.19 Starting four holes to the right (clockwise) from C1, mark every fourth hole C2, C3, C4, etc.

7. [] Turn rim over, rotate rim to look directly at valve hole in inner face of rim, and put an “L” at valve hole.

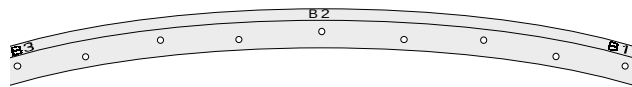
8. [] Mark first up-hole *counterclockwise* (left) of valve hole to be B1. In cases where there is no obvious stagger, mark *first* hole counterclockwise of valve hole to be B1.



16.20 Mark the first up-hole counterclockwise of the valve hole to be B1.

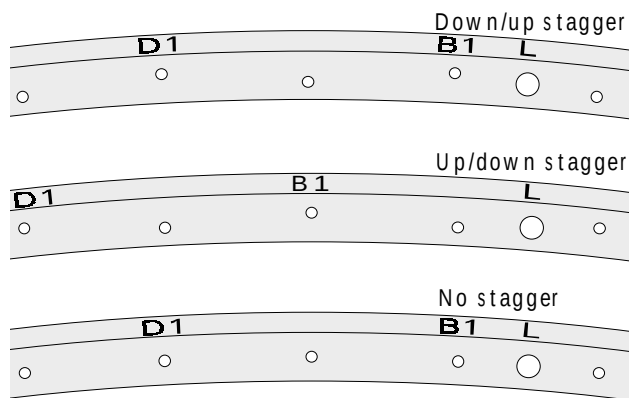
The following step #9 is useful the first few times a wheel is built, but after the lacing process becomes familiar, it is a good step to skip.

9. [] Continue *counterclockwise* (left) around rim marking every fourth hole from B1 to be B2, B3, B4, etc., until back to B1. The last mark will be B7 for 28-hole rims, B8 for 32-hole rims, B9 for 36-hole rims, etc.



16.21 Working to the left (counterclockwise) mark every fourth hole B2, B3, etc.

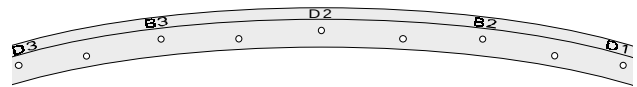
10. [] With left side of rim still up, mark second hole *counterclockwise* (left) of B1 to be D1. This hole will always be halfway between B1 and B2.



16.22 Mark the first up-hole to left of B1 to be D1.

The following step #11 is useful the first few times a wheel is built, but after the lacing process becomes familiar, it is a good step to skip.

11. [] Continue *counterclockwise* (left) around rim marking every fourth hole D2, D3, D4, etc., until back to D1. The last mark will be D7 for 28-hole rims, D8 for 32-hole rims, D9 for 36-hole rims, etc.



16.23 Starting four holes to the left (counterclockwise) from D1, mark every fourth hole D2, D3, D4, etc.

Steps #12 and #13 establish a starting hole in the right flange for spokes of the “A” set. On the rear hub, the freewheel-mounting threads or freehub body clearly distinguish the right side. There is no true right to a front hub, but it is necessary to create one in order to follow the lacing procedure. An easy way to do this is to wrap a rubber band around the axle set to mark the right side.

12. [] Front hubs only, mark one side of hub to indicate an arbitrary right side.

In the following step, any hole in the right flange may be marked. If alternating holes are countersunk, it is optional (but unnecessary) to select a hole that is not countersunk. The merits (or lack of them) to countersinking holes is discussed in the earlier section *Countersunk or chamfered spoke holes* (page 16-9).

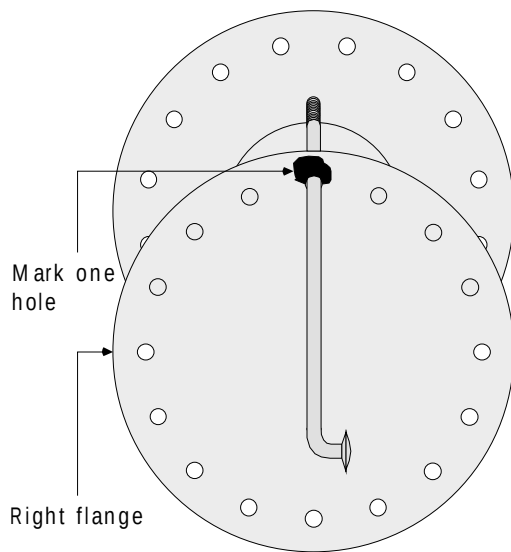
13. [] Use marker to mark any spoke hole in right-side hub flange on both faces of flange. If holes are alternately countersunk, it is optional to mark a hole that is not countersunk.

Step #14 is very straightforward, unless the rim is one of the rare models that have no apparent spoke-hole stagger. In this case, as it was in step #3, it is important to pretend that there is a stagger to the spoke holes, so that the instructions will be consistent for staggered and unstaggered rims.

14. [] With either side of rim up, observe whether first hole to right (*clockwise*) of valve hole is: *up* or *down* (circle one). (If, in step 3, second hole clockwise from valve hole was marked to be A1 because there was no obvious hole stagger, circle *down* for this step.)

16 – WHEEL BUILDING AND RIM REPLACEMENT

15. [] From outside of flange, temporarily insert a spoke several inches into marked hole in right flange.



16.24 Mark any hole in the right flange and insert a spoke as shown.

Step #16 is a critical step that selects the correct hole in the left flange for the first spoke of the “B” set. Insert a spoke from into the right flange (from the outside), keep it parallel to the axle, and stop it against the backside of the left flange between two spoke holes. The design of hubs is such that there is *never* a spoke hole in the left flange that is directly opposite a spoke hole in the right flange, so pick a space between two holes in the left flange to stop the spoke. If not sure the spoke is in the right space between holes, try one space to the right and one space to the left. It should be easy to see *obvious* differences in whether the spoke remains parallel to the axle.

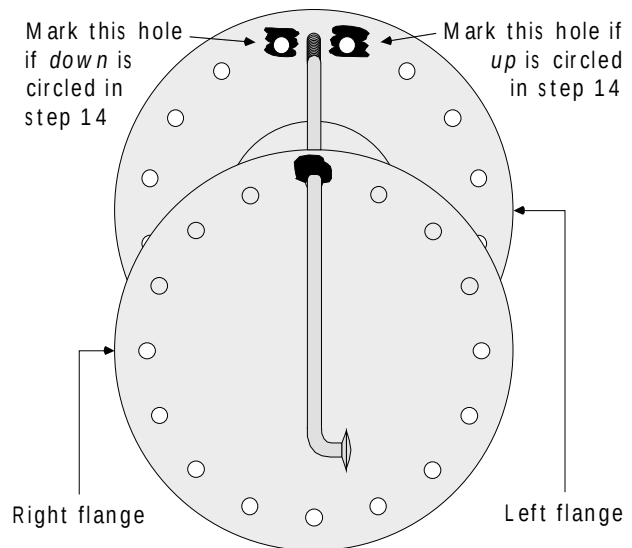
With the left flange away and the right flange close, mark a hole in the left flange to the left or right side of the spoke that is inserted through a spoke hole in the right flange. Whether to mark the hole to the left or to the right depends on whether the first spoke hole to the left of the valve hole in the rim is *up* or *down*, an observation made in step #14. There is no benefit to having the first hole to the left of the valve hole up or down; manufacturers do it different ways as a matter of preference. *However, when building the wheel, ignoring this difference will result in half the spokes ending up much tighter than the others, and the wheel must be rebuilt!* The explanation for why this would happen would only create confusion; simply take care to mark the hole in the left flange correctly. When marking the hole in the left flange, mark it so that the mark can be seen from the outside face of the flange.

The following procedure only applies to wheels that use the same cross pattern on the left and right sides. There is no detailed procedure elsewhere on how to build a mixed-cross pattern (design is not recommended). Marking the hole in which to install the first B spoke is where the change occurs when building mixed-cross wheels; for example, in step 16, assuming a 4X pattern is being built on the right side, to build a 3X on the left side, mark the second hole instead of the first hole to the left. For a 2X it would be the third hole, and for 1X it would be the fourth hole, and for radial it would be the fifth hole. Always mark on additional hole away for each reduction in cross number.

- 16. Hold hub to face right end of axle (left end of axle is pointing away), and the hole with spoke in it is at 12 o'clock. Keeping spoke in line with the axle, push spoke through until it bumps into back side of left flange between two spoke holes. If spoke is straight, end of spoke should end up between two holes in left flange (holes in left and right flange are staggered to each other and do not line up).**

[] Mark first hole (both faces of flange) in left flange to left of spoke if *down* was circled in step 14.

[] Mark first hole (both faces of flange) in left flange to right of spoke if *up* was circled in step 14.



16.25 With the spoke held parallel to the axle, mark the appropriate hole in the left flange to be the first hole of the “B” set.

PREPARING THE SPOKES

17. [] Divide total number of spokes by 4 to determine number of spokes to be in each set of four. Spokes per set is: _____

Nothing is more exasperating then getting a wheel laced up and mostly trued and then discovering that the spokes are the wrong length. Either they all are wrong, or they are mixed up. Step #18 and #19 are critical to prevent this, so they are well worth the effort. In step #18, if using two lengths of spokes for a rear wheel, it is critical to get the correct length on each side of the wheel. Start by putting the short spokes on the right side of the bench and long spokes on the left side of the bench. When selecting a spoke set to install in the right flange, choose a set from the right side of the bench; when selecting a spoke set to install in the left flange, choose a set from the left side of the bench.

In step #19, use a spoke ruler to make sure that all the spokes in a group are the same length, and that all are the correct length. To use a spoke ruler, hang the bend of the spoke in the hole at the “0” end of the ruler and read the length at the end of the thread. If the end of the spoke ends up between two marks, use the higher value. If using a regular ruler, measure from the inside of the bend to the end of the thread.

18. [] Put two sets of spokes on bench to right of rim and two sets to left of rim. If building rear wheel with shorter spokes on right side, be sure shorter spokes are on bench on right side of wheel!

19. [] Arrange all spokes in each set so that thread ends are together. Stand each set up on thread ends and make sure all spokes are same length. Measure one spoke from each set to make sure it is correct length.

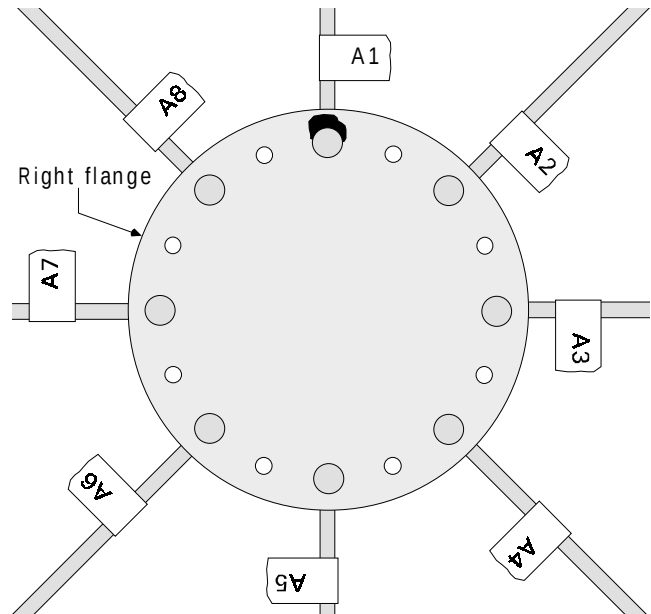
Prepping the threads with either oil or a special spoke-prep compound is vital. Oil will provide reasonable protection from corrosion, but it needs to be renewed periodically. Spoke-prep compounds last longer (in terms of corrosion prevention) and also act as a mild Loctite to keep nipples from unthreading if they loose tension.

20. [] Prep all threads with spoke-prep compound or oil.

LACING THE “A” SET

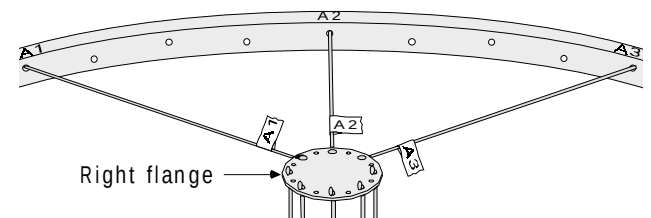
21. [] Insert spoke from one right-side set into marked hole in right flange so that spoke head ends up on outside of flange and tag this spoke with masking tape and mark it A1.

22. [] Insert second spoke from same right-side set in similar fashion into second hole clockwise from marked hole. Continue working clockwise filling every other hole until right flange has every other hole filled with spokes, all with heads facing out.



- 16.26 Insert spoke in marked hole and mark it A1. Insert spokes in every other hole and mark them A2, A3, etc.

23. [] With right side of rim and right end of hub facing up, attach marked spoke to A1 hole in rim, covering approximately half of thread length with nipple. Continue clockwise around hub and rim, inserting each next clockwise spoke to fourth hole clockwise in rim from last spoke and threading each nipple halfway on.



- 16.27 Attach the spokes to their correspondingly-marked holes.

Step #24 is a set of inspections to confirm everything is done correctly so far. It becomes a real nightmare to find out in a later set that something was wrong from early on, so be thorough about these inspections.

24. With right side of rim facing up rotate rim to look at valve hole in inner face of rim and inspect for following:

- [] Right side of axle should be pointing up.

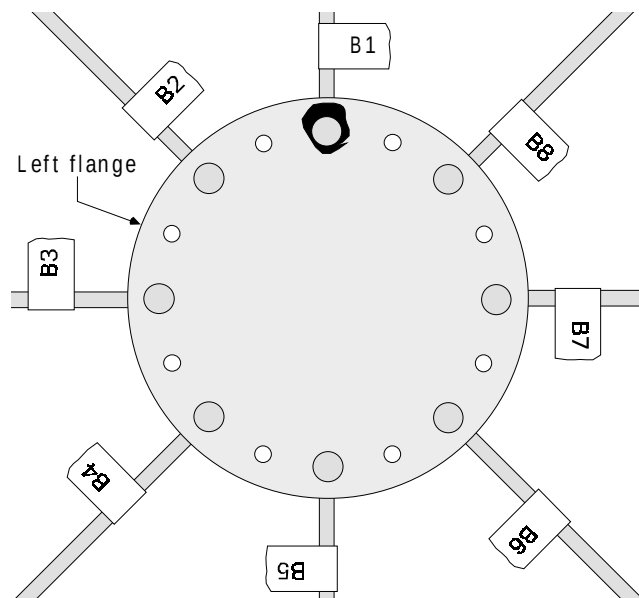
16 – WHEEL BUILDING AND RIM REPLACEMENT

- [] If building a rear wheel with two different spoke lengths, two sets of spokes should be left on bench on left side of wheel.
 - [] A spoke should be in first up-hole clockwise from valve hole.
 - [] Three empty holes should be between every filled spoke hole in rim.
 - [] Every other hole in right hub flange is filled.
 - [] All spoke heads are on outside face of flange.
25. [] If any of inspections in step 24 are failed, remove all spokes and repeat **LACING THE "A" SET**.

LACING THE "B" SET

The "B" set is the mirror image of the "A" set, just on the other side of the wheel. The most important parts of doing the "B" set are already done, step #8 and step #16, when the starting holes for the "B" set in the rim and in the left flange were marked. Because the wheel is turned over, and because the "A" and "B" sets are a mirror image, work counterclockwise in this set, instead of clockwise.

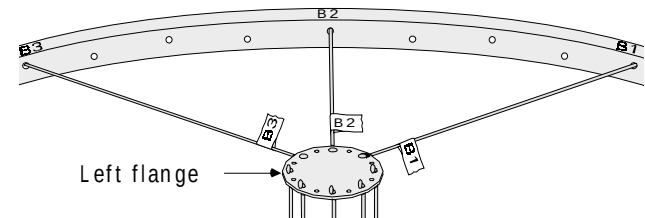
26. [] Turn wheel over so left side of hub and rim are up and rotate rim to look directly at valve hole in inner face of rim.
27. [] Insert spoke from one left-side spoke set into marked hole in left flange, so that spoke head ends up on outside of flange and tag this spoke with masking tape and mark it B1.



16.28 Spoke B1 is put in the hole marked in the left flange in step #16.

28. [] In similar fashion, insert second spoke from same left-side set into hub, in second hole counterclockwise from marked hole. Continue working counterclockwise, filling every other hole until left flange has every other hole filled with spokes, all with heads facing out.

29. [] With left side of rim and left end of hub facing up, attach marked spoke to B1 hole in rim, covering approximately half of thread length with nipple. Continue counterclockwise around hub and rim, inserting each next counterclockwise spoke to fourth hole counterclockwise in rim from last spoke and threading each nipple halfway on.



16.29 Attach the B1 spoke to the B1 hole, and all other B set spokes in every fourth hole counterclockwise from B1. "A" set spokes are in place at this time, but are not shown.

Step #30 is a series of inspections. Just as with the "A" set, if anything is left wrong with the "B" set, it can be extremely difficult to figure out what went wrong with the "C" set. When something goes wrong putting in the "C" set, the tendency will be to think the problem is with the "C" set, instead of with the "B" set. Perform these inspections religiously. Then, if anything goes wrong with the "C" set it will be known that the problem is limited to the spokes just put in.

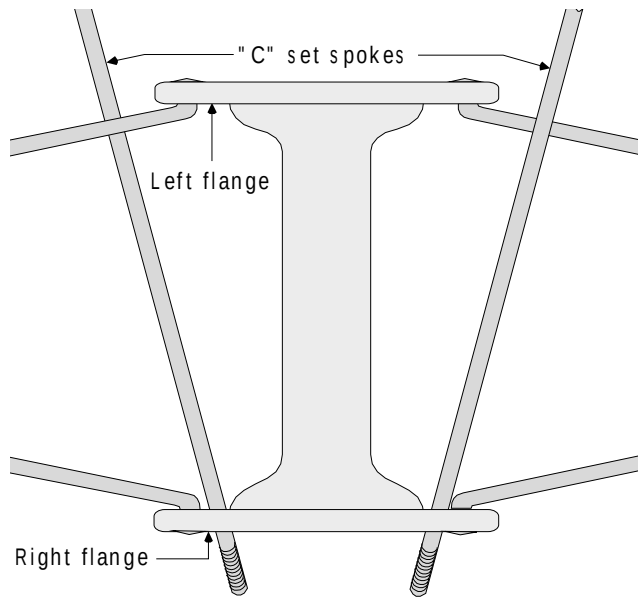
30. With left side of rim facing up, rotate rim to look at valve hole in inner face of rim and inspect for following:

- [] If building a rear wheel with two different spoke lengths, one set of spokes should be left on bench on each side of wheel.
 - [] A spoke should be in first up-hole counterclockwise of valve hole.
 - [] Two empty holes should be between every pair of filled spoke holes in rim.
 - [] Every other hole in left hub flange is filled.
 - [] All spoke heads are on outside face of flange.
31. [] If any of inspections in step 30 are failed, remove all B spokes and repeat **LACING THE "B" SET**.

LACING THE “C” SET

32. [] Cross-pattern wheel only: With left side of wheel still facing up, insert remaining set of right-side spokes down into right flange so that spokes end up with heads on inside of right flange.

Radial wheel only: With right side of wheel facing up, insert remaining set of right-side spokes down into right flange so that spokes end up with heads on outside of right flange.



16.30 Insert the remaining spokes from the right side of the bench in the right flange in this fashion.

The cross pattern is established in the “C” set. Rather than counting crosses to determine where the spokes need to go, the spokes are installed by rote, and then the cross is counted to verify what happened. The “C” set is going in the right flange. The “A” set was the other set in the right flange, and its spokes had the heads to the outside of the flange. Just as sets are alternating from right flange to left flange and back to right flange, sets in the same flange will alternate so that the spoke heads alternate head-out (“A” set) and head-in (“C” set). To do this, the spokes are fed into the right flange from the left side of the hub. Then the wheel is turned over so that the right flange is up.

A key step here is finding the right spoke to mark to be C1. Because the location of C1 will change with each cross pattern, it is necessary to count a different number of spokes (for each different cross pattern) counterclockwise from the marked hole in the right flange (marked in step #13 and now containing spoke A1) to find the correct spoke to mark C1. The exception to this is with radial spoking, in which case

the C1 spoke will be the first “C” set spoke clockwise of the marked hole. For 1X pattern, the C1 spoke will be the first “C” spoke counterclockwise of the marked hole in the right flange. For 2X pattern, the C1 spoke will be the second “C” spoke counterclockwise of the marked hole in the right flange. For 3X pattern, the C1 spoke will be the third “C” spoke counterclockwise of the marked hole in the right flange. For 4X pattern, the C1 spoke will be the fourth “C” spoke counterclockwise of the marked hole in the right flange. With the exception of radial spoking, the number of “C” spokes counted counterclockwise from the marked hole to find C1 always equals the number of the cross pattern.

After finding C1, the rest of the spokes are numbered C2, C3, C4, etc. clockwise from C1.

33. [] Turn wheel over so that right flange faces up.

In the following step, if comfortable with the procedure it is OK to just mark the C1 spoke and skip marking the additional spokes of the C set.

34. Do one of next five options depending on spoke cross pattern being used (see figure 16.31 on following page):

4X SPOKE PATTERN:

[] Mark “C” set spoke that is fourth spoke counterclockwise of only marked hole in right flange, C1.

[] Going clockwise from C1, mark remaining spokes C2, C3, C4, etc.

3X SPOKE PATTERN:

[] Mark “C” set spoke that is third spoke counterclockwise of only marked hole in right flange, C1.

[] Going clockwise from C1, mark remaining spokes C2, C3, C4, etc.

2X SPOKE PATTERN:

[] Mark “C” set spoke that is second spoke counterclockwise of only marked hole in right flange, C1.

[] Going clockwise from C1, mark remaining spokes C2, C3, C4, etc.

1X SPOKE PATTERN:

[] Mark the “C” set spoke that is counterclockwise of the only marked hole in the right flange, C1.

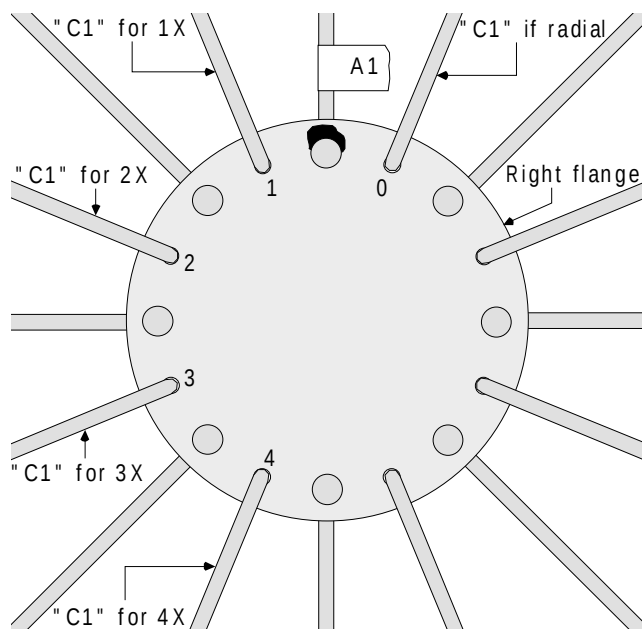
[] Going clockwise from C1, mark remaining spokes C2, C3, C4, etc.

RADIAL SPOKE PATTERN:

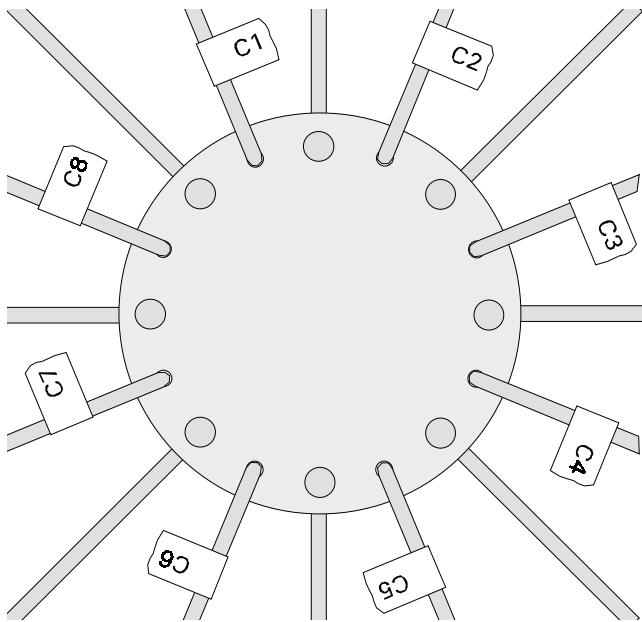
[] Mark the “C” set spoke that is clockwise of the only marked hole in the right flange, C1.

[] Going clockwise, mark remaining spokes in “C” set C2, C3, C4, etc.

16 – WHEEL BUILDING AND RIM REPLACEMENT



16.31 Depending on the cross pattern, different spokes will be marked C1.



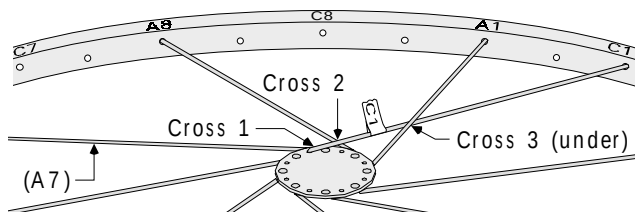
16.32 Mark the remaining "C" set spokes clockwise from C1 to be C2, C3, etc.

35. [] Holding rim stationary, rotate hub clockwise as far as it comfortably can.

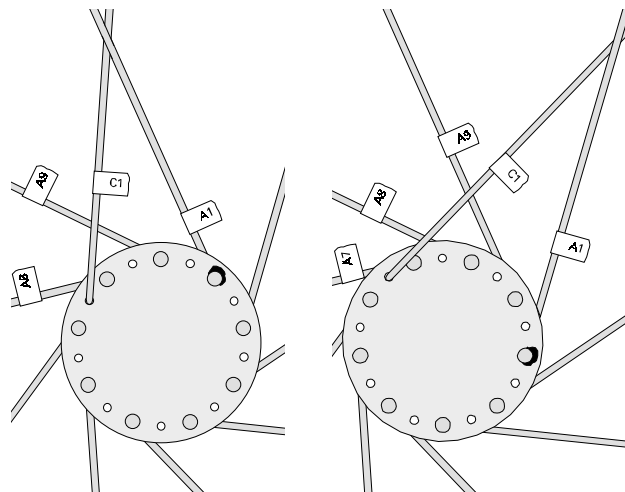
In the next step, create the cross pattern. After attaching spoke C1 to the rim at hole C1, trace the path of spoke C1 back from the rim to the hub flange. It will be found that it crosses the same number of "A" set spokes as the name of the cross pattern. After building a 3X and 36 spoke wheel, it will be found

that C1 crossed A1, A9, and A8. For a 3X and 32 spoke wheel, it will be found that C1 crossed A1, A8, and A7.

"B" spokes in place, but not shown
C2, C3, etc. in flange, but not shown



16.33 In this 3X-32° example, C1 crosses over A7 and A8, then under A1. See figure 16.34 for 3X-36° and 4X-36° examples.

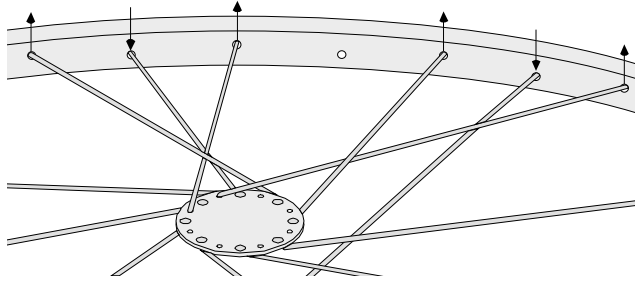


16.34 The left example is a 3X-36° wheel, and the right example is a 4X-36° wheel.

36. [] Move spoke C1 until it points to hole C1. Flex it slightly, in order to pass tip of spoke C1 under spoke A1, then insert spoke C1 into hole C1, covering approximately half of spoke-thread length with nipple.
37. [] Repeat previous step for spoke C2, C3, C4, etc., consecutively. Each spoke will attach to rim exactly four holes after last spoke and will always cross under last A spoke before reaching rim.

The next three steps are inspection steps. As with the previous spoke sets, do not let confidence encourage skipping these steps before doing the “D” set.

38. [] Inspect at rim for each set of three filled spoke holes separated by one empty spoke hole.



16.35 Each set of three spokes separated by an empty hole should consist of one up spoke, a down spoke in the middle, and another up spoke.

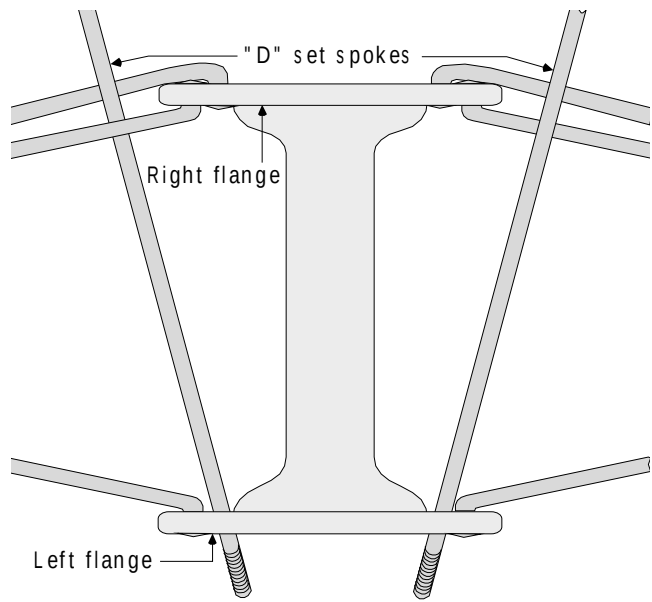
39. [] Inspect one set of three consecutive spokes at rim for whether set consists of, in order, one right (up) flange spoke, one left (down) flange spoke, then one right (up) flange spoke.

40. [] Inspect that each “C” spoke crosses under a “A” spoke just before reaching rim. Correct any spokes that don’t cross under.

41. [] If any of inspections in steps 38 through 39 are failed, or if remaining group of spokes on bench is on right (if building a rear wheel with two spoke lengths), remove all C spokes and repeat LACING THE “C” SET.

LACING THE “D” SET

The “B” set is the first set in the left flange, and its spokes have the heads to the outside of the flange. Just as the insertion of spoke sets has alternated from right flange to left flange and back to right flange, spokes sets in the same flange will alternate so that the spoke heads alternate head-out (“B” set) and head-in (“D” set). To do this, the spokes are fed into the left flange from the right side of the hub. After the spokes have been inserted, the wheel is turned over so that the left flange is up (see figure 16.36).



16.36 Insert the remaining spokes from the left side of the bench in the left flange in this fashion.

42. [] **Cross-pattern wheel only:** With right side of wheel still facing up, insert remaining set of left-side spokes down into left flange so that spokes end up with heads on inside of left flange.

Radial wheel only: With left side of wheel facing up, insert remaining set of left-side spokes down into left flange so that spokes end up with heads on outside of left flange.

43. [] Turn wheel over so that left flange faces up.

A key step here is finding the right spoke to mark to be D1. Because the location of D1 will change with each cross pattern, it is necessary to count a different number of spokes clockwise from the marked hole in the left flange to find the correct spoke to mark D1 (for each different cross pattern). The exception to this is with radial spoking, in which case the D1 spoke will be the first “D” set spoke *counterclockwise* of the marked hole. For a 1X pattern, the D1 spoke will be the first “D” spoke clockwise of the marked hole in the left flange. For a 2X pattern, the D1 spoke will be the second “D” spoke clockwise of the marked hole in the left flange. For a 3X pattern, the D1 spoke will be the third “D” spoke clockwise of the marked hole in the left flange. For a 4X pattern, the D1 spoke will be the fourth “D” spoke clockwise of the marked hole in the left flange. With the exception of radial spoking, the number of “D” spokes counted clockwise from the marked hole to find D1, always equals the number of the cross pattern.

After finding D1, the rest of the spokes are numbered D2, D3, D4, etc. counterclockwise from D1.

16 – WHEEL BUILDING AND RIM REPLACEMENT

In the following step, if comfortable with the procedure, it is OK to just mark the D1 spoke and skip marking the additional spokes of the D set.

44. Do one of next five options depending on spoke cross pattern being used (see figure 16.37):

4X SPOKE PATTERN:

- [] Mark "D" set spoke that is fourth spoke clockwise of only marked hole in left flange, D1.
- [] Going *counterclockwise* from D1, mark remaining spokes D2, D3, D4, etc.

3X SPOKE PATTERN:

- [] Mark "D" set spoke that is third spoke clockwise of only marked hole in left flange, D1.
- [] Going *counterclockwise* from D1, mark remaining spokes D2, D3, D4, etc.

2X SPOKE PATTERN:

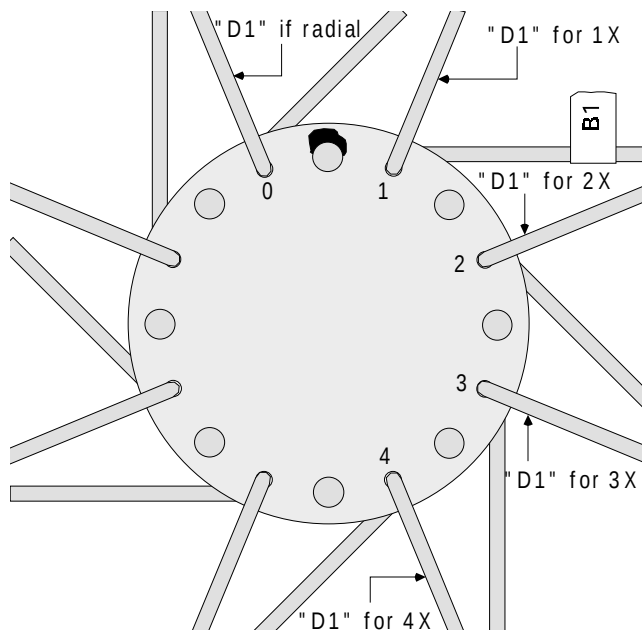
- [] Mark "D" set spoke that is second spoke clockwise of only marked hole in left flange, D1.
- [] Going *counterclockwise* from D1, mark remaining spokes D2, D3, D4, etc.

1X SPOKE PATTERN:

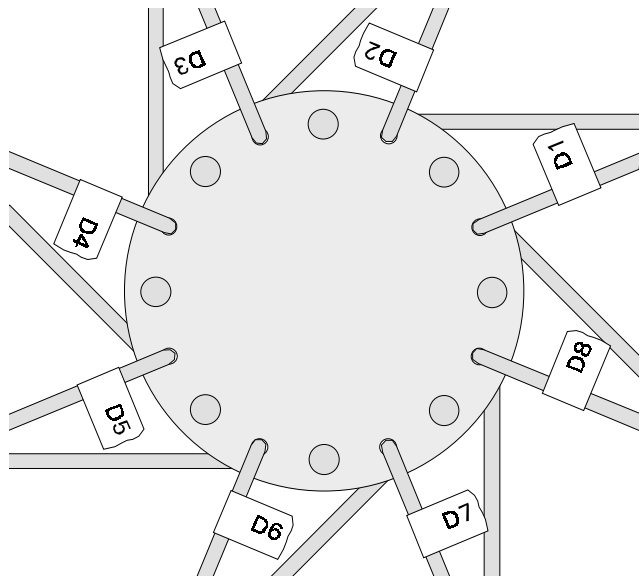
- [] Mark the "D" set spoke that is clockwise of the only marked hole in the left flange, D1.
- [] Going *counterclockwise* from D1, mark remaining spokes D2, D3, D4, etc.

RADIAL SPOKE PATTERN:

- [] Mark the "D" set spoke that is *counterclockwise* of the only marked hole in the left flange, D1.
- [] Going *counterclockwise*, mark remaining spokes in "D" set D2, D3, D4, etc.



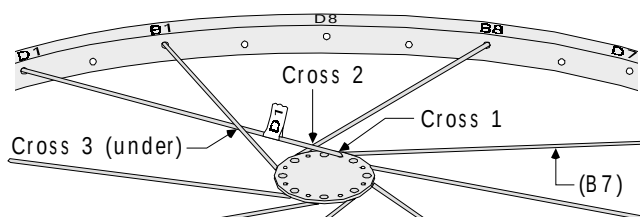
16.37 Depending on the cross pattern, different spokes will be marked D1.



16.38 Working counterclockwise from D1, mark the remaining spokes D2, D3, D4, etc.

- 45. [] Move spoke D1 until it points to hole D1. Flex it slightly, in order to pass tip of spoke D1 under spoke B1, then insert spoke D1 into hole D1, covering approximately half of spoke-thread length with nipple.**

"A" and "B" spokes in place, but not shown
D2, D3, etc. in flange, but not shown



16.39 In this 3X-32° example, D1 crosses over B7 and B8, then under B1.

- 46. [] Repeat previous step for spoke D2, D3, etc.**
47. [] Inspect that each "D" spoke crosses under a "B" spoke just before reaching rim. Correct any spokes that don't cross under.

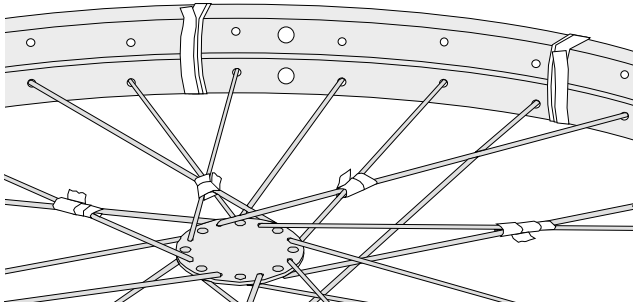
REPLACING RIM AND REUSING OLD SPOKES

Reusing old spokes is strongly recommended against. Spoke fatigue is impossible to detect by inspection. Building a new rim onto an existing wheel, only to have to rebuild the wheel because of fatigued spokes, is a terrible waste of time and money; further-

more, two rims of the same size do not necessarily take the same-size spokes, so unless the replacement rim is identical, the old spokes may not work.

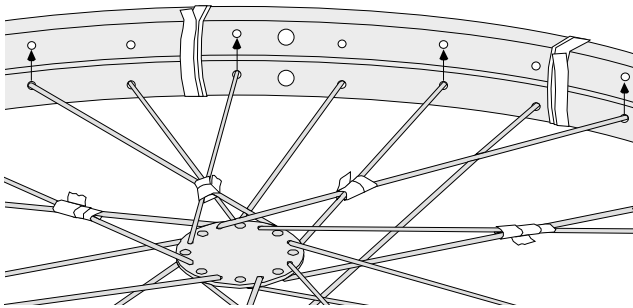
Only if the customer has smashed a virtually new rim and an identical replacement is available, then it would make sense to reuse the old spokes.

1. [] Lay replacement rim on top of damaged rim (right-side up) with valve holes lined up and fix rims together with tape.



16.40 Tape new rim on top of right side of old rim in this fashion, then tape the outermost spoke crosses on the upper set of spokes together.

2. [] Wrap tape securely around each pair of spokes where they cross each other the last time before reaching rim.
3. [] Unthread all nipples on spokes coming from right-side flange.
4. [] Re-attach all right-side spokes to new rim in holes directly adjacent to holes that spokes have been removed from.



16.41 Transfer spokes to new rim.

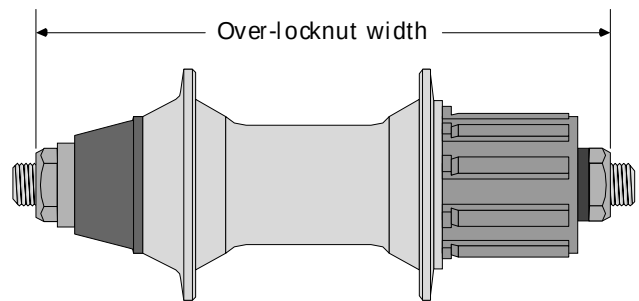
5. [] Turn wheel over so left side is up and new rim is on bottom.
6. [] Unthread all nipples on spokes coming from left-side flange.
7. [] Re-attach all left-side spokes to new rim in holes directly adjacent to holes that spokes have been removed from.
8. [] Remove tape from spoke crosses and remove tape holding rims together.

PREPARING WHEEL FOR TRUING

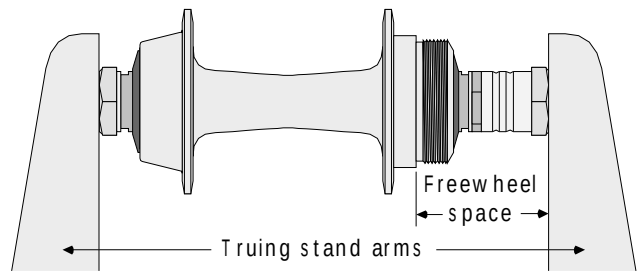
1. [] Put wheel securely in truing stand so that right end of axle is on your right and secure fully.
2. Do one of next two options depending on whether wheel is front wheel, rear wheel with two different spoke lengths, or rear multi-sprocket wheel with one spoke length:
 - [] If building a front wheel or a rear wheel with two spoke lengths, tighten all nipples until 1mm of thread (or two whole threads) is exposed above nipple.
 - [] If building a multi-cog rear wheel with one spoke length, tighten all nipples until 2mm of thread (or 4 whole threads) is exposed above nipple.

NOTE: If building a front wheel, skip to step 4.

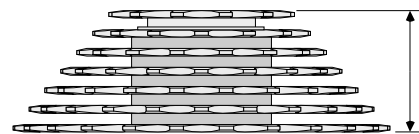
Establishing initial dish:



16.42 Measure over-locknut width in this fashion.



16.43 Measure freewheel space in this fashion.



16.44 Measure cogset width in this fashion.

16 – WHEEL BUILDING AND RIM REPLACEMENT

The following recommended dish corrections are just ball park estimates of what it will take to get the dish adjustment close to ideal. Further dish correction will be likely for many wheels.

3. Do *one* of the following options depending on width of cogset, over-locknut width, and amount of spoke-length differential used between left and right side of rear wheel:

EIGHT-SPEED COGSET, WIDE-WIDTH HUBS
(over-locknut width is 131.1–136.0mm)

- [] If one spoke length was used, tighten all right-side nipples three full turns.
- [] If 1mm shorter spokes were used on right side, tighten all right-side nipples two full turns.
- [] If 2mm shorter spokes were used on right side, skip to step 4.

EIGHT-SPEED COGSET, NARROW-WIDTH HUBS
(over-locknut width is 127.6–131.0mm)

- [] If one spoke length was used, tighten all right-side nipples four full turns.
- [] If 1mm shorter spokes were used on right side, tighten all right-side nipples three full turns.
- [] If 2mm shorter spokes were used on right side, tighten all right-side nipples one full turn.

NORMAL SIX- OR SEVEN-SPEED COGSET AND WIDE-WIDTH HUB

(cogset width is 29-32.5mm or freewheel space of 35.0-38.0mm, over-locknut width is 131.1–136.0mm)

- [] If one spoke length was used, tighten all right-side nipples two full turns.
- [] If 1mm shorter spokes were used on right side, skip to step 4.

NORMAL SIX- OR SEVEN-SPEED COGSET AND MEDIUM-WIDTH HUB

(cogset width is 29-32.5mm or freewheel space of 35.0-38.0mm, over-locknut width is 127.6–131mm)

- [] If one spoke length was used, tighten all right-side nipples three full turns.
- [] If 1mm shorter spokes were used on right side, tighten all right-side nipples one full turn.

NORMAL SIX- OR SEVEN-SPEED COGSET AND NARROW-WIDTH HUB

(cogset width is 29-32.5mm or freewheel space of 35.0-38.0mm, over-locknut width is 124.6–127.5mm)

- [] If one spoke length was used, tighten all right-side nipples four full turns.
- [] If 1mm shorter spokes were used on right side, tighten all right-side nipples two full turns.
- [] If 2mm shorter spokes were used on right side, skip to step 4.

FIVE- OR NARROW SIX-SPEED COGSET AND WIDE-WIDTH HUB

(cogset width is less than 27.5mm or free-wheel space of 30–34mm, over-locknut width is 124.6–127.5mm)

- [] If one spoke length was used, tighten all right-side nipples one full turn.

FIVE- OR NARROW SIX-SPEED COGSET AND WIDE-WIDTH HUB

(cogset width is less than 27.5mm or free-wheel space of 30–34mm, over-locknut width is 119.6–124.5mm)

- [] If 1mm shorter spokes were used on right side, tighten all right-side nipples 1 full turn.
- [] If one spoke length was used, tighten all right-side nipples three full turns.

Establish working tension:

4. Jiggle rim at bottom vigorously side-to-side and observe amount nipples move up and down in rim, then:

- [] If nipples move up and down >2mm, tighten all nipples 3 full turns and check again.
- [] If nipples move up and down 1–2mm, tighten all nipples 2 full turns and check again.
- [] If nipples move up and down <1mm, tighten all nipples 1 whole turn and check again.
- [] If nipples do not move up and down, skip to step 5.

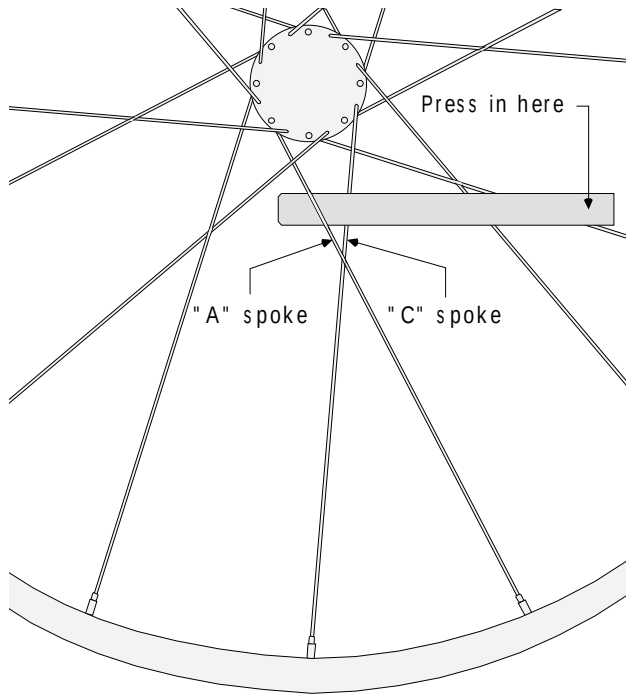
5. [] Pluck numerous spokes on right side of wheel and feel and hear for resonation in rim. If no resonation is felt or heard, tighten all nipples ½ turn.

Pre-set spoke bends (skip to step 11 if reusing old spokes):

As can be observed, spokes do not naturally take a straight line from the hub flange to the rim. They tend to arc on their way out of the flange, although they will straighten up when tensioned. Once the tension is gone, they will go back to being bowed. When a wheel is in use, the spokes are constantly getting tighter and looser. If they are also bowing and straightening when riding, then they will fatigue much faster. The following group of steps is designed to get the spokes to follow a straight line from the hub to the nipple, even when the spokes are relaxed, so that as they loosen and tighten under use, they will not be bowing and straightening as well.

16 – WHEEL BUILDING AND RIM REPLACEMENT

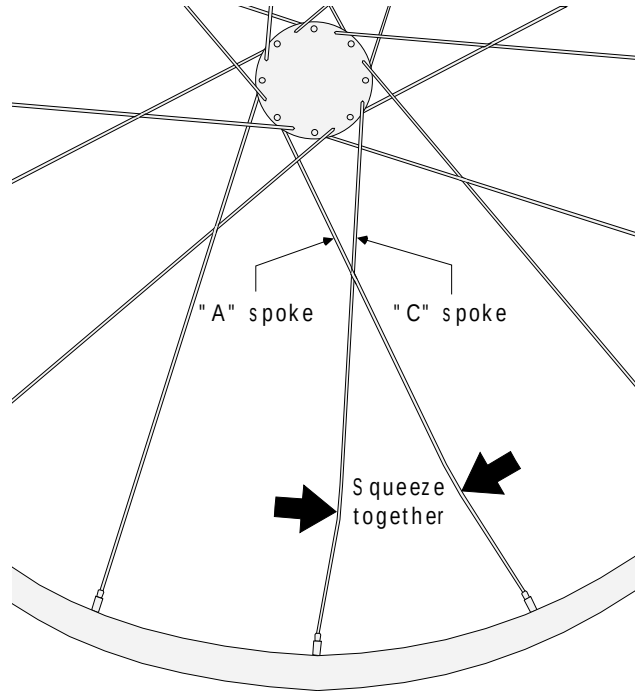
6. [] On right side of wheel, insert broad flat tool (such as a cone wrench or large combination wrench) between cross of spokes A1 and C1 and the right hub flange, then apply leverage in direction that forces A1 away from central plane of wheel and C1 toward central plane of wheel. Repeat for A2 and C2 pair, A3 and C3 pair, etc.



16.45 Just inside of the point where they cross each other, lever each A–C pair with the same number so that the A spoke is moved out and the C spoke is moved in to preset the spoke bends where the spokes come out of the flange.

7. [] On left side of wheel, insert broad flat tool (such as cone wrench or large combination wrench) between cross of spokes B1 and D1 and the left hub flange, then apply leverage in direction that forces B1 away from central plane of wheel and D1 toward central plane of wheel. Repeat for B2 and D2 pair, B3 and D3 pair, etc.

8. [] On right side of wheel, grab spoke pair A1 and C1 close to rim and squeeze pair together firmly. Repeat for pairs A2 and C2, A3 and C3, etc.



16.46 Squeeze each A–C pair with the same number, and then each B–D pair with the same number firmly together just above the nipples to preset the bend where the spokes come out of the nipples.

9. [] On left side of wheel, grab spoke pair B1 and D1 close to rim and squeeze pair together firmly. Repeat for pairs B2 and D2, B3 and D3, etc.

10. [] Repeat steps 4 and 5 as necessary.

WHEEL TRUING

11. [] Jiggle rim side-to-side to check hub for play (Remove wheel and adjust hub to eliminate play if hub is loose. Reinstall wheel in stand when done).
12. [] Put a drop of oil where each nipple enters rim.
13. Use procedure **TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES, AND NIPPLES**(page 17-11) from step 13 to complete truing.

17 – WHEEL TRUING AND REPAIR

ABOUT THIS CHAPTER

This chapter is about repairing wheels. It covers truing the wheels (adjusting spokes so that the rim is more round, centered, and wobbles less), replacing broken spokes and damaged nipples, and fixing minor rim damage. The chapter **WHEEL BUILDING AND RIM REPLACEMENT** is about replacing rims and building new wheels. That chapter does not include anything about truing wheels, but refers back to this chapter for that process.

GENERAL INFORMATION

TERMINOLOGY

Rim: The metal hoop at the outer end of the spokes that the rubber tire attaches to. The word “rim” is sometimes misused to apply to the wheel, including the spokes and hub.

Rim sidewall: The face of the rim that contacts the brake pads.

Rim beads: The two edges of the rim at the rims outer perimeter.

Hub: The mechanism at the center of the wheel that an axle rotates inside of, and the spokes attach to the outside of.

Hub flange: The disc on either end of the hub to which the spokes attach.

Spokes: The wires that go between the hub and the rim.

Spoke elbow: The end of the spoke that makes a 90° bend where the spoke goes through the hole in the hub flange.

Spoke head: The flattened disc at the end of the spoke elbow that keeps the spoke from pulling through the holes in the hub flange.

Nipple: The elongated nut that threads onto the threaded end of the spoke and attaches the spoke to the rim.

Spoke hole: The hole in the rim where the nipple comes out, although it would be better called the “nipple hole.” With regard to the hub, the hole in the hub flange that the spoke goes through is also called the spoke hole.

Eyelet: A separate metal reinforcement that goes in the spoke nipple hole in the rim.

Cross pattern: The pattern created by two sets of spokes in a hub flange that radiate in opposite directions on their way to the rim. If one clockwise radiating spoke crosses three counterclockwise radiating spokes from the same hub flange, then the wheel is said to be a “three-cross pattern.”

Interlace: If a spoke switches from crossing over spokes to crossing under the last spoke it crosses on way to the rim, the switch from crossing over to crossing under is called an interlace.

Dish: The centering of the rim to the hub locknuts. Because the flanges of a rear hub may not be equidistant from the locknuts, a rim centered to the locknuts is not necessarily centered to the hub flanges. Viewed from the wheel’s edge, this makes the wheel appear like a dish viewed from its edge.

Radial error: This is a deviation in the round of the rim. Radial errors are sometimes called “round errors.”

Radial bump: This is a radial error that deviates further from the center of the wheel than the rest of the rim.

Radial dip: This is a radial error that deviates closer to the center of the wheel than the rest of the rim.

Kgf: Stands for *kilograms of force*. This is a unit used to measure the tension of a spoke.

Reading unit: A number that is read from a spoke-tension meter. The reading unit must be looked up on a chart specific to the spoke-tension tool being used to convert to kgf.

PREREQUISITES

Wheel removal and installation

Before repairing a wheel, the wheel must be removed from the bike. See the **WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION** chapter (page 18-6) if unsure about wheel removal and installation.

Tire removal and installation

Before repairing a wheel, the tire usually must be removed from the wheel. See the **TIRES AND TUBES** chapter (page 19-3) if unsure about tire removal and installation.

17 – WHEEL TRUING AND REPAIR

Freewheel removal and installation

To replace a broken spoke, it is necessary to remove the freewheel or freehub cogs. See the **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** chapter for freewheel removal (page 25-9) and freehub cog removal (page 25-16).

Hub adjustment

Before truing a wheel, the hub must be adjusted to have no free play when out of the bike. See the **ADJUSTABLE-CONE HUBS** chapter (page 12-13).

INDICATIONS

Symptoms indicating need of wheel repair

There are several reasons to repair wheels.

Truing is needed when the side-to-side wobble (lateral error) of the rim makes it difficult to adjust the brakes (to eliminate brake-pad rub) without compromising the brake adjustment. Truing might also be needed because the rim is out of round (radial error), causing difficulty with getting the brake pads set at one height that is not too high at one point and too low at another point. Another reason wheel truing might be needed is that the rim needs to be centered to the hub (dished). The symptoms that would lead to suspicion that the wheel needs dishing are that the bike has a tendency to pull to one side (particularly when riding no hands), or that it is difficult to get the rim properly centered in the frame or fork. The symptoms indicating that the rim needs dishing can be caused by many things other than rim dish, but dish is one of the easiest causes to check for and correct, so it should be done first. See the troubleshooting section of this chapter (page 17-30) for other possible solutions when dishing a rim does not eliminate the symptom(s).

Replacing a broken spoke needs to be done whenever a spoke breaks. More importantly, a broken spoke indicates other problems. If spokes continue to break, it indicates that the life of the spokes is used up and the wheel should be rebuilt or replaced.

Repairing minor rim damage is advisable when truing is unsuccessful in eliminating the lateral errors while maintaining proper spoke tension. There are severe limitations to what can be done about repairing damaged rims, so very often the ultimate repair is rim or wheel replacement.

Symptoms indicating need of wheel replacement or rebuilding

Either during the course of a wheel repair, or even before the repair is attempted, symptoms might be experienced that indicate it would be better to replace or rebuild the wheel. These symptoms are:

Multiple broken spokes, either all at once or one at a time, over the last few hundred miles.

Multiple corroded nipples that won't turn.

Multiple damaged nipples (rounded off flats).

Dents or bends in the rim that cannot be adequately straightened by normal spoke adjustment and unbending techniques.

Cracks in the rim.

Severe rim-sidewall wear.

Maintenance cycles

There is not much routine maintenance to wheels other than repairing them when one of the above symptoms is experienced, but two things are very important. First, the key to wheel longevity is proper spoke tension. Proper tension promotes longer spoke life, long-lasting true, and longer rim life. Fortunately, another thing proper spoke tension promotes is stable spoke tension. Once tension is set right, it probably will not need regular attention. Unfortunately, only a minority of bicycle manufacturers and bike shops pay attention to this critical factor. Whenever assembling a bike, or truing used wheels, check the spoke tension first.

The second form of wheel maintenance is nipple lubrication. The nipples are the little elongated nuts at the rim end of each spoke. These nipples are tightened or loosened, which is how the wheel is trued. In many climates, the nipples have a tendency to corrode solid even before the wheel needs to be trued the first time. The shop should put a drop of light oil that can penetrate at the top of each nipple so that it will soak down into the threads whenever general maintenance is done. The only exceptions to this are when it is known that the threads have been treated with a compound such as Wheelsmith Spoke Prep (a "lifetime" corrosion preventative) or when you know that the climate is so dry that rust and corrosion are not a problem.

TOOL CHOICES

The following list covers all tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance of ease of use, quality, versatility,

and economy. When more than one tool for one function is in **bold** it means that several tools are required for different configurations of parts, or that two or more tools are equally suitable for the job.

WHEEL-REPAIR TOOLS(table 17-1)

Tool	Fits and considerations
NIPPLE WRENCHES (inaccurately called "spoke wrenches")	
Campagnolo 1103	Fits six sizes, but awkward to hold
Generic multi-wrenches	Fit multiple sizes, but usually not all critical ones, awkward to hold
Park SW-0	Black wrench fits 2.0/1.8mm-gauge spokes with 3.2mm nipples
Park SW-1	Green wrench fits 2.0/1.8mm-gauge spokes with 3.3mm nipples
Park SW-2	Red wrench fits 2.0/1.8mm-gauge spokes with 3.5mm nipples
Park SW-3	Blue wrench fits 12-gauge spoke nipples
Park SW-4	Yellow wrench fits 11-gauge spoke nipples
Park SW-7	Three-size multi-wrench that is painful to hold
Park SW-10	Adjustable clamping wrench fits all odd sizes and partially damaged nipples
Rika Spokey (red)	Comfortable, resists slippage, fits 3.3mm nipples
Rika Spokey (yellow)	Comfortable, resists slippage, fits 3.5mm nipples
Spline Drive S/T	Fits spline-drive nipples
VAR 51/1	Fits 2.0/1.8mm-gauge spokes with 3.3mm nipples
VAR 51/2	Fits 2.0/1.8mm-gauge spokes with 3.5mm nipples
SPOKE-SIZING TOOLS	
Hozan C915	Relatively inexpensive spoke-threading machine, impractical for more than 2–3 spokes at a time. Valuable for creating replacement spokes in unusual sizes. For wheels that just need a few spokes replaced
Phil Wood Spoke Threading Machine	Cuts and threads spokes, difficult to cost-justify, difficult to create consistent length of threading (makes truing more difficult).
DT Spoke Ruler	Inexpensive spoke ruler measures in millimeters and inches, aluminum gauge notches loose accuracy quickly.
Phil Wood Spoke Length Gauge	Expensive, precise and durable. Metric and inches. Superior variety of gauge notches that retain accuracy.
Wheelsmith TR-001	Precise and durable. Metric and inches. Limited variety of gauge notches.
TENSION METERS	
Hozan C737	Expensive, fragile, precise readings, cannot be re-calibrated
Wheelsmith N001	Less expensive, durable, less precise readings, but can be re-calibrated
SPOKE CUTTERS	
Eldi 2620	Heavy duty spoke cutter for cutting out old spokes
Eldi 297	Cuts excess spoke off at nipple head, fits inside few rims
Hozan C216	Cuts excess spoke off at nipple head, fits inside few rims
DISHING TOOLS	
Campagnolo N	Slow to use, fits 26" and larger only
Minoura (all)	Cheap, effective, not compatible with all locknuts, fits 26" and larger only
Park WAG-1	Will fit wheel in stand, can create false readings in some cases, fits 20" and up
VAR 143	Quick and easy to use, fits 20" and up
Wheelsmith F001	Awkward to read at axle, foldable, fits 26" and larger only

Continued

TIME AND DIFFICULTY

Truing a wheel is a 15–35 minute job of moderate-to-high difficulty. Replacing broken spokes, then truing the wheel, is a high-difficulty job that could take from 20–35 minutes. Repairing a damaged rim then truing the wheel could take 25–90 minutes, and is exceptionally difficult to do successfully unless the damage is minor. Precision spoke-tension balancing (optional on high-performance wheels) can add 15–30 minutes.

COMPLICATIONS

Loose hub adjustment

A wheel cannot be trued if the hub adjustment has any free play. The mechanic changes the existing adjustment by eliminating free play. The mechanic is responsible to return the adjustment to at least as good as it was originally. The mechanic is not responsible to make the adjustment more correct than it started out, unless the customer agrees to pay for a hub adjustment.

Rounded wrench flats on nipples

As soon as one rounded nipple is encountered, turn all the nipples on the wheel to see if others will be a problem. A wheel with many damaged nipples is not cost effective to repair. A damaged nipple can be turned or removed with a Park SW-10 nipple wrench.

Frozen nipples

As soon as one frozen nipple is encountered, turn all the nipples on the wheel to see if others will be a problem. A wheel with many frozen nipples is not cost effective to repair. A frozen nipple can be turned or removed with a Park SW-10 nipple wrench, although it is often necessary to find a way to keep the spoke from turning.

Broken spoke

A broken spoke is routine in itself, and not necessarily a complication. On a rear wheel, it often leads to freewheel removal, which itself can become very problematic.

WHEEL-REPAIR TOOLS (table 17-1 continued)

Tool	Fits and considerations
RIM REPAIR TOOLS	
Bicycle Research RS-1	Pliers-type tool squeezes blips out of rims and aligns offset spliced rim seams
TRUING STANDS AND STAND ACCESSORIES	
Bicycle Engineering TSAG	Gauge for centering Park TS-2 truing stand, not needed
United Bicycle Tool CV-290	Metric feeler-gauge set for measuring round, lateral, and dish errors
Coyote Jaw Inserts	Beefs up axle slot on Park TS-2
Hozan A340	Oversize motorcycle-wheel true stand
Minoura Workman Pro	Consumer-model stand that will cost more time than cheap price justifies
Park TS-2	Durable, easy wheel in/out, easy adjust of reading gauges
Park TS-6	Consumer-model stand that will cost more time than cheap price justifies
Park TSB-2	Tilt base for Park TS-2 helps compensate for mounting TS-2 at poor height
Pure Cycle True Stand	Only consumer stand suitable for shop use. Prime advantage is compactness.
United Bicycle UB-DI	Dial indicator for adding to existing true stand that can provide readouts to .025mm. Unnecessary accuracy, not a time saver.
VAR 74	Awkward wheel installation and indicator adjustment
VAR 485	Expensive, awkward wheel installation, amplifying runout pointers make small errors look big
SUPPLIES	
DT Spoke Freeze	Thread-preparation compound reduces corrosion and vibration loosening, can be applied to assembled wheel
Wheelsmith Spoke Prep	Thread-preparation compound reduces corrosion and vibration loosening, cannot be applied to assembled wheel so is best used during lacing
Sanford Sharpie Fine Point permanent marker	Used for marking on rim to keep track of correction zones and tension readings
1/2" masking tape	Used for tagging a spoke in order to keep track of it

Multiple broken spokes

Multiple broken spokes can be encountered several different ways: the wheel may come into the shop with several broken spokes; several spokes may break while truing the wheel; there may be only one broken spoke currently, but evidence of other previously broken spokes due to the presence of mismatched nipples or spokes. The problem is that a wheel with multiple broken spokes is certain to break more spokes soon. Replacing the current broken ones becomes a very temporary repair that costs the customer a lot of money in the long run, especially if it is done over and over again.

Damaged spokes

Spokes may be bowed, bent, kinked, or chewed up. Most bows and bends are not a problems, but a kinked spoke (sharp bend) is weak.

The most common damage is for all the head-in spokes in the right flange to be chewed up by a chain that has shifted past the innermost rear cog. Although these spokes are weakened, one must balance the fact that they could have some reasonable life left, against the fact that the only cost-effective repair for the shop is to rebuild the wheel (complicated by the issue of whether or not to rebuild with the same rim). It's usually best to true a wheel with chewed-up spokes, and rebuild it completely if and when the spokes begin to break.

Replacing spokes of unusual length

It is very likely that customers will bring in wheels for which the shop has no matching lengths of spokes. Hozan makes an inexpensive spoke threader that is a better choice than turning away the work or ordering the spokes.

Spokes protruding past nipples

When spokes protrude past the nipples, they may puncture the tube, or the nipples may be running out of thread.

A small amount of protrusion in a rim that has nipples down in a recessed well is not a problem. If the end of the spoke can reach the rim strip, then it must be ground down with a small stone on a rotary tool, or filed if accessible. This is time consuming.

If the spoke protrudes, the nipple is hard to turn, and the spoke tension is low, the nipples are running out of thread on the spoke. Since proper tension cannot be achieved, the wheel is unreliable.

Bent rims

Four types of bent rims may be encountered. These are radial flat spots, simple lateral bends, bent rim beads, and collapsed rims.

Radial flat spots are revealed by having loose spokes in the very section of the wheel that should be loosened in order to make the rim more round. These radial flat spots are caused by impact to the rim that occurs in-line with the plane of the wheel (such as hitting curbs or landing too hard). Repair is possible, but success is rare.

Simple lateral bends are revealed by having loose spokes just in the section of the wheel on the side that should be loosened to correct a lateral error, or by very tight spokes right where it would be best to tighten some to correct a lateral error. These lateral bends are caused by impact to the rim from the side. Repair is possible, but success is rare.

Another type of rim bend is a ding in the bead. The outer perimeter of the rim is deformed, but the body of the rim is unharmed. If the bead is collapsed straight in, there is no real problem and no solution. If the bead is deformed outward, it can be pressed back in with some success.

Rims can collapse catastrophically. The wheel will have a shape like a potato chip, with two large wobbles to the right alternating with two large wobbles to the left. This is unrepairable.

Cracked rims

Cracks can occur in rims at the nipple holes, at the inner perimeter of the sidewall, or in the sidewall. In all these cases, the rim is useless. Cracks around nipple holes or at the inner perimeter of the sidewall usually indicate excessive spoke tension. Cracks in the face of the sidewall may be from abuse or, more likely, from excessive rim wear.

Worn out rim sidewalls

Worn-out sidewalls occur primarily on off-road bikes that are used in a lot of wet conditions. The dirt being ground between the brake pads and the rim wears away the rim surface. Although texture is a good indicator of wear, the best indicator is a concave shape (curved in) to the sidewall. Most rims have flat surfaces or convex surfaces. Rim failure is imminent and can be catastrophic.

Poor quality rim seams

Rim seams can be offset, narrow, fat, or flat at the bead. A Bicycle Research RS1 can be used to eliminate offset on non-welded rims, or to squeeze down a fat seam. If a rim has a narrow seam or a very short radial dip at the seam, the error at the seam should be ignored while truing the wheel. Any error at the

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seam that includes less than the distance between the two spokes adjacent to the seam is a seam problem, not a true problem.

Poor quality rims

Inexpensive bikes often have rims that are so poorly made that both beads cannot be round at the same time and/or both sidewalls cannot be true at the same time. If one side looks round and true and the other jumps all over the place, then rim quality is to blame and further truing is a waste of time.

Tubular tire on rim to be trued

Tubular tires (glued on) present problems with correcting round, dish, and replacing a nipple. The shop cannot afford the expense of removing and re-gluing within the normal price of truing a wheel. In addition, many shops refuse to glue tubulars because of liability.

If the rim is box shaped, then radial truing can be done by setting the truing-stands radial-true indicators to the inner perimeter of the rim. If the rim has an aerodynamic profile, then nothing is possible except eyeballing the round.

Dish is problematic on tubular rims because the tire interferes with the dish tool, and it is not unusual for the tire to wobble back and forth on the rim. The best solution is to deflate the tire and deflect it enough so that the dish tool can rest on the rim.

Nipple replacement is a problem because the tire must be partially unglued from the rim. Usually lifting up a two-inch segment is adequate. Using an unattached spoke, feed the spoke up through the nipple hole at angle so that it comes out beside the tire, attach the nipple, and use the spoke to pull the nipple down into the rim. Remove the spoke from the nipple, then thread the nipple onto the spoke that is coming from the hub. *Be sure to put fresh glue under the section of the tire that was lifted!*

Mis-laced wheels

Usually mis-laced wheels are encountered when truing up a wheel that has just been laced up. There may either be erratic tight and loose spokes, or there will be a pattern of tight and loose spokes.

Erratic tight and loose spokes usually indicated that a few spokes were installed wrong, such as one two cross and one four cross in a wheel that is otherwise fully three cross. Find and fix the offending mis-laced spokes.

A pattern of tightness and looseness will usually have alternating pairs, with two in a row tight, then two in a row loose. Each pair would include one pull-

ing spoke and one pushing spoke. When this pattern occurs, it indicates that one whole side is mis-laced (all the spokes at least one hole off from where they should be in the flange). The wheel should be re-laced.

ABOUT THE REST OF THIS CHAPTER

The next section is about truing a wheel that has no rim damage, broken spokes, or damaged nipples. Everything in this section is also part of the process of repairing a wheel with rim damage, broken spokes, or damaged nipples. After the section on repairing the undamaged wheel is a section on replacing damaged nipples and broken spokes. The procedure for this section goes only as far as necessary to recover from the damage, then refers back to truing an undamaged wheel to complete the job. The last section is concerned with repairing damaged rims, which once again only goes as far as recovering from the damage, then refers back to the first part on truing undamaged wheels.

TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES, AND NIPPLES

AVOIDING COMMON PITFALLS

Based on decades of teaching experience, there are ten common pitfalls to truing wheels a mechanic should watch out for at all times. The pitfalls are listed here, and in some cases are repeated as the procedure is described later on.

Pitfall #1: Avoid turning the nipple the wrong way. Nipples are a right-hand thread, just like any type of jar lid. The problem is that while turning the nipple, the viewpoint is the same as looking at the “jar” upside down. With the tire off and looking at the nipple from the tire-side of the rim (the nipple’s “tire end”), the viewpoint is the same as looking at the top of the “jar lid.” When the view is of the end of the nipple that the spoke attaches to (the “hub end”), it is the same as looking at the “jar” upside down.

Try this experiment. Get any empty jar (preferably clear), and hold it upside down. Now, look through the bottom of the jar, and turn the lid off. The lid had to be turned clockwise (the normal way to tighten lids) to get it off. Loosening a nipple when

looking at it from “hub end” is just like loosening the lid on the upside-down jar. Tightening it is just the opposite. If you have trouble with this visualization technique, use a felt tip pen to draw a half-circle arrow on the inner perimeter of the rim around every fourth nipple in the *counterclockwise* direction. Turn nipples the direction the arrow indicates when tightening, and opposite the arrow when loosening.

Pitfall #2: There is feedback designed into the wheel-truing procedure recommended in this chapter that confirms things are on the right track; don’t bypass the procedure and lose the feedback. When correcting lateral (side-to-side) errors and radial (round) errors, set the truing stand so that its indicators *just barely contact the rim*. Then, a very small correction is made. If the correct adjustment is made there will be immediate feedback in the form of *the slight contact disappearing!* If it does not disappear, either the wrong spoke is being turned, or the correct spoke in the wrong direction.

If the contact between the truing-stand indicator and the rim is too heavy, there will be no immediate feedback as to whether the correction is the right one. Then it is easy to do the wrong thing for a long time before discovering it, or too much of the right thing, which is ultimately the wrong thing, as well.

Along with this, keep the following guidelines in mind: turning a nipple a whole turn is a huge adjustment, turning a nipple a half turn is a normal adjustment, turning a nipple a quarter turn is a fine adjustment.

Pitfall #3: Don’t make dish (rim centering to the hub) corrections backwards, worsening instead of improving an out-of-dish problem. For some reason, many people have an intuitive understanding of how to correct a dish problem that is just the opposite of the correct way. When making dish corrections, *follow procedures, not instinct!*

Pitfall #4: Don’t assume that once dish is checked and found to be correct, it will remain correct from then on. On rear wheels, there is a tendency for the rim to pull to the left slightly as the spokes get tighter. Advanced wheel mechanics use this to their advantage by tolerating minor errors to the right when the wheel is at low tension, expecting them to self-correct as the wheel is tightened. Another way that dish is sometimes lost is when starting with a well-dished wheel with a major round error. In correcting the round error, some substantial lateral error is created. In correcting the lateral error, the dish adjustment is lost. As a beginner, just keep checking wheel dish, even if it checked out fine early on.

Pitfall #5: Don’t check for dish error when the wheel has significant lateral errors. This is like using a level to check whether a warped stud is perpendicular to the ground. Where the level is put completely changes the interpretation of any error. Always be sure that the lateral true is acceptable before using a dish gauge.

Pitfall #6: Don’t lose track of the right and left sides of the wheel when making dish corrections. A good technique is to always wrap a rubber band around the right end of the axle before starting truing the wheel. Always install the wheel in the truing stand with the rubber band on the right, and always start each dish measurement on the right side of the wheel. By using these habits consistently, the chance of getting turned around and performing a reverse correction is minimized.

Pitfall #7: Avoid assuming that the lateral alignment of the rim remains constant when correcting a series of radial errors. It is natural to lose some lateral true while adjusting radial. For this reason, after every three radial corrections, interrupt the process and go back and recheck for lateral errors. What makes switching back and forth between radial and lateral corrections so important is that a rim never moves strictly side-to-side. Think of the rim as a swinging pendulum. As it goes left of center it goes up. As it goes right of center, it goes up. While working on radial errors, the wheel will develop more and more lateral error. If you work on radial errors for too long without backtracking to lateral-error correction, there will be more and more *false* radial errors. It’s a viscous cycle.

Pitfall #8: Don’t fail to balance the left- and right-side corrections when correcting a round error (I am getting a little ahead here, but just try to grasp this concept). If trying to move a section of the rim closer to the hub, spokes need to be tightened. If only a left-side spoke is tightened, the rim will be pulled closer to the hub, but it will also be pulled closer to the left side of the hub, since that is where the spoke comes from. If a nearby right-side spoke is tightened an equal amount, it too will pull the section of rim closer to the hub, but to the right side as well. Since both spokes were tightened equally and one pulled the rim left and the other pulled the rim right, the net effect is that the rim moved closer to the hub, but stayed laterally stable (did not move closer to the left or right). For this reason, never use one spoke when correcting a radial error. If using two spokes, the amount each spoke should be adjusted will always be equal. If adjusting three spokes in a row (it gets trickier now), the total adjustment on left-side spokes has to equal the total adjustment on right-side spokes. For example, if the group

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of three included two left-side spokes straddling one right-side spoke, tighten the left-side spokes a quarter turn each (two quarters equals one half) and the one right-side spoke one half turn.

Pitfall #9: Don't make errors reading the spoke-tension-meter tool, and don't make errors using math to average a series of readings. The tension meter does not read in familiar units like a ruler. If measuring something familiar like a letter-size sheet of paper with a ruler and the measurement was something ridiculous like 12" x 18", it would obviously need to be redone. Without any fundamental understanding of the realities of spoke tension and the units that tension is measured in, extreme care is called for. Watch out for these pitfalls:

Confusing very low readings with very high readings. The nature of the WheelSmith tension meter is to simultaneously read "0" and "100" when measuring tension on a tensionless spoke. As readings of "100" are virtually impossible, and readings of "0" are quite common, it is safe to assume the lower number. Pluck the spoke in question and trust what it feels like. If it sings like a bird, the "100" is right. If it has no tone at all, go with the "0". Do not measure left-side spokes when determining a rear wheel's overall tension average. By nature, rear-wheel left-side spokes are significantly lower in tension than right-side spokes. It is the right-side spokes that reach maximum tension first, and if left-side spokes are measured it will result in over-tightening the right side.

Part of tensioning the wheel is taking readings on a number of spokes and then average the readings. Over and over again, students at Barnett Bicycle Institute take ten readings ranging from 60 to 70 each, average them, come up with an answer of 72.3, and then go on as though nothing were wrong. Their mistake is to have left one of the readings out of a group of ten, but still divide by ten to get the average. Sometimes they make the opposite error of adding a number in twice. In this case the average will be near or below the lowest readings they took. *Be suspicious if an average that is close to or beyond the lowest or highest numbers being averaged!*

Pitfall #10: Don't lose perspective, avoid seeing little errors as big errors. As the wheel takes longer and longer to complete, it is easy to become more and

more able to see errors. A significant number of students at Barnett Bicycle Institute make substantial progress on a wheel *and become convinced that it was worse than when they started!* For this reason, it is imperative to measure errors before fixing them, and measure them to determine when to stop, rather than relying on subjective judgment.

PREPARATIONS AND INSPECTIONS

1. [] Remove wheel from bike and skewer (if any) from hub.
2. [] Remove tire from rim.
3. [] Mark right end of axle with tape or rubber band.
4. [] Jerk axle side-to-side to check hub for play. (Adjust hub to eliminate play if hub is loose.)
5. [] Install wheel securely in stand with right side of wheel on right side of stand.
6. [] Put a drop of oil where each nipple enters rim and a drop of oil on the end of each nipple where spoke comes out.
7. Measure spoke at its midpoint to determine gauge. Check off closest of following measurements.

ROUND CROSS-SECTION SPOKE SIZES

- [] 2.0mm– 14 gauge
- [] 1.8mm– 15 gauge
- [] 1.7mm– 16 gauge
- [] 1.55mm– 17 gauge

ELLIPTICAL CROSS-SECTION SPOKE SIZES (measure the minor thickness)

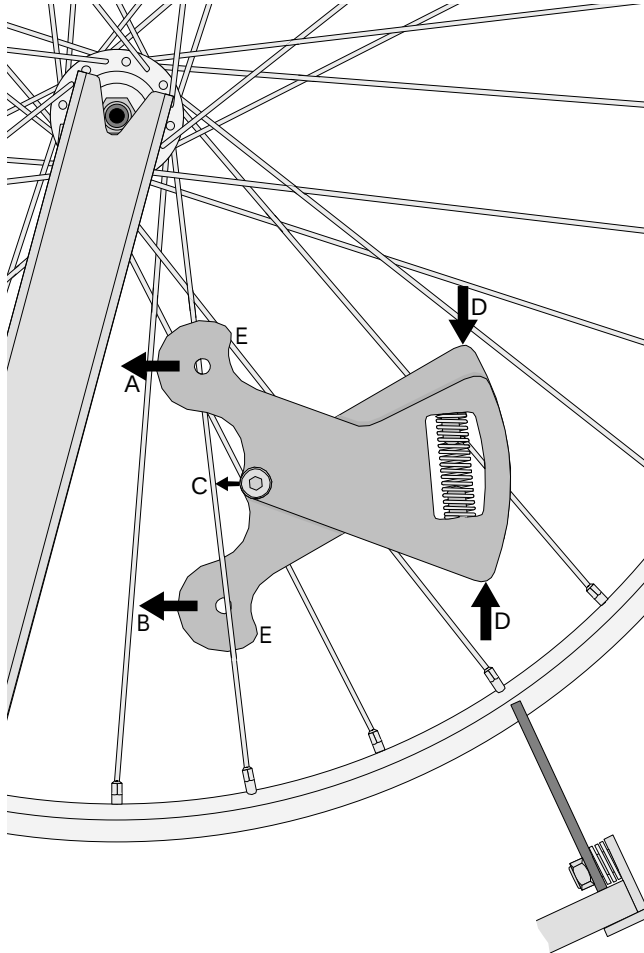
- [] 1.2mm, 2.0mm ends
- [] 1.2mm, 1.8mm ends

ESTABLISHING STARTING TENSION

In the next step, measure the tension on the spokes (right side only if a rear wheel). The reason to start with this measurement is that the process of truing more than likely will add tension to the wheel. If the wheel starts out with a high tension, it might end up being tightened too much. Usually, if the tension is over 80kgf, it makes sense to loosen the wheel before starting to true the wheel. Resist the tendency to tighten a wheel that starts out loose (under 80kgf); a loose wheel automatically becomes tighter from the truing process (tightening the wheel before truing will lead to too much tension). If the wheel does not gain enough tension from truing, more tension can be easily added at the end of the truing process.

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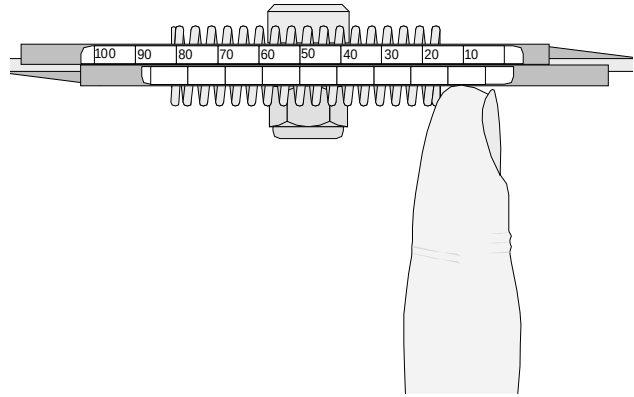
Before tension can be measured, get familiar with how to use the Wheelsmith Tensiometer. Take a look at figure 17.1 (below) to see how the tool is placed on the spoke. One ear of the tool goes over the spoke and one goes under the same spoke. When the tool is installed correctly, it will hold itself on the spoke.



17.1 The Wheelsmith Tensiometer is placed on the spoke so that the ear marked "A" goes over the spoke and the ear marked "B" goes under the spoke. When point "C" contacts the spoke, squeeze the tool together at the points marked "D," so that the points marked "E" can catch on the opposite side of the spoke from point "C."

It is important where the tool is placed along the length of the spoke. The *entire* tool must be between the rim and the last point where the spokes cross each other on the way to the rim. Also, if the spokes are butted (thick on the ends and thin in the middle) the entire tool needs to be on the thin portion of the spoke. Sometimes butting is hard to see. Grasp the spoke between two fingertips and feel for a change as you slide your fingers from one end of the spoke to the other, or set a caliper tight on the spoke near the middle of its length and see if the caliper jams before it will slide all the way to the nipple.

One more important tip about the Wheelsmith Tensiometer is how to hold it while taking a reading. It is best to support it on one finger, as in the next picture. If held between two fingers, there is a chance the additional pressure will influence the reading.

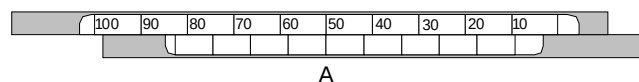


17.2 Holding a Wheelsmith Tensiometer while taking a reading.

Reading increments of 10

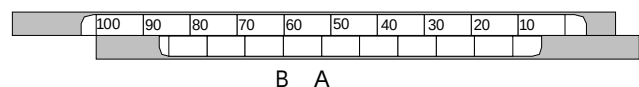
Now look at the tool scale and figure out how to read it. The top scale has lines numbered 10 to 100 (right to left). The bottom scale has no numbers. The easiest reading to make is if one of the lines on the bottom scale touches one of the lines on the top scale. The reading is then the number adjacent to the line on the top scale that is being touched by a line on the bottom scale. (See following figures 17.3 and 17.4.)

A reading of 50



17.3 In this example, the reading on the Wheelsmith Tensiometer is 50 because the lower-scale line indicated by "A" lines up exactly with the upper-scale line marked "50."

A reading of 60



17.4 In this example, the reading on the Wheelsmith Tensiometer is 60 because the lower-scale line indicated by "B" lines up exactly with the upper-scale line marked "60."

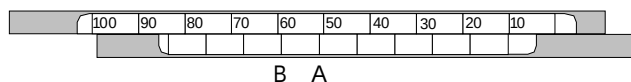
Reading increments of 5

If none of the lines on the bottom scale touch any of the lines on the top scale, look for the two lines that come closer to touching than any of the others. Let's say there is a line on the bottom scale that comes close to touching the 50 line on the top scale, and

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there is another line on the bottom scale that comes equally close to touching the 60 line. In this case, split the difference between 50 and 60 and call the reading a 55. (See following figure 17.5.)

A reading of 55

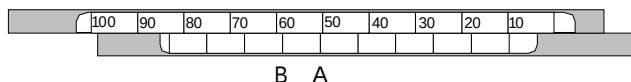


17.5 In this example, the lower-scale line indicated by “A” is close to the upper-scale line marked “50,” the lower scale line indicated by “B” is close to the upper-scale line marked “60,” and they are equally close. Consequently, the reading is halfway between 50 and 60, which is 55.

Reading increments of 2.5 and 7.5

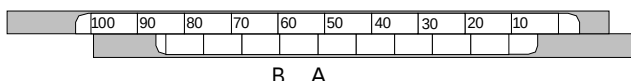
When no lines touch, it will not always be the case that the two closest will be equally close to the lines they don’t quite touch. Sticking with the above example, if the line close to 50 is closer to 50 than the line close to 60 is close to 60, then the reading would be 52.5. If the reverse were true, with the line near 60 being the closer, then the reading would be 57.5 instead. (See following figures 17.6 and 17.7.)

A reading of 52.5



17.6 In this example, the reading on the Wheelsmith Tensiometer is close to 50 because the lower-scale line marked “A” is closer than any other line on the lower scale is close to any other line on the upper scale. The reading is more than 50 because the “A” line is on the 60 side of 50. The reading is below 55 because the “A” line is closer to 50 than the “B” line is close to 60, so the reading is 52.5.

A reading of 57.5



17.7 In this example, the reading on the Wheelsmith Tensiometer is close to 60 because the lower-scale line marked “B” is closer than any other line on the lower scale is close to any other line on the upper scale. The reading is less than 60 because the “B” line is on the 50 side of 60. The reading is above 55 because the “B” line is closer to 60 than the “A” line is close to 50, so the reading is 57.5.

To get an idea of what the tension level is, measure about ten spokes and average their readings, then look up the average reading in the reading column on a table supplied with the tool, then look across to the appropriate spoke-gauge column to find the equivalent tension in kilograms of force (kgf). Let’s pretend we have just taken a batch of readings and they aver-

aged 62.5. The spoke gauge is 1.8mm. On the accompanying chart, the average reading is found in the reading column (halfway between 60 and 65), and the kgf is interpolated to be 118 (halfway between 108 which is the tension for a reading of 60, and 128 which is the tension for a reading of 65).

Spoke Tension in Kilograms of Force (kgf)

Spoke Gauge and center dimension (mm)*

Tensiometer Reading	SS-14 2.0	SS-15 1.8	DB-14 1.7
10			
15			
20			48
25		49	52
30		53	57
35		58	63
40		64	70
45	51	71	78
50	55	80	90
55	61	92	105
60	68	108	126
65	77	128	158
70	89		
75	104		
80	127		

62.5 = 118

17.8 A Wheelsmith Tensiometer chart.

8. [] Measure tension on ten consecutive right-side spokes, record readings in following blanks, and total.

_____ + _____ + _____ + _____ + _____
 _____ + _____ + _____ + _____ + _____ = _____

9. [] Divide step 44 total by 10 _____ ÷ 10
 Average reading is: _____ = _____

10. [] Record reading that is equal to 70kgf for spoke gauge in use: _____

11. [] Look average reading up on tension-meter chart and across to column for spoke gauge used on wheel, and decide whether tension is: <70kgf >70kgf (circle one choice).

NOTE: If <70kgf circled in previous step, skip to step 13):

If the average tension is more than 70kgf

12. [] Loosen all spokes one-half turn and repeat steps 8–12 until average is <70kgf.

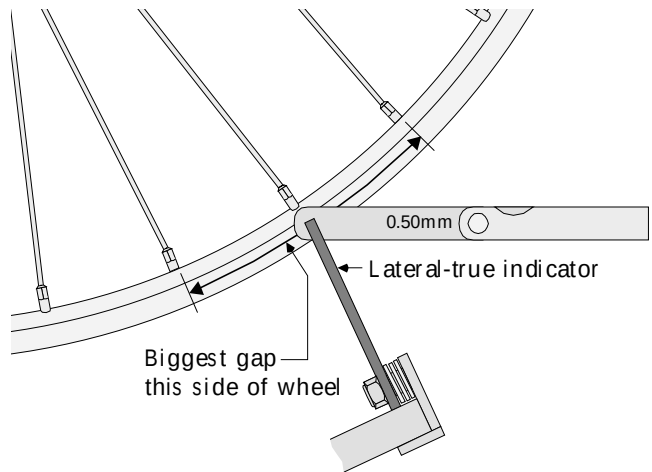
CORRECTING LATERAL ERRORS

Lateral error needs to be corrected before radial error or dish error because measuring and correcting radial or dish errors is compromised if there is significant lateral error. The basic technique when correcting lateral error is to set the truing indicators to barely rub the rim at one point as the wheel rotates in the stand, stop the wheel at that point, and tighten one spoke just enough to eliminate the rub. Then the indicators are moved in just enough to create another rub, which is then eliminated. This is repeated over and over again until the lateral error becomes insignificant ($<.5\text{mm}$). Because there is no way to predict how many times it will be necessary to repeat the process, the next steps are written as a repetitive cycle, each time ending with: **“Insert .5mm feeler gauge in gap to determine if it is $<.5\text{mm}$ and return to step 16 if it is not.”** Once the tolerance is met, move on to the next step.

Depending on the brand of truing stand being used, there are different techniques to setting the truing indicator(s) so that they just rub. If using a stand such as the VAR 74, which has separately adjustable left and right indicators, it takes a little adjustment to set them into position. First, just get the wheel spinning at a good clip. As it spins, try to get an idea of where the rim is the majority of the time. If it is running generally straight but with a few pronounced wobbles, decide whether those wobbles are primarily to the right, or to the left. If they are predominantly to one side, use the indicator on that side of the stand. If unsure, or the rim appears to wobble equally to the right and the left, alternate each lateral correction between the worst rub on the left and the worst rub on the right. If using the Park stand, the two indicators move in simultaneously to the rim. This can be a blessing or a problem. It's a blessing because the indicators determine by themselves whether the worst rub is to the right or left side. It's a problem when the wheel or stand is off-center and it keeps rubbing on one side when the worst wobble is to the other side. This can be solved by either turning the wheel around in the stand, or finding something to wedge underneath one of the indicators so that it does not move in anymore.

Start the next series of steps with a measurement to determine whether there is a need to make corrections. Use feeler gauges to measure the error. Start the wheel spinning, and adjust the lateral-true indicator(s) until there is the slightest detectable rub. Now turn

the wheel slowly and find what looks like the largest gap that occurs between the lateral-true indicator that rubbed the rim and the rim.



17.9 Using a .5mm feeler gauge to check the lateral error.

13. [] Spin wheel and set lateral-truing indicators so that they just barely touch rim.

14. [] Turn wheel slowly and find largest gap between rim and indicator that touched rim.

15. [] Insert .5mm feeler gauge into gap to determine if gap is: $\geq .5\text{mm}$ (bad) $<.5\text{mm}$ (good)

A handy technique is to use a “marker” on the rim at each point a correction will be made. The marker could be a 1/2" piece of tape, such as masking tape. Each time a rub is found, mark the center by putting the tape on top of the rim (not on the face where the truing indicator might knock it off). Alternatively, use two markers to mark where a rub begins and where it ends.

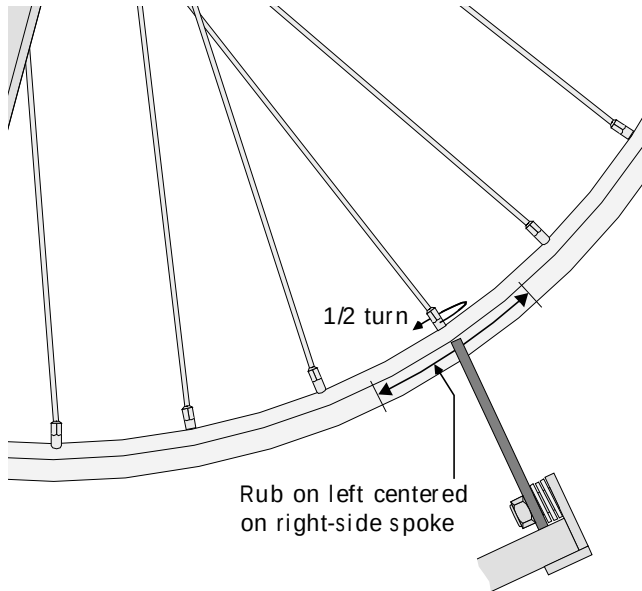
16. [] Spin wheel slowly and stop it at the point where rim just rubs the lateral-truing indicator. If wheel rotates past rub, be sure to turn wheel back so rim is contacting indicator. Find center of rub zone, not just one end, and put a marker on rim at this point.

In the next step, pick which spoke(s) to use to correct the rub. It will always come from the opposite side of the wheel than where the indicator is rubbing. If the indicator is rubbing on the right side of the rim over a short distance directly opposite a left-side spoke, then tighten that left-side spoke one-half turn. If the rub on the right is short and halfway between two left-side spokes, or slightly longer and includes two left-side spokes, then it is necessary to pick which spoke to use for the correction. Pluck the two spokes in question. If one is obviously looser than the other, tighten it. If

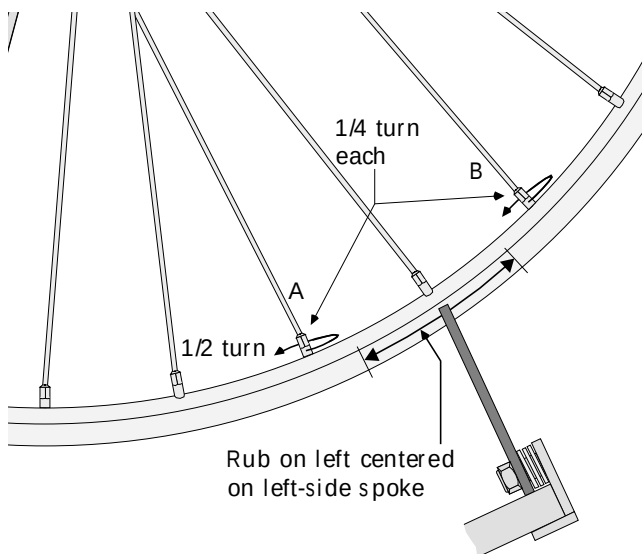
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they are equal, then it is OK to split the half turn correction between them with a quarter turn each. Beginners should stick with using one spoke.

- 17.[] Find spoke (or two, at most) from side of hub opposite side of rub that is closest to center of rub (or lesser-tensioned spoke of pair that are both close to center of rub) and tighten it one-half turn (quarter turn each if adjusting two spokes).**



17.10 *If there is a short rub on the left centered exactly opposite a right-side spoke, tighten that spoke one-half turn.*



17.11 *There is a short rub on the left that is centered between two right-side spokes; if A is looser than B, tighten A one-half turn. If they seem equally tight, then tighten them both a quarter turn.*

- 18.[] Move marker past true indicator again to check that rub is eliminated.**

- 19.[] Spin wheel and set lateral-truing indicators so that they just barely touch rim.**

- 20.[] Only if wheel looks reasonably true, turn wheel slowly and find largest gap between rim and indicator that touched rim. If errors remain obvious, return to step 16 now.**

- 21.[] Insert a .5mm feeler gauge in gap to determine if it is <.5mm and return to step 16 if it is not.**

NOTE: If gap is <.5mm go to step 22.

CORRECTING RADIAL ERRORS

Radial-error correction is probably the most demanding part of truing wheels. Many judgments have to be made about how many spokes to include in a correction. Both rubbing and the lack of rubbing may indicate errors. So, some corrections must be done by loosening and some by tightening. Radial corrections must constantly be interrupted to recheck and correct any lateral errors that develop while working on round. Remember: make sure that the total turns of correction on one side of the wheel equal the total turns of correction on the other side of the wheel.

Radial errors can either be a place where the rim is further or closer to the hub than a perfectly round wheel. Those places where the rim is further from the wheel center are called “bumps” and those that are closer to the wheel center “dips.” Think of it as though the outer perimeter of the rim were a road, and the irregularities on the road are bumps and dips.

The strategy when correcting radial errors is to take care of bumps before taking care of dips. There are two reasons for this. First, it is easier to detect the bumps (by the rim rubbing on the truing indicators) than it is to detect the dips (by looking for gaps). Second, it is like building a nice flat highway through hilly terrain. It is easier to smooth off the hilltops than it is to fill in the valleys. Also, by reducing the size of the hills, you also diminish the valleys — if you don’t get that right away, you will. Rims are not quite the same, but the effect is. By working on eliminating bumps first, there will be less to do with dips.

The first step is to measure the radial error, so it is known how much work must be done and when progress has been made. To do this, set the truing indicator so that it barely scrapes against the outer perimeter of the turning rim. Turn the rim slowly and find the biggest gap between the rim and the truing indicator, and use a feeler gauge(s) to measure this gap.

If the truing stand is a VAR or similar model, there is a separate plate that slides up and down that is the radial-truing indicator. If the plate will tip a little to

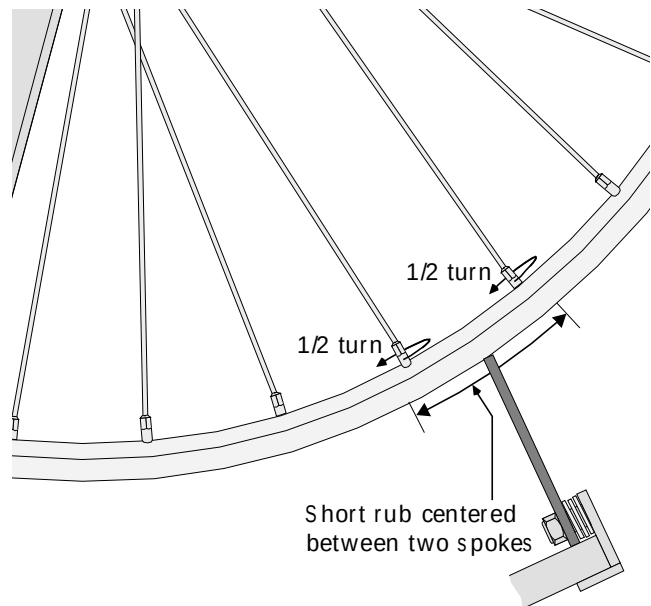
the side, it can be set so that it contacts one edge of the rim only. This is preferable! The Park stand uses the same indicators for radial true as it does for lateral true. Tighten the knob under the big arm so that the indicators will miss the rim entirely when they are adjusted in toward the rim. When the indicators are under the rim, start the rim turning and loosen the knob under the big arm until an indicator just touches the rim. In almost every case, it will touch at one edge of the rim before the other. Once again, this is preferable. When correcting radial true, it is preferable to get information from only one edge of the rim. The adjustment for the radial at the right edge of the rim is the identical adjustment for the radial at the left edge of the rim. When correcting deviations observed at one edge, the other edge is getting rounder simultaneously. Since it is impossible for any rim to have exactly identical left and right edges, if the indicator touches both edges at once you will get confusing information. Adjust the radial by one edge of the rim and trust that the other will also end up in tolerance.

Eliminating bump errors

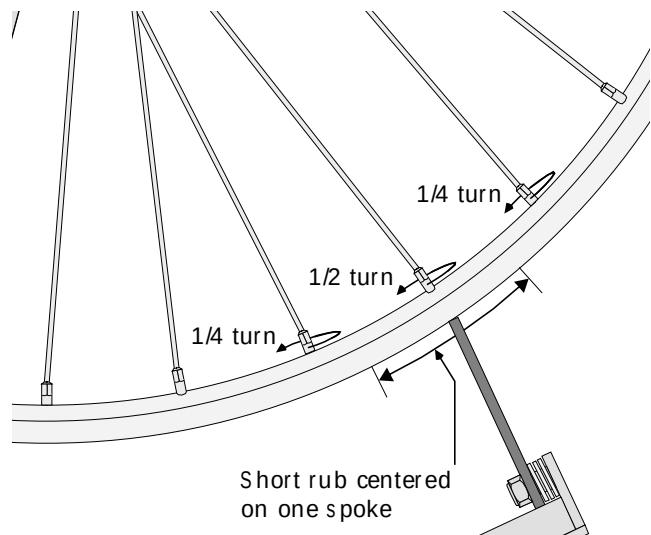
22. [] Spin wheel and adjust radial-truing indicator so that rim just barely rubs it as rim turns. Observe whether rub is on left or right edge of rim.
23. [] Turn rim slowly and look for biggest gap between indicator and edge of rim *on same side as rub occurred* and stop rim at biggest gap.
24. [] Insert .5mm feeler gauge into gap to determine if gap is: $\geq .5\text{mm}$ (bad) $< .5\text{mm}$ (good)

With the radial indicator still set in the same way, give the wheel another spin and again find the slight rub that is occurring. If the wheel spins past the rub, be sure to back up to it. Figure out where the rub begins and where it ends. Put a marker on the inner perimeter of the rim at the center of the rub. The rub might be short (including two or three spokes in its range), or long (including four or more spokes in its range). Long rubs in the early going often indicate that the truing indicator is set to tight against the rim. See if the indicator can be set looser to get a shorter rub.

A different technique is required for fixing a short rub including two spokes than a short rub including three spokes. For two spokes, tighten both spokes equally (generally a half turn each, or perhaps just a quarter). For three spokes, tighten the two on the ends a quarter turn each and the one in the middle a half turn. With this method, the total number of turns on right-side spokes equals the total number of turns on left-side spokes; therefore, the impact on the lateral true will be minimized.



17.12 Fix a radial bump including two spokes in its range by tightening both spokes equally.

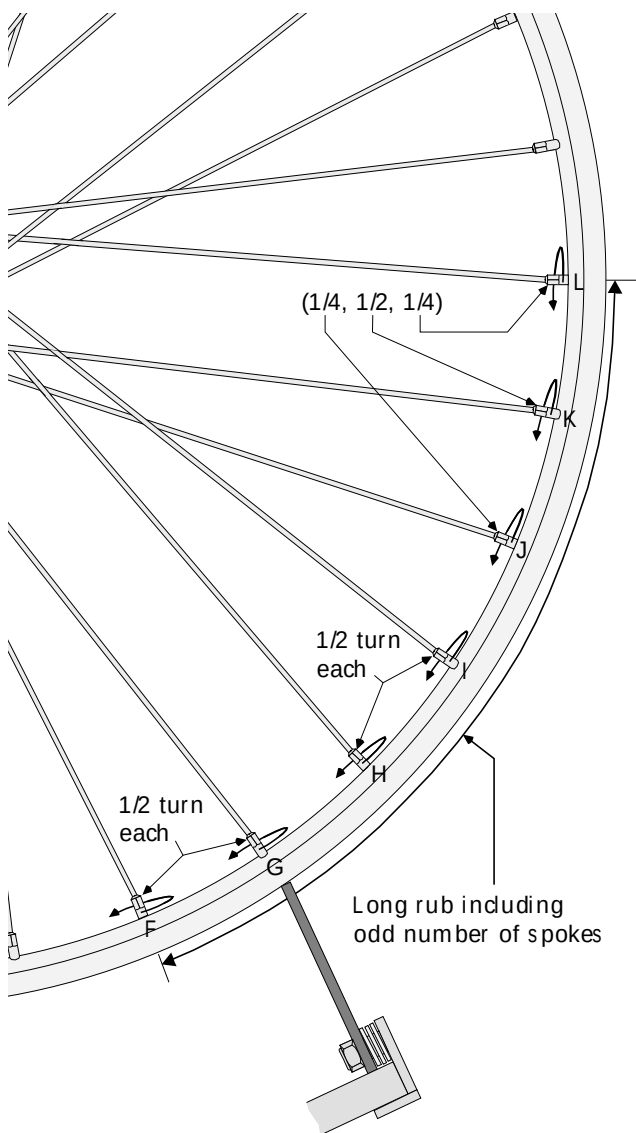


17.13 Fix a radial bump including three spokes in its range by tightening the end spokes a quarter turn each and the middle spoke a half turn.

Fixing rubs over four or more spokes is different. The easiest way to deal with a bigger problem is to make it a number of smaller problems. In this case, instead of putting the marker in the middle of the rub, put a marker at each end of the rub. Instead of thinking of the rub as one big error, think of it as a number of two-spoke rub errors. (If the rub range included an odd number of spokes, the last correction will be a three-spoke correction $[1/4, 1/2, 1/4]$, instead of a two-spoke correction like all the others.) If you are unclear about this system, follow the two examples below. The

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first example is a rub that includes four spokes in its range. For the sake of this discussion, the spokes will be called spoke A, B, C, and D. Correct this four-spoke rub by treating it like two short rubs involving two spokes each. Tighten A and B a half turn each (first correction) and then C and D a half turn each (second correction). The second example involves a longer rub including seven spokes, called spokes F, G, H, I, J, K, and L. The first correction is to tighten F and G a half turn each. The second correction is to tighten H and I a half turn each. The third correction is to tighten J a quarter turn, K a half turn, and L a quarter turn. Once again the rule of tightening left- and right-side spokes equal amounts applies.



17.14 Fix a radial bump of four or more spokes by breaking it down into short sections including two spokes, with the last section including three spokes if the total range of the rub included an odd number of spokes.

As with the correction of lateral rubs, if these corrections are done properly, the result will be that the rub disappears. If it does not, either nipples are being turned the wrong way, the range of the rub has not been determined accurately, or the truing indicator have been set too tight so that the rub was not light.

Once the rub goes away, go on to the next correction. After three corrections (count every two- or three-spoke group as a correction), interrupt the radial work and check the lateral again, correcting it if necessary until the largest gap is <.5mm.

25. [] Rotate rim slowly to find radial rub and place marker at center of range of rub.

26. [] Tighten appropriate group of spokes (two or three) so that spokes on each side of the wheel are tightened equal amounts (1/2, 1/2 or 1/4, 1/2, 1/4).

27. [] Move rim back and forth to check that rub is gone at marker.

28. [] Spin wheel and adjust radial-true indicator to barely rub again.

29. [] Turn wheel slowly to check for largest gap at edge where rub occurs to check if gap is <.5mm and repeat steps 25–29 if not. After every three cycles of steps 25 through 29, check and correct lateral errors until largest gap is <.5mm.

NOTE: At end of step 29 if largest gap is <.5mm, proceed to CORRECTING DISH ERRORS section.

30. [] If largest gap is >.5mm, but setting truing indicator to slight contact results in rub around rim at a number of sections including over 50% of spokes, proceed to Eliminating dip errors.

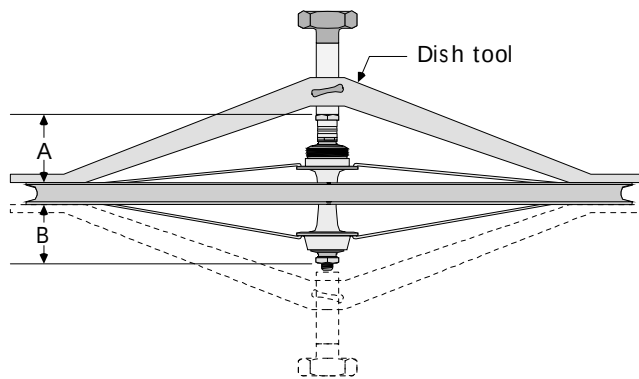
Eliminating dip errors

The very nature of a dip error makes it harder to find because the truing indicator skips over the dip without any obvious feedback that the error is there. Make this an advantage by setting the radial-true indicator so that it rubs so firmly against the rim that it rubs everywhere but one short range. This quiet range is the worst radial dip. Determine where the dip begins and ends and put a marker on the inner perimeter of the rim at the center of the quiet range. Just like the bumps, dips can involve two spokes, three spokes, or longer sections involving four or more spokes that must be broken down into a series of two- or three-spoke corrections. Other than looking for the quiet range instead of a rub, the only difference between fixing dips instead of bumps is that spokes must be *loosened* in the quiet range instead of tightened in the rubbing range. A correction is completed when the rim just barely rubs at the marker where before it was quiet.

31. [] Set truing-stand radial indicators firmly against outer perimeter of rim so that only one short section of rim does not rub as wheel is rotated.
32. [] Rotate rim slowly to find quiet range and place marker at center of quiet range.
33. [] Loosen appropriate group of spokes (two or three) so that spokes on each side of wheel are loosened equal amounts ($1/2$ & $1/2$, or $1/4$ & $1/4$).
34. [] Move rim back and forth to check that rub has developed at marker.
35. [] Spin wheel and adjust radial-true indicator to barely rub again.
36. [] Turn wheel slowly to check for largest gap at edge where rub occurs to check if gap is $<.5\text{mm}$ and repeat steps 31–36 if not. After every three cycles of steps 31–36, check and correct lateral errors until largest gap is $<.5\text{mm}$.
37. [] If largest gap is $<.5\text{mm}$ proceed to **CORRECTING DISH ERRORS**.

CORRECTING DISH ERRORS

Dish corrections are made to center the rim in the bike. A rim can be moved to the right by tightening all the right-side spokes, or loosening all the left-side spokes. A rim can be moved to the left in the opposite way.



17.15 Dish error exists when dimension A and B are not equal. The dish tool is used to make this comparative measurement.

Dish and spoke tension

The average tension of the wheel has changed since lateral and radial errors were corrected. After determining a dish error exists, you need to know whether to tighten or loosen spoke tension, and on which side. If it is still low, spokes must be tightened. If the tension is too high, spokes must be loosened to correct dish. If the tension is fine, a mix of tightening and loosening spokes is needed to correct the dish error.

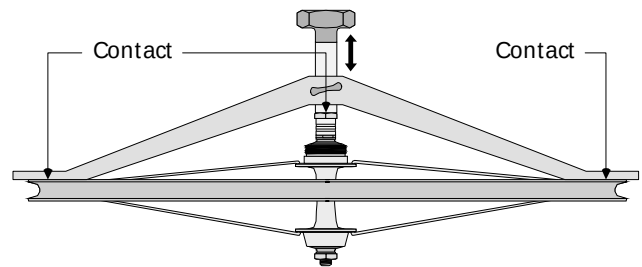
For example, if a dish error is detected that would be corrected by either tightening all the right-side spokes a half turn or loosening all the left-side spokes a half turn, but the tension on the wheel is correct, then the dish correction would be made by tightening the right-side spokes a quarter turn each and loosening the left-side spokes a quarter turn each.

Dish and lateral errors

Lateral error and dish error are closely related. As mentioned in pitfall #5, useful information about dish cannot be determined when the wheel has significant lateral errors. At the conclusion of the radial-error corrections, lateral errors were checked and cleaned up as necessary, so at this point the wheel is ready for the initial dish observation. Once a dish correction is made, check the lateral again (and correct if necessary) before re-checking the dish.

Measuring dish error

To determine the amount of dish error, use a tool called a dish gauge. The dish gauge rests on the rim at two points 180° apart, and then an adjustable part is set to contact the face of the locknut on the axle, so that the tool is contacting the wheel at three points (two on the rim and one on the hub). Theoretically, the tool can be initially set on either side of the wheel; for the purposes of simplicity and clarity, the following discussion assumes that the dish tool has been set for three-point contact on the right side of the wheel.

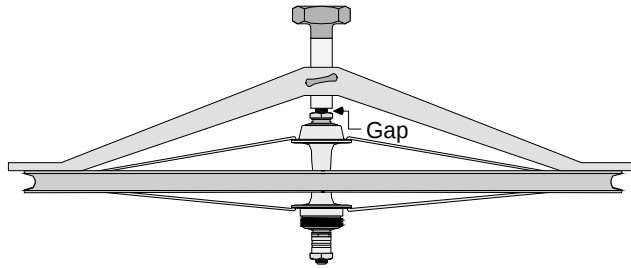


17.16 Adjust the dish tool to have three-point contact.

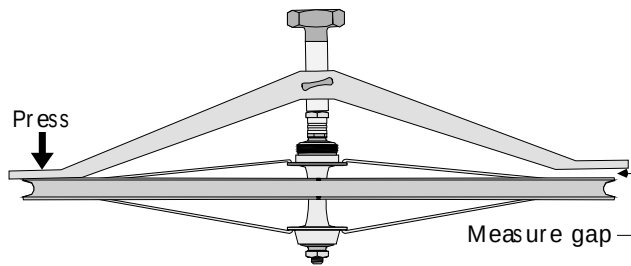
Next, the tool is transferred to the left side of the wheel. At random, one of three conditions might be found. The tool might contact at three points, indicating no dish correction is needed. Second, when the dish tool is held down against the rim at one end, it contacts at the hub, but has a gap at the other point on the rim (180° away). In this case, the gap should be measured (with feeler gauges) and perhaps corrected. The last possibility is that the tool might contact the rim at two points, but has a gap at the hub. There is an error that needs to be measured and perhaps corrected, but not until the tool is reset on the left side of

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the wheel for three-point contact and transferred back to the right side so that the error can be measured at a gap at the rim.



17.17 A gap seen at the hub after transferring the tool to the second side. Reset the tool and transfer back to the other side.



17.18 Measure the gap between the end of the dish tool and the rim.

Whether to measure dish error at hub or rim

The last condition of re-setting the tool and transferring back to the right side needs to be explained. Error can legitimately be measured either at the gap at the rim or at the gap at the hub. (When referring to gap at the rim, it always mean that with one end of the tool held to the rim there is gap at the other end of the tool.) Two things change, in either case.

If the gap is at the *rim* (on the left, for example) and spokes will be *tightened*, they will be tightened on the *same* side of the wheel (left side, in this case). If the gap is at the left side of the *rim* and spokes will be *loosened*, they will be loosened on the *opposite* side of the wheel (right side, in this example). If the gap is at the *hub* (on the left, for example) and spokes will be *tightened*, they will be tightened on the *opposite* side of the wheel (right side, in this case). If the gap is at the left side of the *hub* and spokes will be *loosened*, they will be loosened on the *same* side of the wheel (left side, in this case).

Additionally, for a given amount of dish error, the gap seen at the hub will always be half the size of the gap at the rim when the tool is transferred to the other side. Use a formula (described in the next paragraph, and built into the procedure) to convert gap size to the size (number of turns) of the correction. If

the formula is designed to be correct for converting gap-at-rim to turns-of-correction, then it will be wrong for converting gap-at-hub to turns-of-correction.

The formula for converting gap-at-rim to turns-of-correction is simply to divide the size of the gap by eight (if gap is measured in millimeters). For example, an 8mm gap measured at the rim on the right side would be corrected by turning all the nipples on one side one whole turn ($8 \div 8 = 1$). If the wheel were in need of tightening, it would a whole turn on the right. If it were in need of loosening, it would be a whole turn on the left. Whether to tighten or to loosen all the nipples is determined by the exiting spoke tension.

Consider two more examples. There is a 5mm gap on the right side. Divide 5mm by eight and the answer is .625. Should the correction be 625 thousandths of a turn on each nipple? No, too complicated. The number .625 is exactly halfway between .500 (one half) and .750 (three quarters). Quarter-turn increments are the smallest ones that should be used when adjusting nipples to correct dish. What should you do in this example, one half turn or three quarter turns? Be conservative and err on the side of caution by going with one half turn. On the other hand, if you divided the gap by eight and got .718 (for example), definitely go with three-quarter turn nipple adjustments.

Fixing dish errors

To fix dish, set the dish tool so that a gap is found between one end of the tool and the rim on the side of the wheel opposite from where the tool had perfect three-point contact. Second, measure the gap and divide by eight (gap in millimeters) and round the answer to the nearest quarter-turn increment to determine the size of the nipple adjustments. Third, measure the tension in order to know whether to tighten or loosen nipples when correcting dish (see page 17-9). Make the adjustment by either tightening the nipples on the same side of the wheel as where the dish tool showed a gap to the rim, or by loosening the nipples on the other side of the wheel.

38. [] Set dish tool to have three-point contact on right side of wheel.

39. [] Transfer dish tool to left side of wheel.

Check one of following:

[] gap at rim is 0–2mm, proceed to step 52.

[] gap at rim is >2mm, proceed to step 42.

[] gap is seen at the hub.

If gap is seen at the hub:

40. [] Set dish tool to have three-point contact on left side of wheel.

41. [] Transfer dish tool to right side of wheel. Gap will now be found at rim, proceed to step 42.

If gap is seen at one end of dish tool when one end is held to rim:

42. [] With one end of dish tool held to rim, measure gap at other end and record gap here: _____ on **Left side** **Right side** (circle one)
(If <2mm, go to **SETTING FINAL TENSION**.)
43. [] Divide number in step 42 by eight and round answer to nearest quarter. This number is necessary turns of correction for nipples. Record here: _____ turn(s) of nipples

Before making the dish correction, determine the wheel tension in order to know whether to tighten or loosen when correcting dish. The acceptable tension range for a wheel is 80–120kgf, with ideal being about 100kgf. If the existing tension is anywhere under 90kgf, nipples should be tightened (unless the size of the correction is going to be a whole turn or more, in which case it should be split into a correction in which spokes on one side of the wheel are tightened and the other side are loosened). If the tension is between 90–100kgf, loosen all the spokes on one side by half the necessary correction and tighten all the spokes on the other side by half the necessary correction. If the existing tension is anywhere over 100kgf, loosen nipples for the dish correction.

44. [] Measure tension on ten consecutive right-side spokes, record readings in following blanks, and total.

_____ + _____ + _____ + _____ + _____

_____ + _____ + _____ + _____ + _____ = _____

45. [] Divide step 44 total by 10 _____ ÷ 10
Average reading is: _____ = _____

46. Look average reading up on tensiometer chart and across to column for spoke gauge used on wheel and decide whether tension is: (check one choice)
- [] <80kgf & step 43 is **£1**(tighten nipples)
- [] 80–100kgf or step 43 is >1 (split, one side tighten, other side loosen)
- [] >100kgf (loosen nipples)

47. Based on step 46, dish correction should be:
- [] Tighten nipples
- [] Split, loosen one side and tighten other
- [] Loosen nipples

In step #48, one of three choices will be checked, then the blank in the checked choice should be filled in. Check the same choice as was checked in step #47 (for example, if “[] Tighten...” was checked in step #47, check “[] Tighten...” in step #48). The blank in

the checked choice should be filled in with the value that was calculated in step #43. After checking off a choice and filling in the blank, circle the notation **left** or **right** in the checked choice in step #48. Wherever the option checked is “tighten,” circle the **left** or **right** choice to match whether **Left side** or **Right side** was circled in step #42. Wherever the option checked is “loosen,” circle the **left** or **right** choice to be the opposite of whether **Left side** or **Right side** was circled in step #42.

48. Check one of following choices, based on whether to tighten, split, or loosen spokes (determined in step 47). If tightening, always tighten on same side of wheel as gap was found at rim; if loosening, always loosen on opposite side of wheel from where gap was found at rim (determined in step 42). Fill in blank in checked option with amount calculated in step 43:

- [] Tighten on **left right** (circle one) by _____ turns of nipples.
- [] Split, loosen on **left right** (circle one) by _____ turns of nipples
and tighten on **left right** (circle one) by _____ turns of nipples.
- [] Loosen on **left right** (circle one) by _____ turns of nipples.

49. [] Perform correction described in step 48, turning nipples as uniformly as possible.

50. [] Check and correct lateral errors until largest gap is <.5mm.

51. [] Check with dish tool for size of gap at rim again. If gap is £2mm go to **SETTING FINAL TENSION**. If >2mm repeat steps 38–51.

SETTING FINAL TENSION

Even after all this, the wheel’s average tension might still be too low, or it might be too high. The tension is important because low tension causes premature spoke fatigue and unstable true. High tension causes fatigue cracks in the rim and increases the likelihood of a complete wheel collapse.

The acceptable tension range for *all* wheels is very broad, about 80–120kgf. Specific wheels might need a more specific tension. The conditions that lead to a need for setting spoke tension in the lower half of the range (80–100kgf) are

Front wheels

Light-weight rider

Extreme light-weight rims

Poor nipple condition or corroded nipples that won’t turn

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The conditions that lead to a need for setting spoke tension in the higher half of the range (100–120kgf) are

Rear wheels with pronounced dish

Heavy-weight riders

Extreme heavy-duty usage

When making a tension adjustment, always turn all the spokes in the wheel an equal amount. This amount might be a quarter turn, a half turn, or a whole turn. In general, never use a whole turn unless increasing from average tension that is 50kgf or below. Use a half turn if increasing from an average that is more than 50kgf and less than 80kgf. Use quarter turns when increasing from a tension that is in the 80–95kgf range. If over-tight, always loosen by half turns. If you release too much tension, increase tension again in quarter-turn increments.

52. [] Measure tension on ten consecutive right-side spokes, record readings in following blanks, and total.

_____ + _____ + _____ + _____ + _____
 _____ + _____ + _____ + _____ + _____ = _____

53. [] Divide step 52 total by 10 ÷ 1 0
 Average reading is: _____ = _____

54. [] Look up average reading on tension-meter chart and read across to column for spoke gauge used on wheel.
 Write approximate kgf here: _____ kgf

55. Tension is (check one of following):
 [] 95–120kgf, go to step 81
 [] <50 kgf, tighten all nipples 1 turn
 [] 50–80kgf, tighten all nipples $\frac{1}{2}$ turn
 [] 81–95kgf, tighten all nipples $\frac{1}{4}$ turn
 [] >120kgf, loosen all nipples $\frac{1}{2}$ turn

56. [] Perform adjustment indicated in step 55 on all nipples.

57. [] Check and adjust lateral error until largest gap is <.5mm.

58. [] Check and correct dish error as in steps 38 through 51, if gap at rim is >2mm.

59. [] Measure tension on ten consecutive right-side spokes, record readings in following blanks, and total.

_____ + _____ + _____ + _____ + _____
 _____ + _____ + _____ + _____ + _____ = _____

60. [] Divide step 59 total by 10 ÷ 1 0
 Average reading is: _____ = _____

61. [] Look up average reading on tension-meter chart and read across to column for spoke gauge used on wheel
 Write approximate kgf here: _____ kgf

62. Tension is (check one of following):

[] 95–120kgf, go to step 81
 [] <50 kgf, tighten by 1 turn
 [] 50–80kgf, tighten by $\frac{1}{2}$ turn
 [] 81–95kgf, tighten by $\frac{1}{4}$ turn
 [] >120kgf, loosen by $\frac{1}{2}$ turn

63. [] Perform adjustment indicated in step 62 on all nipples.

64. [] Check and adjust lateral error until largest gap is <.5mm.

65. [] Check and correct dish error as in steps 38 through 51, if gap at rim is >2mm.

66. [] Measure tension on ten consecutive right-side spokes, record readings in following blanks, and total.

_____ + _____ + _____ + _____ + _____
 _____ + _____ + _____ + _____ + _____ = _____

67. [] Divide step 66 total by 10 ÷ 1 0
 Average reading is: _____ = _____

68. [] Look up average reading on tension-meter chart and read across to column for spoke gauge used on wheel
 Write approximate kgf here: _____ kgf

69. Tension is (check one of following):

[] 95–120kgf, go to step 81
 [] <50 kgf, tighten by 1 turn
 [] 50–80kgf, tighten by $\frac{1}{2}$ turn
 [] 81–95kgf, tighten by $\frac{1}{4}$ turn
 [] >120kgf, loosen by $\frac{1}{2}$ turn

70. [] Perform adjustment indicated in step 69 on all nipples.

71. [] Check and adjust lateral error until largest gap is <.5mm.

72. [] Check and correct dish error as in steps 38 through 51, if gap at rim is >2mm.

73. [] Measure tension on ten consecutive right-side spokes, record readings in following blanks, and total.

_____ + _____ + _____ + _____ + _____
 _____ + _____ + _____ + _____ + _____ = _____

74. [] Divide step 73 total by 10 ÷ 1 0
 Average reading is: _____ = _____

75. [] Look up average reading on tension-meter chart and read across to column for spoke gauge used on wheel
 Write approximate kgf here: _____ kgf

76. Tension is (check one of following):

[] 95–120kgf, go to step 81
 [] <50 kgf, tighten by 1 turn
 [] 50–80kgf, tighten by $\frac{1}{2}$ turn
 [] 81–95kgf, tighten by $\frac{1}{4}$ turn
 [] >120kgf, loosen by $\frac{1}{2}$ turn

77. [] Perform adjustment indicated in step 76 on all nipples.
78. [] Check and adjust lateral error until largest gap is <.5mm.
79. [] Check and correct dish error as in steps 38 through 51, if gap at rim is >2mm.
80. [] Repeat steps 73 through 79 as many times as necessary until tension is 95–120kgf.

TENSION BALANCING SPOKES

Theory

In taking the readings to determine the tension average, it will probably be observed that the spokes on one side of the wheel vary wildly in tension. Variations in readings are within acceptable limits if they vary by the equivalent of ± 20 kgf and would be considered excellent at the equivalent of ± 10 kgf.

When spoke tension needs balancing, there will be excessively tight spokes and excessively loose spokes. Both conditions cause problems.

High-tension:

High-tension spokes cause localized stress at the rim at each nipple hole, which can lead to rim failure.

High-tension spokes are much more likely to lead to nipple failure (rounded wrench flats) than spokes under normal tension, particularly if the overall tension is near its upper limit and/or the spoke and nipple quality is low.

High-tension spokes twist (called *wind-up*) more while truing the wheel and lead to more work when stressing the wheel to eliminate wind-up.

Low-tension:

Low-tension spokes fatigue more quickly because of the likelihood that they will go slack when they are at the bottom of the loaded wheel, leading to a “snap” effect when they return to tension.

Low-tension spokes are more likely to have their nipples unwind, leading to loss of true.

Low-tension spokes limit the potential to true errors by loosening spokes. This is particularly true when working with the left side of a rear wheel with exaggerated dish.

The tension-balancing process is a good diagnostic tool. During the process, a normal wheel will have some spokes that have a high tension and others that are low. If the wheel is not damaged, these high and low-tension spokes will virtually always be present as adjacent pairs. The process of correction is to find a high and a low spoke that are adjacent and adjust one

down and the other up. When many consecutive high-tension spokes are found (and the wheel is true) it indicates rim damage. The same is true when there are multiple consecutive low-tension spokes.

Three procedure alternatives

There are three ways to tension-balance wheels.

The first method, *preventative balancing*, is informal and imprecise, but reasonably effective. It is incorporated into the lateral-truing procedure described earlier. All it consists of is checking two adjacent spokes for relative tension when deciding which one of them to use to correct a lateral error.

The second method, *reading balancing*, has a detailed procedure starting with step #81 following. With this method, an average reading based on all the spokes on one side of the wheel is determined and a simple mathematical formula is applied to the average to determine the acceptable-reading range. Spokes outside the range are then adjusted. This method works well on spokes of common thickness in wheels that are near a 100kgf average, but is less applicable to wheels with very thin spokes or very low or high average tensions.

The third method, *precision balancing*, is described at the end of the whole wheel-truing process under the heading **PRECISION TENSION BALANCING** (page 17-24). This method is the most precise, but is very time consuming and has some complicated mathematical procedures. This method is the best one to use if the spokes are a thin gauge or the tensions are near the limits of the acceptable range.

Reading balancing with a Wheelsmith Tensionmeter

Step #85–#89 and #103–#107 use the *reading balancing* method of determining the acceptable range. This method is only suitable if a Wheelsmith tensionmeter is being used and the average tension is 80–100kgf. The reason for this tension limitation is that there is not a direct linear comparison between reading values and kgf values on the tension-meter chart. If the tension is 80–100kgf, then reading balancing can be done by adding and subtracting 3 from the average reading and rounding the result to the nearest increment of 2.5 (*plus-3/minus-3* method).

For example, consider a wheel with 2.0mm spokes and an average tension reading of 72. Using the plus-3/minus-3 method of determining the acceptable-reading range, the result would be a reading range of 70 to 75. Looking these values up on the example tension-meter chart on page 17-10, a tension range of 89-104kgf

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is determined. The average reading of 72 equals 95kgf; the tension range of 89-104kgf is well within the recommended ± 10 kgf range of the 95kgf average.

If the average tension is above 100kgf, the *plus-3/minus-3* method will create a tension range that is too wide to achieve the desired properties of rim durability and true stability (unacceptable spoke tensions will be left alone). If on the same wheel with 2.0mm spokes, the spoke tension averaged 110kgf, the average reading would be 76.25. Using the *plus-3/minus-3* method of determining the acceptable-reading range, the result would be a reading range of 72.5–80. Looking these readings up on the same chart, it is apparent that a tension range of 96.5–127kgf results. This range is –13.5kgf to +17kgf of the 110kgf average tension for this wheel. This is well outside of the recommended ± 10 kgf range. This discrepancy is why the alternate *precision tension-balancing* method involves so much math. Using the *precision tension-balancing* method would determine an acceptable-reading range of 72.5–77.5 for the same wheel at 110kgf. This reading range would result in something much closer to ± 10 kgf recommendation.

If the average tension is below 80kgf, the *plus-3/minus-3* method will create an unacceptable tension range that is too narrow (spokes with acceptable tensions will be adjusted unnecessarily). If on the same wheel with 2.0mm spokes, the spoke tension averaged 75kgf, the average reading would be 63.9. Using the *plus-3/minus-3* method of determining the acceptable-reading range, the result would be a reading range of 60.0–67.5. Looking these readings up on the same chart, it is apparent that a tension range of 68–83kgf results (–7kgf/+8kgf of the 75kgf average tension). This is well within the recommended ± 10 kgf range; spokes within this range are pointless to balance. This discrepancy is why the alternate *precision tension-balancing* method involves so much math. Using the *precision tension-balancing* method would determine an acceptable-reading range of 57.5–67.5 for the same wheel at 75kgf. This reading range would result in something much closer to ± 10 kgf recommendation.

If the *plus-3/minus-3 reading balance* method is used when tensions are outside the 80–100kgf range, it is quite likely that time will be spent trying to balance spokes that are acceptable, or some spokes that need balancing will not be balanced.

Following are some examples that show that using the *plus-3/minus-3 reading balance* method will create an acceptable-reading range that will be either 5 or 7.5. To calculate the acceptable-reading range, add and

subtract 3 from the average reading to determine the minimum and maximum acceptable readings. Round these two answers to the nearest 2.5 reading increment value. The two numbers that result from the rounding are the minimum and maximum acceptable readings, and should range from 5 to 7.5 reading units.

For example, if the average reading is 70.2:

$$70.2 + 3 = 73.2 \text{ (round to 72.5)}$$

$$70.2 - 3 = 67.2 \text{ (round to 67.5)}$$

See in this example that the average reading is close to halfway between the minimum and maximum readings (2.3 below 72.5 and 2.7 above 67.5). The resulting acceptable-reading range is 5 reading units.

For another example, if the average reading is 71.3:

$$71.3 + 3 = 74.3 \text{ (round to 75)}$$

$$71.3 - 3 = 68.3 \text{ (round to 67.5)}$$

See in this second example that the average reading is close to halfway between the minimum and maximum readings (3.7 below 75 and 3.8 above 67.5). The resulting acceptable-reading range is 7.5 reading units. Had a 5 unit reading range been used in this case (70 to 75), then the average would not be close to halfway between the minimum and maximum readings, making the mechanical process of correcting the unbalanced pairs more challenging.

This method, in summary, requires picking an acceptable-reading range that has the average reading close to halfway between the minimum and maximum readings. Ideally this range would be 5, but if necessary it would be 7.5. Any reading range (when using a WheelSmith tension meter) of 10 or more would usually be considerably more than a ± 10 kgf range, and in some cases more than ± 20 kgf.

Determine right-side acceptable reading range

The following procedure only applies if using a WheelSmith Tensiometer.

NOTE: If not tension balancing the wheel, go to step 117.

81. [] Measure tension of all spokes on right side of wheel and record readings on right face of rim adjacent to each spoke.

82. [] Add all right-side readings together and record right-side total here: _____

83. [] Divide by number of readings: _____ $\div$ _____

84. [] Right-side average reading is: _____ $=$ _____

NOTE: For a more precise alternative to determining the minimum and maximum readings than the method in steps 85–89, use steps 1–37 of the PRECISION TENSION BALANCING procedure.

85. [] Range reduction: _____ –3

86. [] Right-side MINIMUM READING: _____ $=$ _____

87. [] Repeat step 84: _____

88. [] Range increase: _____ + 3

89. [] Right-side MAXIMUM READING: = _____

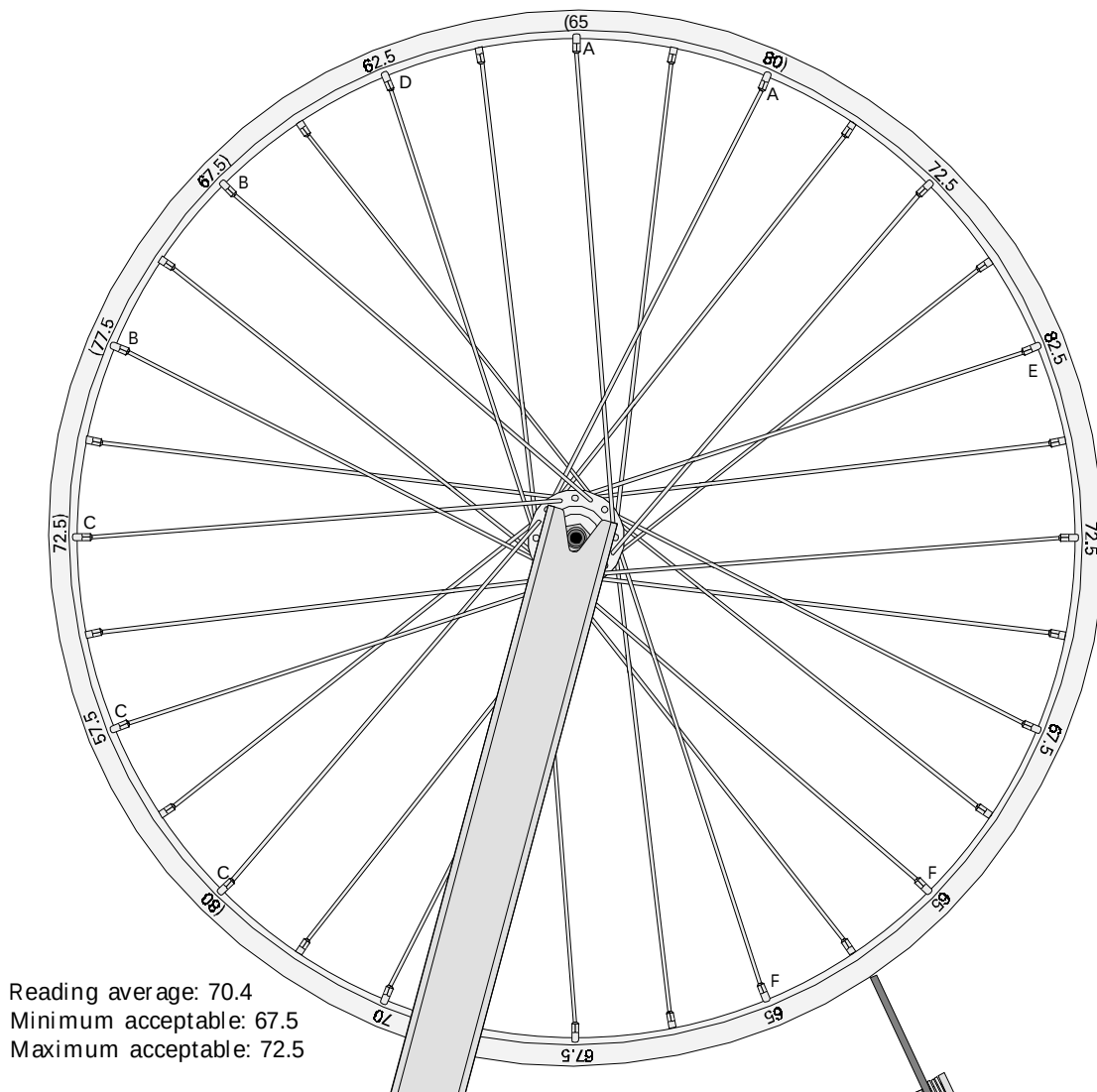
Examine the tension markings on the rim for sets of “high/low” spokes. A high/low set would be two consecutive spokes at the rim from the same flange in which one spoke was higher than the acceptable-reading range calculated, and the other was either unacceptably low or in the low side of the acceptable range. Or, it could be one spoke that was unacceptably low and the adjacent spoke was in the high side of the acceptable range. Mark these pairs by drawing bracket marks on the face of the rim that include the pair of high/low-tension readings.

It is possible to find isolated single spokes that are high or low tension, and there are no apparent spokes next to them to balance with the high- or low-tension

spoke. These isolated unbalanced spokes indicate either a truing error in the wheel at that point or a defect or damage point in the rim. If it is a new rim that is precisely trued, this might be grounds for seeking warranty satisfaction.

If the wheel is true and there are multiple consecutive high-tension or low-tension spokes, it is a sure sign of rim damage.

In figure 17.19, a wheel has had the tension readings written on the face of the rim and pairs (marked A, B, and C) have been selected for balancing. The reading marked D is an isolated low-tension spoke that cannot be balanced. The reading marked E is an isolated high-tension spoke that cannot be balanced. The group marked F is a group of consecutive low-tension spokes that indicate a rim defect if both the lateral and radial true are good at that point.

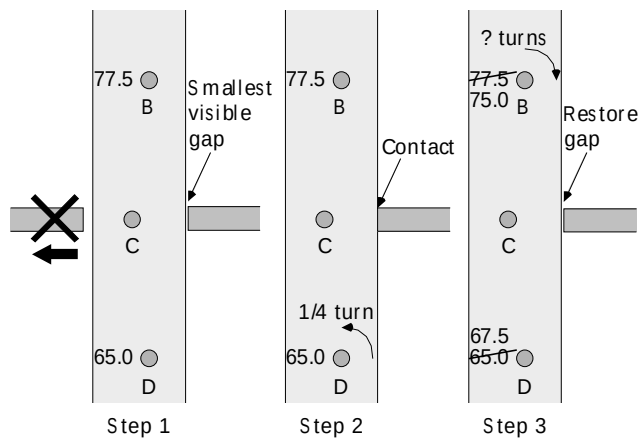


17.19 This rim has been marked with tension readings for all the spokes on this side. Pairs suitable for balancing are bracketed. See the above text for a detailed explanation.

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Correcting right-side tension-balance errors

A high/low pair of adjacent, same-side spokes can be balanced because the spokes have overlapping zones of influence on the rim. Two adjacent spokes on the same side of the wheel both influence the lateral true at the halfway point between the spokes. If a lateral-true indicator on the truing stand is set to almost contact the rim at this halfway point, and the low-tension spoke on one side of the true indicator is tightened a quarter turn, then when the high-tension spoke on the other side is loosened then the true can be restored at the halfway point. Tension of both spokes has been maintained and the lateral true halfway between them has been maintained. See the below illustration for a graphic example of how to tension balance a pair of spokes.



- 17.20** *In this example, spokes B and D need to be balanced.*
- Step 1) Eliminate the left true indicator and set the right true indicator to the smallest visible gap.*
- Step 2) Turn nipple D 1/4 turn counterclockwise. The indicator should contact.*
- Step 3) Turn nipple B clockwise just until the original gap is restored, then mark new tensions for spokes B and D.*

90. [] Bracket pairs of spokes on wheel that need balancing.

91. [] Select pair to balance.

92. [] Cancel out lateral-truing indicator on left side of wheel.

93. [] Set right-side indicator to just barely clear rim at point halfway between spokes being balanced.

94. [] Tighten looser of two spokes being balanced 1/4 turn. Observe clearance at point halfway between spokes disappear.

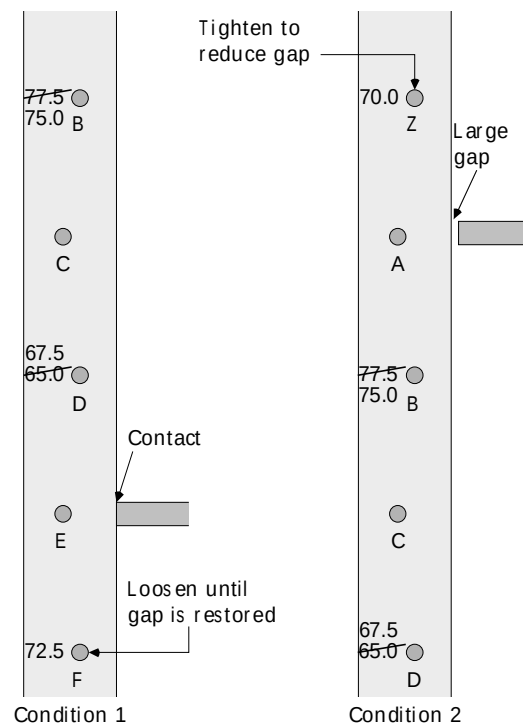
95. [] Loosen tighter of two spokes being balanced just enough to restore initial clearance set at point halfway between two spokes being balanced.

96. [] Measure new tensions on spokes being balanced and repeat steps 93–95 if necessary.

Even though true has been maintained at the point halfway between the spokes, there is a chance that the true has been lost just outside the zone between the two spokes.

Check to see if more than one spoke might potentially be used to correct the lateral error. Remember, depending on the lateral stiffness of the rim, each spoke can affect an area 3–5" in each direction. The spoke that will be used to correct the lateral error will be on the same side of the rim as the ones that are being tension balanced.

To correct the lateral error that has developed, choose whichever spoke has the most appropriate tension level to allow further loosening or tightening, as the case may be. See the below illustration.



17.21 *Condition 1— When lateral true is checked at E after balancing B and D, a contact is found at E. Since F is tighter than D, loosen F to eliminate the contact.*

Condition 2— When lateral true is checked at A after balancing B and D, an excessive gap is found. Since Z is looser than B, tighten Z to fix the gap.

97. [] Once both spokes have tension in acceptable range, check true just outside of balance zone on both sides. Correct true by finding closest spoke *with suitable tension* that will affect lateral in area in need.

98. [] Repeat steps 91–97 for all other pairs bracketed on right side of wheel.

Determine left-side acceptable reading range

99. [] Measure tension of all spokes on left side of wheel and record readings on left face of rim adjacent to each spoke.

100. [] Add all left-side readings together and record left-side total here: _____

101. [] Divide by number of readings: $\div$ _____

102. [] Left-side average reading is: = _____

103. [] Range reduction: _____ -3

NOTE: For a more precise alternative to determining the minimum and maximum readings, use steps 1–37 of the **PRECISION TENSION BALANCING** procedure.

104. [] Left-side MINIMUM READING: = _____

105. [] Repeat step 102: _____

106. [] Range increase: _____ + 3

107. [] Left-side MAXIMUM READING: = _____

Correcting left-side tension-balance errors

108. [] Bracket pairs of spokes on wheel that need balancing.

109. [] Select pair to balance.

110. [] Cancel out lateral-truing indicator on right side of wheel.

111. [] Set left-side indicator to just barely clear rim at point halfway between spokes being balanced.

112. [] Tighten looser of two spokes being balanced 1/4 turn. Observe clearance at point halfway between spokes disappear.

113. [] Loosen tighter of two spokes being balanced just enough to restore initial clearance set at point halfway between two spokes being balanced.

114. [] Measure new tensions on spokes being balanced and repeat steps 111–113 if necessary.

115. [] Once both spokes have tension in acceptable range check true just outside of balance zone on both sides. Correct true by finding closest spoke *with suitable tension* that will affect lateral in area in need.

116. [] Repeat steps 109–115 for all other pairs bracketed on left side of wheel.

STABILIZING THE TRUE

While the nipples were being tightened, some of the spokes have been turning with them (wind-up). When the bike is ridden, the spokes will all unload temporarily and will unwind to varying degrees. The unloading effects the lateral true. The common signal that this is happening is one or several sounds coming from the wheel when it is first ridden after truing, that then go away.

There are several techniques for stabilizing wheel true. Two are safe but ineffective, one is safe and effective but inefficient, and one is risky but effective and efficient.

One safe and ineffective technique is often seen in books. It consists of slightly over-tightening a nipple and then backing off some. Although this technique works in principle, there is no correct amount of over-tightening and backing off that works every time.

The other safe but ineffective method is to squeeze parallel pairs of spokes on each side of the wheel once the truing is completed. After using this method, spokes still ping on the first test ride and the wheel still goes out of true.

A safe, effective, and inefficient method is to simply test-ride the wheel after truing it. Follow this up with another ride and another re-true if necessary. Then another, if necessary. It could take up to three or four cycles of installing the wheel on the bike, riding, removing the wheel, and re-truing before the true is stabilized. Another version of this is to put some sort of vertical load on the wheel at the axle or at the top of the rim. Experimentation with this shows that it is only partially effective. The wheel will still ping and go out of true some once ridden.

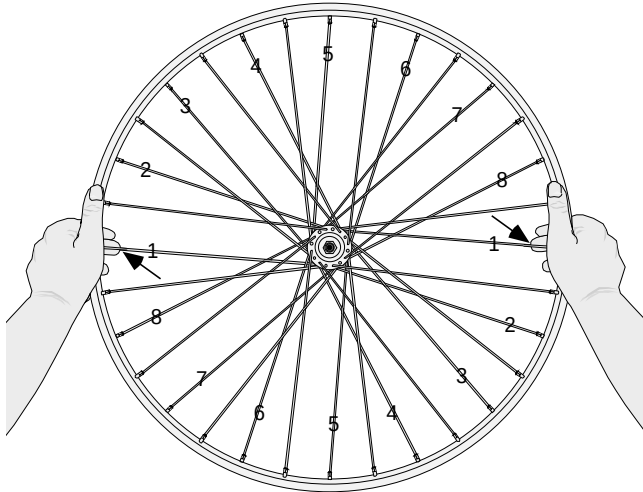
The risky but effective technique is to side-load the wheel. The wheel is supported at the axle and pressed down simultaneously at two points 180° apart at the rim. This is done repeatedly on both sides of the wheel until all the spokes have been momentarily relieved of tension. What makes this effective is that the wheel has very little lateral strength so it is easy to deflect the rim enough to successfully unload a spoke. It is this very thing that makes this technique risky. The lateral weakness of the wheel, combined with careless technique, can result in a collapsed wheel.

To safely side-load a wheel the tension must not be too high. This technique should never be used when a tension meter has not been used to confirm the average right-side tension is below 120kgf. Additionally, it is important to use several forms of feedback to be able to tell when just enough load has been applied. The feedback might be a noise from a spoke, a twitching sensation felt in a spoke, or any sensation that the rim is deflecting. *Whichever form of feedback occurs first, indicates that the wheel has been adequately loaded at that point!*

The correct technique to side-load the wheel is to place it on a solid surface that is low enough to be able to lean over it. Protect the surface from the axle by using a small block of wood. Place a hand at the 3 o'clock position on the rim and a hand at the 9 o'clock

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position on the rim. At both positions the hand should be centered over a spoke that comes from the lower flange and a finger should rap around the outside of the rim and touch the lower-flange spoke. This finger is critical because it is used to feel for any twitch in the spoke that indicates the side-load level is enough. With elbows locked, shove gently down on the rim and be sensitive to the ping sound, a spoke twitch, or the feeling of the rim deflecting. If nothing is felt, shove a little harder. If the rim seems to suddenly give way, break loose the locked elbows *immediately*.



17.22 To stress the wheel, center the balls of your thumbs over two spokes from the bottom flange that are 180° apart. Reach from below to place a finger against each spoke. Press firmly until you hear or feel a spoke unwind. Repeat for sets 2–8, then repeat on other side of wheel.

- 117. []** Place wheel right-side down on low surface.
- 118. []** Position hands 180° apart on rim with hands centered over spokes coming from low flange and fingers touching same spokes.
- 119. []** With locked elbows gently shove against rim until ping, spoke twitch, or rim flex is experienced. Increase effort if none are experienced.
- 120. []** Move hands to adjacent spokes from lower flange and repeat step 119. Repeat until all spokes from lower flange have been unloaded.
- 121. []** Turn wheel over and repeat steps 118–120 for second side.
- 122. []** Place wheel in truing stand and check if lateral-true error exceeds maximum allowed.

Side-loading eliminates spoke wind-up. Spoke wind-up was created by tightening nipples. If nipple tightening is used to eliminate lateral errors that appear after side-loading, then the wind-up will be reintroduced. Therefore, when correcting these lateral errors, the best technique is to loosen a spoke that is on the same side of the wheel as the lateral-true indicator that is contact-

ing the rim. For example: if the contact is on the right side of the rim, loosen the right-side spoke that is closest to the center of the contact. Loosening will not create as much wind-up as tightening.

- 123. []** Correct lateral-true errors if necessary by loosening spoke(s) at point of contact coming from same side of hub as side that is contacting.

- 124. []** Repeat steps 117–123 repeatedly until wheel remains within desired lateral tolerance. (When spokes are adjusted on one side only, side-loading need only be done with that side down.)

Post-truing completion

- 125. []** Re-adjust hub as necessary. (Remember, a properly adjusted quick-release, conventional-bearing hub has play when out of bike that had to be eliminated to true wheel.)
- 126. []** Reinstall tire, quick release skewer, and wheel in bike.
- 127. []** Clean rim of any oily residues left over from truing process.

PRECISION TENSION BALANCING

Precision balancing is a more precise way to determine the acceptable tension reading range for a given side of a wheel. This procedure is an alternative to steps #85–89 or #103–107 of the **TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES, AND NIPPLE** procedure. This procedure is preferred if limitations of the wheel require that the average tension be outside the recommended 80-100kgf range, or if more precision is desired. For most wheels, the *reading-balancing* method is adequate. The *precision tension-balancing* method requires more time and more math.

The *precision tension-balancing* process consists of four basic steps. Each step is a mathematical calculation. The first step is to convert the average reading from the wheel into an exact tension average. Because the tension-meter chart has relatively large jumps between values in the reading column, when the average reading falls between two readings that appear on the chart, a mathematical process called “interpolation” is needed to determine the tension value that is equivalent to the average reading. The second step is to determine an acceptable tension range for the wheel. This is accomplished by adding 10 to the average tension to determine that maximum tension, and by subtracting 10 from the average tension to determine the minimum tension. The last two steps of the process use the process of interpolation to convert the maximum and minimum acceptable tensions to minimum and maximum

acceptable reading values. Once the process of calculating the minimum and maximum acceptable reading values is completed, then the wheel can be reviewed for spokes that fall outside the acceptable range.

The maximum reading value (X), determined in the following process, can be used in steps #89 or #107, and the minimum reading value (y), determined in the following process, can be used in steps #86 or #104 of the **TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES, AND NIPPLES** worksheet. Step #1 gets its value from step #84 or #102 of the **TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES, AND NIPPLES** worksheet.

Determining exact tension from average reading

By means of mathematical interpolation, steps #1 through #11 convert the average reading from the tension meter into a precise average tension (K).

1. [] Average of readings from one side (from step 84 or 102): _____ A
2. [] Closest reading value <A from tension-meter chart reading line: _____ B
3. [] Closest reading value >A from tension-meter chart reading line: _____ C
4. [] Kgf value equal to B from tension-meter chart kgf line: _____ D
5. [] Kgf value equal to C from tension-meter chart kgf line: _____ E
6. [] $A - B = F$ _____ - _____ = _____ F
7. [] $E - D = G$ _____ - _____ = _____ G
8. [] $F \times G = H$ _____ $\times$ _____ = _____ H
9. [] $C - B = I$ _____ - _____ = _____ I
10. [] $H \div I = J$ _____ $\div$ _____ = _____ J
11. [] $D + J = K$ _____ + _____ = _____ K

Steps #6 through #11 can be expressed algebraically, which is easier for someone familiar with algebra. The formula is:

$$\frac{(A-B) \times (E-D)}{(C-B)} + D = K$$

Determining the acceptable tension range for tension balancing

Now that the precise average spoke tension has been determined, a simple process is used to determine the acceptable tension range.

12. [] Maximum tension in kgf (M)
 $K + 10 = M$ _____ + _____ = _____ M
13. [] Minimum tension in kgf (L)
 $K - 10 = L$ _____ - _____ = _____ L

Determining a tension reading equal to M

Steps #14 through #24 convert the maximum acceptable tension (M) from step #12 into an equivalent tension-meter reading (X) for the tension meter in use.

14. [] Maximum tension for this side: _____ M
15. [] Closest kgf value <M from tension-meter chart kgf line: _____ N
16. [] Closest kgf value >M from tension-meter chart kgf line: _____ P
17. [] Reading value equal to N from tension-meter chart reading line: _____ Q
18. [] Reading value equal to P from tension-meter chart reading line: _____ R
19. [] $M - N = S$ _____ - _____ = _____ S
20. [] $R - Q = T$ _____ - _____ = _____ T
21. [] $S \times T = U$ _____ $\times$ _____ = _____ U
22. [] $P - N = V$ _____ - _____ = _____ V
23. [] $U \div V = W$ _____ $\div$ _____ = _____ W
24. [] $W + Q = X$ _____ + _____ = _____ X

Steps #19 through #24 can be expressed algebraically, which is easier for someone familiar with algebra. The formula is:

$$\frac{(M-N) \times (R-Q)}{(P-N)} + Q = X$$

In the next step, the exact value of X needs to be rounded to a number that can actually be read from the tension meter. The finest increments recommended earlier for reading a WheelSmith Tensiometer are 0, 2.5, 5, and 7.5. Here are some examples.

Round anything from 58.8–61.2 to 60.0

Round anything from 61.3–63.7 to 62.5

Round anything from 63.8–66.2 to 65.0

Round anything from 66.3–68.7 to 67.5

The value determined in step #25 is used in the **TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES, AND NIPPLE** worksheet. Transfer the value to step #89 of the wheel truing worksheet (if tension-balancing the right side of wheel), or to step #107 (if tension-balancing the left side of wheel).

25. [] Round X to nearest reading ending in 0, 2.5, 5, or 7.5 and record here:
MAXIMUM READING is: _____

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Determining a tension reading equal to L

Steps #26 through #36 convert the minimum acceptable tension (L) from step #13 into an equivalent tension-meter reading (y) for the tension meter in use.

26. [] Minimum tension for this side: _____ L
27. [] Closest kgf value <L from tension-meter chart *kgf line*: _____ n
28. [] Closest kgf value >L from tension-meter chart *kgf line*: _____ p
29. [] Reading value equal to n from tension-meter chart *reading line*: _____ q
30. [] Reading value equal to p from tension-meter chart *reading line*: _____ r
31. [] $L - n = s$ _____ - _____ = _____ s
32. [] $r - q = t$ _____ - _____ = _____ t
33. [] $s \times t = u$ _____ $\times$ _____ = _____ u
34. [] $p - n = v$ _____ - _____ = _____ v
35. [] $u \div v = w$ _____ $\div$ _____ = _____ w
36. [] $w + q = y$ _____ + _____ = _____ y

Steps #31 through #36 can be expressed algebraically, which is easier for someone familiar with algebra. the formula is:

$$\frac{(L-n) \times (r-q)}{(p-n)} + q = y$$

In the next step, the exact value of y needs to be rounded to a number that can actually be read from the tension meter. The finest increments recommended earlier for reading a Wheelsmith Tensiometer are 0, 2.5, 5, and 7.5. Here are some examples.

Round anything from 68.8–71.2 to 70.0

Round anything from 71.3–73.7 to 72.5

Round anything from 73.8–76.2 to 75.0

Round anything from 76.3–78.7 to 77.5

The value determined in step #37 is used in the **TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES, AND NIPPLE** worksheet. Transfer the value to step #86 of the wheel truing worksheet (if tension-balancing the right side of wheel), or to step #104 (if tension-balancing the left side of wheel).

37. [] Round y to nearest reading ending in 0, 2.5, 5, or 7.5 and record here:
MINIMUM READING is: _____

TRUING WHEELS WITH BROKEN SPOKES OR DAMAGED NIPPLES

Most of repairing a wheel with a damaged nipple or broken spoke is the same as truing an undamaged wheel. The main differences are it is necessary to de-

termine the spoke length for a replacement spoke, and it is necessary to determine the spoke gauge for a replacement nipple. There can also be a little bit of a problem removing the damaged nipple.

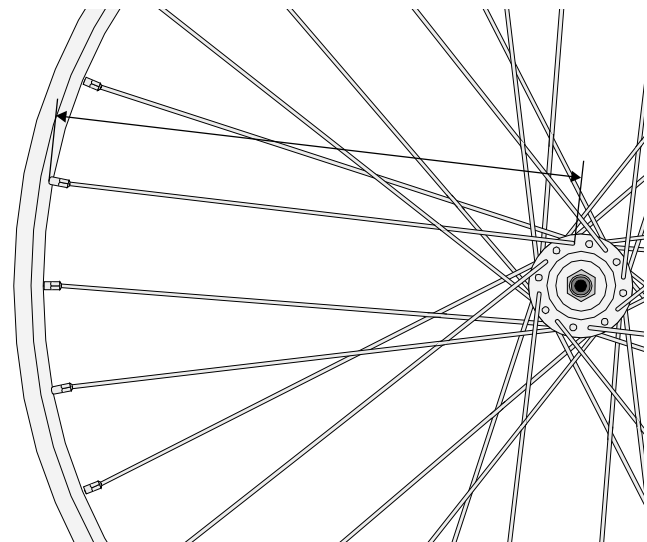
Preparations and inspections

1. [] Do steps 1–7 from **TRUING WHEELS WITH UN-DAMAGED RIMS, SPOKES OR NIPPLES** procedure.
2. [] Remove rim strip from rim.
3. [] Rear wheels only, remove freehub cogs, or freewheel.

Determining correct spoke length if replacing spoke

The spoke length can be calculated using various spoke-length programs or tables; when replacing a spoke, the simplest way to determine the correct length is to measure an existing spoke in the wheel. It will not be a precise measurement, but it will be adequate. Measure with a metric tape measure.

The proper way to measure a spoke that is installed in the wheel is to measure from the base of the nipple (where the nipple comes out of the rim) to edge of the spoke hole in the hub flange (the edge that is closest to the center of the wheel). This is easiest to do by measuring a spoke that has its head on the inside of the hub flange, otherwise the spoke head covers the hole. On rear wheels, left and right spokes can be different lengths, so measure on the side of the wheel that needs the spoke replaced.



17.23 Measuring a spoke in the wheel.

4. [] Measure length of an installed spoke on same side of wheel as replacing spoke. Measure from inside face of rim to far edge of spoke hole in flange and write number here: _____ mm.

Determining the correct spoke gauge if replacing a nipple or spoke

In step #7, from the **TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES, AND NIPPLES** procedure, the spoke gauge at the midpoint was measured so that the information could be used later to determine spoke tension. If the spoke is butted or aerodynamic, this measurement will not determine the right gauge for the nipple or spoke. It is best to double check, anyway. Use the midpoint measurement and the following end measurement to get a replacement spoke of the correct gauge as well.

- 5. Use calipers or spoke ruler to measure diameter of spoke just before it enters nipple. Compare measurement to following and check off one to indicate spoke gauge:**
- ☐ 2.6mm- 12 gauge
 - ☐ 2.3mm- 13 gauge
 - ☐ 2.0mm- 14 gauge
 - ☐ 1.8mm- 15 gauge

Removing and replacing a broken spoke

The easiest way to remove a broken spoke is to cut it an inch from the hub flange and then work the remainder out. Note which side of the flange the spoke head is on, then install the new spoke so that the spoke head ends up on the same side of the flange.

Look at the hub flange and see that the spokes alternate having their heads to the inside and to the outside of the flange.

If the new spoke is going to be a “head-out” spoke, after starting the new spoke through the hole in the correct direction, it may be necessary to flex it away from the hub when it gets to the other flange so that it will come out the opposite side of the wheel just beyond the crotch of two spokes in the opposite flange. If the spoke bows while doing this, it is not a problem.

A “head-in” spoke can just be laid out flat once it is pushed all the way into the flange.

Spokes will need to be bowed slightly to weave them past the other spokes and into their final position. Note that each spoke crosses several others in its path from the hub to the rim. Typically “head-in” spokes cross under the last spoke on the way to the rim, and “head-out” spokes cross over the last spoke on the way to the rim. Just follow the pattern of the other spokes.

- 6. ☐ Remove broken spoke(s).**
7. ☐ Put new spoke(s) in and thread on nipple(s) without tightening.

Removing and replacing a damaged nipple

Nipples are damaged from being over-tightened or from a misfit wrench being used. Sometimes they round off while being tightened and can still be turned the opposite way to loosen them. Sometimes they must be grasped with pliers or vise-grip pliers to break them loose. Try using a Park SW-10 nipple wrench instead. If the SW-10 slips, use a file to increase the flats on the nipple. Once the spoke is getting slack, it's all right to cut the spoke. Often the threads of the spoke are also damaged, and the spoke must be replaced.

- 8. ☐ Remove damaged nipple(s).**

- 9. ☐ Thread on new nipple(s) without tightening.**

Determining starting tension for the replaced spoke or spoke with replaced nipple

When a nipple is removed or a spoke is broken, the wheel can go wildly out of true, and it can look like a lot more than one spoke will be involved in making the correction. If the wheel was reasonably true to start with before the spoke broke or damaged nipple was removed, then all it will take to get it back to the same degree of true is to adjust the new spoke/nipple. The key to doing this is to determine the tension average on the side of the wheel with the new spoke or nipple, then tighten the new nipple/spoke to that tension. In the following steps, measure the tension of ten spokes on the side with the new spoke or nipple (excluding the new spoke or spoke with new nipple) and average the readings. Then tighten the new spoke or spoke with new nipple to the average reading. There is no need to use the tension-meter chart to convert readings to kilograms.

- 10. ☐ Measure tension on ten consecutive spokes on side with new spoke/nipple and record readings in following blanks.**

_____ + _____ + _____ + _____ + _____

_____ + _____ + _____ + _____ + _____ = _____

- 11. ☐ Divide step 10 total by 10** _____ **÷ 10**
Average reading is: _____

- 12. ☐ Tighten new spoke/nipple to average reading calculated in step 11.**

- 13. ☐ Replace freewheel/freehub cogs.**

- 14. ☐ Do steps 8-127 from **TRUING WHEELS WITH UN-DAMAGED RIMS, SPOKES AND NIPPLES** procedure (page 17-10).**

TRUING WHEELS WITH DAMAGED RIMS

The fundamental problems with repairing wheels with bends is that when metal bends it elongates. Bending it back will not shrink it again. Bending it back just elongates it more. What this implies is that once a rim is bent, it can never be fully straightened. One big dent can be changed into a series of small, less obvious dips and bumps, but in cannot be eliminated. The more severe the bend is, the less likelihood of a successful outcome. The more over-correcting and re-correcting is done, the less likely the repair will ever make it to a successful point.

Rim bends can be broken down into three categories. These are dings in the outer perimeter of the rim, radial bends in the body of the rim, and lateral bends. Dings in the outer perimeter of the rim can be identified by two characteristics. There is a lack of any apparent radial error in the inner perimeter of the rim and there is no evidence of loose spokes at the point of the radial error. Radial bends in the body of the rim can be identified by the fact the fact that the very spokes that should be loosened to let out the dip are already looser than all the other spokes in the wheel. Lateral bends in the rim are identified by the fact that the very spokes that should be tightened to correct the rub are already tighter than any other spokes on their side of the wheel, or the very spokes that should be loosened to correct the rub are already looser than any other spokes on the same side of the wheel.

FIXING DINGS IN THE OUTER PERIMETER OF THE RIM

Dings limited to the outer perimeter of the rim are only a problem if they cause the rim sidewall to bulge out at the point of the ding, and this is unusual with aluminum rims. In any case, a tool is made to fix these, and they are relatively easy to fix as long as the dings are not severe.

1. [] Do steps 1–21 from **TRUING WHEELS WITH UN-DAMAGED RIMS, SPOKES, AND NIPPLES** worksheet.

The Bicycle Research RS1 Rim Saver is used to squeeze in rim-sidewall bulges. This tool is a pair of pliers with a wide jaw and a narrow jaw. The narrow jaw is placed against the sidewall bulge and the wide jaw is placed against the other side of the rim. Be careful to squeeze the handles gently. Because no tool is made to spread the rim back out, it is better to under correct and need to repeat the attempt then to over

correct and make the rim too narrow. To check whether the job is done, set a caliper to the rim width on an undamaged section of rim and try to slide the caliper past the damaged point. If it hangs up, continue to squeeze the rim narrower.

2. [] Use Bicycle Research RS1 to squeeze in any sidewall bulges detected during step 13 or step 16 of **TRUING WHEELS WITH UN-DAMAGED RIMS, SPOKES, AND NIPPLES** worksheet.
3. [] Do steps 21–127 from **TRUING WHEELS WITH UN-DAMAGED RIMS, SPOKES, AND NIPPLES** worksheet.

FIXING RADIAL BENDS IN THE BODY OF THE RIM

Radial bends in the body of the rim are detected during normal truing when the point is reached of correcting dips while truing radial. When correcting a dip (which is done by loosening spokes in the vicinity of the dip) it is found that the spokes are already looser than any others in the wheel, a radial bend has been found.

To fix the problem loosen the loose spokes even further, support the rim on wood blocks, apply impact to the inner perimeter of the rim, and then re-tighten the spokes. The reason that spokes must be loosened first is that the rim needs to be moved past the point where it must end up. Before the rim was damaged, the loose spokes at the point of damage were probably tight. If the repair is attempted without loosening the spokes, there will be resistance from the spokes before the rim is moved far enough.

To set up the wheel for repair, first loosen the spokes in the affected area at least five full turns each. Support the rim just outside the flattened area on two soft blocks of wood, such as firring strips (1×2 boards). The blocks of wood should be in line with the rim, not perpendicular. The repair will be done by striking the center of the bent section of rim with a rubber mallet.

After pushing out the rim, the spokes are tightened until the bump is eliminated. If they are at normal tension once the rim is round, the correction is done. If they are still loose, additional correction is needed. If they end up over-tight, the bend has been over-corrected. There is no good solution to this except to live with the rim having a bump and the spokes at that point being a little over-tight.

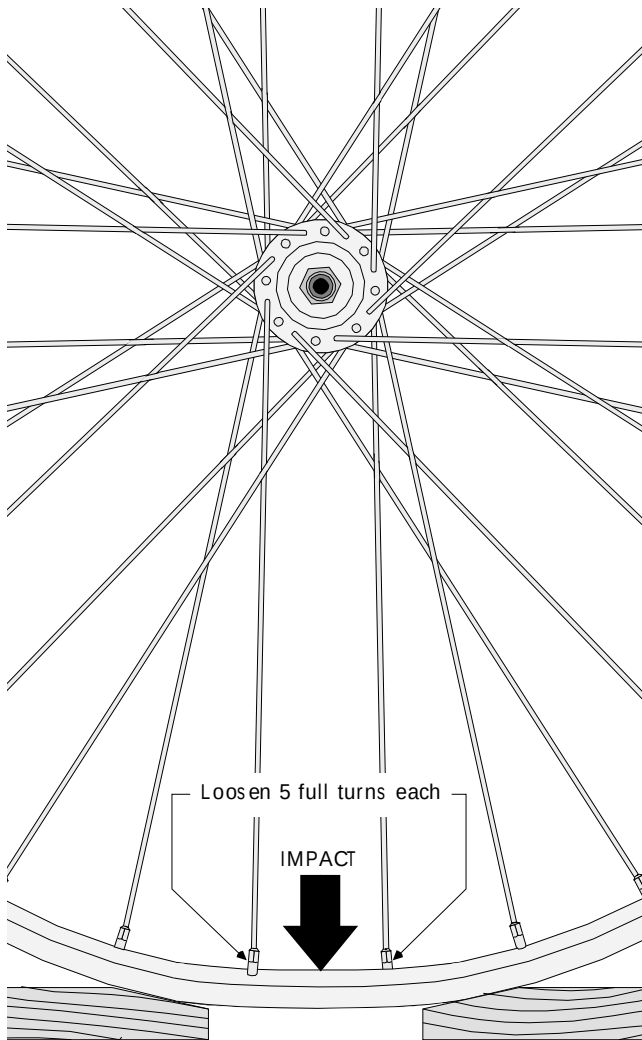
On paper this all sounds better than in actually works. It is difficult to hit the rim with the correct force, and the rim may bend in where it is supported on the blocks. A great deal of patience and skill with a rubber hammer is needed.

FIXING LATERAL BENDS IN THE RIM

A lateral bend is identified when the spokes that need tightening to correct a rub are already over-tight, or a spoke that needs loosening to correct a rub is already very loose.

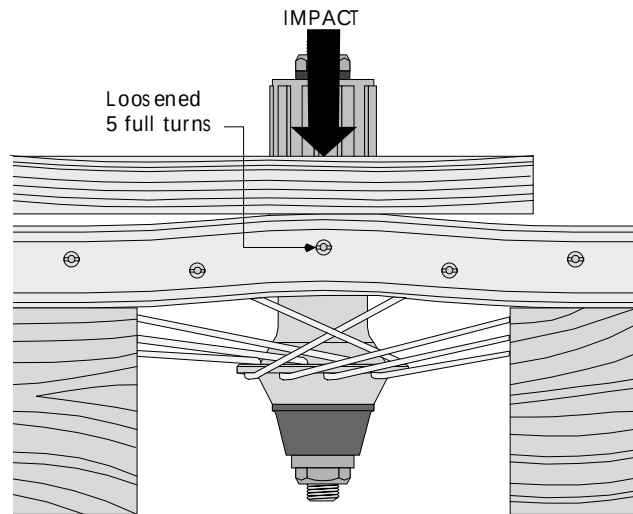
There is no more difficult wheel repair than repairing a rim with a lateral bend. The rim needs to be unbent and the only way to do it is to hit it on something (or with something), or stick the affected area in some sort of crack and apply leverage to the wheel. How much force to use can only be learned by trial and error. If putting the wheel in some crack and apply leverage, finding the right crack and figuring out how much rim to insert are a challenge. If using impact, it is recommended to put the rim on two wood blocks that support the rim just beyond the damaged area, with the side of the wheel that the rim bends to facing up. Next, cut a wood block that is just a little bit shorter than the damaged area and rest it on top of the rim on the damaged section. Strike the block on top of the rim with a hammer.

Like when repairing a radial bend, it is important to loosen the spokes on the side of the wheel where the damage is so that the rim can be pushed easily past the point that it should end up.



17.24 Fixing a radial bend.

1. [] Do steps 1–36 from **TRUING WHEELS WITH UN-DAMAGED RIMS, SPOKES AND NIPPLES** procedure.
2. If at any time in step 33, spokes needing loosening seem too loose to start with, rim is bent.
 - [] Loosen all spokes in affected area until nipples are almost off (at least 5 full turns).
 - [] Place rim on wood blocks in line with rim, with blocks just past end of dip.
 - [] Strike inner perimeter of rim near center of dip with rubber mallet.
 - [] Put wheel in truing stand.
 - [] Tighten spokes in affected area until bump is eliminated.
 - [] Measure tension on spokes in affected area and compare to other spokes just outside affected area.
 - [] If tensions are low, loosen spokes again and repeat procedure.
 - [] If tensions are normal or high, continue from step 35 on **TRUING WHEELS WITH UN-DAMAGED RIMS, SPOKES AND NIPPLES** procedure.



17.25 Fixing a lateral bend.

1. [] Do steps 1–17 from **TRUING WHEELS WITH UN-DAMAGED RIMS, SPOKES AND NIPPLES** procedure.
2. [] When a lateral bend is detected while doing step 17, mark all spokes that are loose. (If none are obviously loose but on other side of wheel there are obviously tight spokes, mark all spokes on contact side of wheel from tight spokes that are within zone of tight spokes.)

17 – WHEEL TRUING AND REPAIR

3. [] Loosen nipples on all marked spokes exactly five *full* turns.
4. [] Remove rim from truing stand.
5. [] Use 3 foot-long two-by-fours to support the rim in following fashion. With the side of the wheel with loosened spokes facing up, put one two-by-four on its edge under rim 180° away from loosened spokes. Put other two-by-fours on their edges so that they are just either side of range of loosened spokes and so that each two-by-four's full length supports rim.
6. [] Cut a short section of firing strip (one-by-two board) to be slightly shorter than affected area and place it on top of affected area.
7. [] Strike firing strip with hammer.
8. [] Put wheel in truing stand and check whether rub in affected area has switched to opposite side of wheel. (If not, repeat steps 4–8.)
9. [] Tighten spokes that were loosened exactly five *full* turns and check how spoke tension in affected area compares to adjacent spokes. If spokes that were loose are still loose, repeat steps 3–9.
10. [] Continue at step 19 from *TRUING WHEELS WITH UNDAMAGED RIMS, SPOKES AND NIPPLES* procedure.

WHEEL TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>A wheel fails to stay true for a reasonable time after truing, but there is no evidence of a damaged rim.</i>	
Wheel was not stabilized.	Stabilize the true. (See page 17-24, step 117.)
Spoke tensions were too low.	Re-true wheel and set tension average closer to the maximum.
SYMPTOM: <i>Spokes lose tension rapidly.</i>	
Spokes were not tightened well.	Re-tighten spokes closer to maximum tension.
SYMPTOM: <i>Wheel will not hold tension even when it was tensioned high to begin with.</i>	
Rim and/or spoke choice is too light.	Rebuild with heavier components, or rebuild with Wheelsmith Spoke Prep or DT Spoke Freeze.
SYMPTOM: <i>Spokes are breaking at the bend or at the nipple.</i>	
Spokes are fatigued from age.	Rebuild or replace wheel.
Spokes are too light gauge (particularly if wheel is new and rider or usage can be described as heavy).	Rebuild wheel with heavier spokes.
Tensions are too low.	Rebuild wheel. (Low tension causes premature fatigue of all spokes.)
SYMPTOM: <i>Spokes are breaking in the middle.</i>	
Impact to spoke(s).	Replace broken spokes.
Low tension if at interlace.	Replace spoke, tighten spokes.
SYMPTOM: <i>Butted spokes are breaking at the transition of one gauge to the other.</i>	
Low-quality spokes.	Rebuild or replace wheel.
SYMPTOM: <i>More than one spoke is broken at the flange or at the nipples, or a variety of nipple and/or spoke types in the wheel indicate that spokes have broken in the past in addition to a single broken spoke that is being dealt with now.</i>	
Spokes are generally fatigued.	Rebuild or replace wheel.
SYMPTOM: <i>A spoke breaks when accelerating hard, hitting a bump or while truing the wheel.</i>	
Spokes are generally fatigued.	Rebuild or replace wheel.
SYMPTOM: <i>Dimples or bulges are found in the sidewall of the rim.</i>	
Tire compresses fully when the wheel hits bumps.	Maintain full tire pressure and/or use a larger cross-section tire.
SYMPTOM: <i>Cracks are appearing in the rim sidewall, the rim sidewall is concave when it used to be flat or convex, the rim beads are wider apart than they were originally.</i>	
Rim sidewall is being worn thin by brake pads.	Replace rim immediately.

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Cracks are appearing at the nipple holes in the rim.</i>	
Spoke tension too high.	Replace rim immediately.
SYMPTOM: <i>While truing a lateral deviation, the spoke that needs tightening is too tight, or the spoke that needs loosening is too loose.</i>	
Rim has a lateral bend.	Bend rim back or replace rim.
SYMPTOM: <i>Rim has a lateral bend.</i>	
Excessive side loads have been applied to the rim through accident or abuse.	Avoid excessive side loads and/or use a stronger rim.
SYMPTOM: <i>While eliminating a radial dip (flat spot), the spokes that need to be loosened are too loose already.</i>	
Rim has a radial bend.	Bend rim back or replace rim.
SYMPTOM: <i>Rim has a radial bend (flat spot).</i>	
Impact to wheel.	Maintain correct tire pressure and avoid road hazards, or use larger cross-section of tire.
Rim is too light (particularly when bend occurs repeatedly and tire pressure has been maintained).	Use a heavier rim.
Spoke gauge is too heavy for a lightweight rim.	Use light spokes with light rims.
SYMPTOM: <i>Complete wheel collapse (hyperbolic parabola).</i>	
Over-tight spokes.	Repair if possible, avoid over-tightening spokes.
Excess lateral loads on wheel.	Repair if possible, avoid loading wheel from side if possible.
SYMPTOM: <i>Stripped nipple wrench flats.</i>	
Over-tight spokes.	Avoid over-tightening.
Failure to lubricate nipple threads and heads.	Lubricate before truing.
Use of oversize nipple wrench.	Use correct size.
Attempted repair of damaged rim by spoke adjustment only.	Re-bend, then re-true if possible.
SYMPTOM: <i>Nipples frozen by corrosion.</i>	
Failure to lubricate or treat threads.	Lubricate or treat threads at time of building, at all times when re-truing and once a month in climates where rust is a problem. Use stainless steel spokes whenever possible.
SYMPTOM: <i>Bulges in the sidewall of the rim at each spoke, or cracks or bulging at each spoke hole in the rim.</i>	
Spoke tension too high for rim strength.	Use less tension, but replace rim if cracked.
Inadequate support of the nipple at the rim.	Use nipple washers in non-eyeleted lightweight rims.
SYMPTOM: <i>Wheel will not install centered in frame or fork or bicycle pulls to one side when ridden.</i>	
Dish is incorrect.	Check and correct dish.
If dish is correct, frame or fork may be off-center.	Check and correct frame or fork alignment.
If dish is correct and frame or fork is aligned, dropouts may be unequal height.	File dropout slots to equalize height.
SYMPTOM: <i>A pinging or popping sound is heard continuously from the wheel (particularly rear) while riding.</i>	
Spoke tension is too low and slack spokes are rubbing on each other or on the spoke guard.	Tighten spokes.
SYMPTOM: <i>When the wheel is first ridden, popping and pinging sounds are emitted from the wheel, particularly when accelerating.</i>	
True was not stabilized, and spokes are unwinding when relieved of tension.	Stabilize the true. (See page 17-24, step 117.)

18 – WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

ABOUT THIS CHAPTER

This chapter is about removing and re-installing wheels, as well as installing a replacement wheel or rebuilt wheel.

GENERAL INFORMATION

TERMINOLOGY

Rim: The metal hoop at the outer perimeter of the wheel that the tire attaches to.

Wheel: The assembly of the hub, spokes, and rim. The word “rim” is sometimes misused to mean “wheel.” When the tire is mounted to the rim, the word “wheel” can be used to refer to the hub, spokes, rim and tire.

Quick-release mechanism: When used in regard to a wheel, this term refers to a mechanism that attaches the wheel to the bicycle. It includes a quick-release lever, a skewer, and a quick-release adjusting nut. The quick-release mechanism is often called just the “quick-release.”

Quick-release wheel: A wheel that is secured to the bike by the means of a quick-release mechanism.

Quick-release lever: The approximate two-inch lever that pivots 180° to apply the clamping force that holds the wheel to the bicycle. It may also be called a “cam lever,” because the pivot of the lever is a cam that converts rotational motion to linear motion.

Skewer: The shaft of the quick-release lever that goes through the hollow axle in the hub. It connects the cam mechanism at one end to the tension-adjusting nut at the other end. The word “skewer” is sometimes used to refer to the entire quick-release mechanism.

Quick-release adjusting nut: On the opposite end of the quick-release mechanism from the quick-release lever is the quick-release adjusting nut. When the mechanism is loose, this nut is tightened or loosened to determine how tightly the quick-release mechanism will clamp.

Axle nut: A large hex nut that threads onto the axle that is *outside* the dropout that the wheel attaches to. The axle nut should not be confused with the *locknut*.

The locknut is a nut that threads onto all threaded axles and locks the position of the cone on the axle. When looking at a mounted wheel, any nut inside the frame is a locknut, and any nut outside the frame is an axle nut.

Solid-axle wheel: A wheel that is secured to the bike by the means of axle nuts.

Dropout: The portion of the frame or fork that the wheel attaches to. It may also be called a *fork end* or *fork tip* (these terms apply to both front and rear dropouts).

Fork blades: The two tubes that join the frame to the front hub.

Seat stays: The two frame tubes that go from the rear dropouts to the frame joint just under the seat.

Chain stays: The two frame tubes that go from the rear dropouts to the frame joint that is between the pedals (usually at the bottom-bracket shell).

PREREQUISITES

Tire removal and installation

Before replacing a wheel, the tire should be removed. See the **TIRES AND TUBES** chapter (page 19-3) if unsure about tire removal and installation.

Freewheel removal and installation

To replace a wheel, it is necessary to remove the freewheel or freehub cogs. See the **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** chapter for freewheel removal (page 25-9) and freehub-cog removal (page 25-16).

Hub re-spacing and adjustment

To improve the fit of an original or replacement hub, it may be necessary to add or subtract spacers from the axle set or change the amount that the axle protrudes past the outer locknut. These operations may require hub overhaul, and definitely require hub adjustment. See the **ADJUSTABLE-CONE HUBS** chapter (page 12-7) for hub overhaul and adjustment.

Wheel dishing

After spacing an axle set to improve fit of the wheel to the frame or fork, or fit of the freewheel to the wheel, chances are it will be necessary to re-dish the wheel (center the rim to the hub). See page 17-15.

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Rear-derailleur adjustment

If installing a replacement rear wheel that does not exactly match the way the original hub positioned the rear cogs (or if in re-spacing the original hub the positioning of the rear cogs is changed), it will be necessary to re-adjust the rear derailleur. See the **REAR DERAILLEURS** chapter (page 32-1).

Brake adjustment

If re-installing an original wheel that was not correctly installed before removal, or if installing an original wheel that has been re-dished, or if installing a replacement wheel that has more correct rim dish than the original wheel, it will be necessary to center the brake pads to the rim. If installing a wheel with a different rim diameter or width, it will be necessary to adjust pad alignment and brake-cable length. See the **CABLE-OPERATED RIM-BRAKE CALIPERS** chapter (page 36-1) for brake adjustments.

INDICATIONS

Wheel removal and re-installation

Wheels need to be removed and re-installed for a variety of reasons, including flat-tire repair, tire replacement, wheel truing, wheel rebuilding, hub adjustment and overhaul, freewheel/freehub-cog servicing, and headset adjustment and overhaul.

Wheel replacement

Either during the course of repair, or even before attempting repair, symptoms might be experienced indicating that it would be better to replace the wheel than repair it. These are

- Multiple broken spokes, either all at once or one at a time over the last few hundred miles of use
- Multiple corroded nipples that won't turn
- Multiple damaged nipples (rounded-off wrench flats)
- Dents or bends in the rim that cannot be adequately straightened by normal spoke adjustment and unbending techniques
- Cracks in the rim
- Severe rim-sidewall wear, evidenced by a concave rim sidewall, or by rim beads that have become wider than they were originally

All these problems aside, you may also elect to replace the wheels in order to upgrade the bicycle's performance.

TOOL CHOICES

There are no special tools required to remove and install a wheel.

TIME AND DIFFICULTY

Wheel removal and re-installation is a 1–2 minute job of little difficulty. Fitting a new replacement wheel, which can include hub overhaul, wheel dishing, and brake adjustments is a 30–45 minute job of moderate difficulty. If brake adjustments or rear-derailleur adjustments are required after installing the wheel, these will add to the time of the job. See the appropriate chapters on these subjects to get an idea of what time might be involved in these operations.

COMPLICATIONS

Unsafe wheel installation

It is not unusual to find a wheel on a bike that has been unsafely installed, due to loose axle nuts or missing washers on nut-type hubs, or loose or mis-used quick-release skewers on quick-release hubs. It is the mechanic's responsibility to make sure that the customer gets informed about the problem and the correct way to install the wheel.

Wheel-mounting failure

There are five traditional methods used to determine whether a quick-release mechanism is adequately secure, and all are flawed. One traditional method is to base whether the quick-release lever is adequately secure is to adjust the mechanism so that the lever leaves an imprint on the palm of the hand from the effort of closing the lever. This is the "palm-imprint" method; any method that focuses on the closure effort is a variation of the "palm-imprint" method. Simply stated, there are too many variables that affect whether a properly adjusted quick-release mechanism would leave an imprint on the palm. The quality of fabrication, the presence of rust or dirt, the types of materials used, the type of surface on the lever, and the toughness of the mechanic's palm are just a few of the factors that could affect the outcome of the "palm-imprint" method. More importantly, the palm-imprint method leads the mechanic to focus on the wrong things; the right things to focus on are the point in the lever's motion where clamping begins, and the position at which the lever stops.

Another traditional method of determining whether a quick-release mechanism is adequately secured is the "dropout-imprint" method. With this

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method, it is said that the quick-release mechanism is adequately secured when it leaves an imprint in the face of the dropout. The size of the clamping surface, the texture of the clamping surface, and the type of dropout material all affect what it will take to cause the quick-release mechanism to leave an imprint in a dropout. Furthermore, once the dropout has been imprinted numerous times from previous closings of the quick-release mechanism, there is no way to tell whether the quick-release mechanism at its current setting is creating a new imprint. Most importantly, this method leads the mechanic to focus on the wrong things; the right things to focus on are the point in the lever's motion where clamping begins, and the position that the lever stops at.

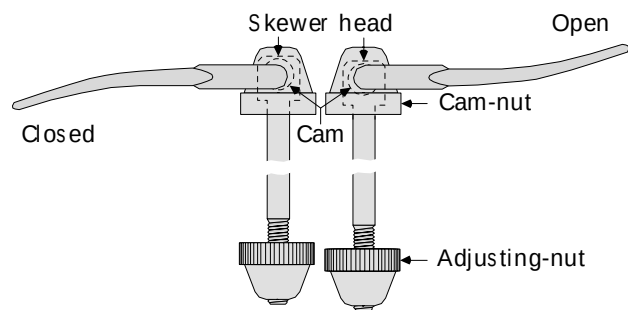
The third flawed method is the “release-force” method. In this method, the mechanic adjusts and closes the quick-release mechanism, then opens it again to subjectively evaluate the effort required to open, or release, the mechanism. This method has all the same limitations of the palm-imprint method.

The fourth flawed method involves striking the wheel to determine if it is secure. With this method, the mechanic simply strikes the tire with a fist to see if the wheel comes out. The CPSC (Consumer Product Safety Commission) requires that wheels resist a force of hundreds of pounds without coming out. A meaningful striking force applied with a fist would either break the mechanic's fist or put a flat spot in the rim.

The last traditional method (also flawed) involves setting the lever to a specific position, tightening the adjusting nut, then closing the lever. This method could be called the “nut-setting” method. In this method, the mechanic starts by setting the base of the quick-release lever to be parallel to the skewer, and then turns the adjusting nut until it is snug. After snugging the adjusting nut, the lever is closed. The problem with this method is that there are a number of factors that influence the point at which the adjusting-nut feels snug. If the dropouts are wider than the hub width, and the frame is reasonably stiff, then the adjusting-nut will get difficult to turn when it begins to compress the dropout width down to the width of the hub. In this case, closing the quick-release lever will do little more than reduce the dropout width further, closing the gaps between the inside faces of the dropouts and the faces of the hub locknuts. When this condition exists, it is not unusual to have to turn the quick-release lever like a big wing-nut, in order to tighten the adjusting nut enough; it is quite possible that several revolutions of the lever-end of the quick-release mechanism will be

needed, after the adjusting nut has been turned as far as is possible with fingers. The shape of the adjusting nut (how easy it is to grasp), and whether the adjusting nut face is smooth or textured, also influence the point at which the adjusting-nut feels “snug.”

The method recommended in the following procedure is based on starting position and ending position of the quick-release lever. To understand why this method is best, it is necessary to understand how a quick-release mechanism works (see figure 18.1). The axle (pivot) of the quick-release lever is a cam. A cam is a cylinder that rotates around a point that is not at the center of the cylinder, for the purpose of converting rotational motion into linear motion. On a quick release, as the cam rotates, the skewer-head (which encircles the cam) is moved away from the dropout (linear motion). The cam turns inside the skewer-head, which is often hidden inside the housing that the quick-release lever pivots in (the cam housing). Rotating the quick-release lever rotates the cam, which changes the position of the skewer-head in the cam housing (cam-nut). The number of degrees of rotation determines the amount that the skewer head is pulled into the cam nut; when this happens, the distance between the cam-nut and the adjusting-nut decreases, which causes the two nuts to apply pressure to the dropouts. Since virtually all skewers are steel rods of a relatively constant diameter (all types of steel rods are equally elastic if dimensions are constant), the only factor that determines clamping force is the amount that the skewer-head moves after the clamping force begins. Virtually all traditionally-designed quick-release mechanisms have the same amount of movement differential over a 90° rotation.

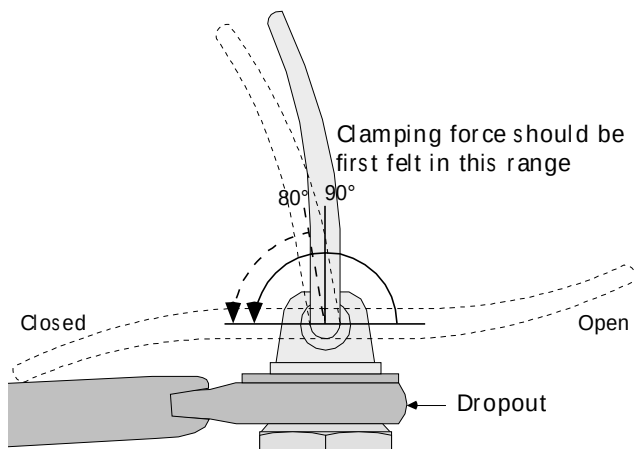


18.1 As the lever swings from the open to closed position, it rotates the cam, which moves the skewer-head further into the cam-nut, effectively moving the cam-nut and adjusting-nut closer together (which creates the clamping force).

The recommended method for setting the quick-release mechanism is to start by setting the adjusting nut so that as the lever swings from the open position

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to the closed position, the clamping force begins when the base of the quick-release lever is perpendicular to the dropout face. This ensures that the clamping force begins at a point that will allow enough rotation of the cam to create enough displacement of the skewer head after clamping begins. The lever is then closed until the base of the lever is parallel to the dropout (see figure 18.2). This does two things. First, it creates a 90° rotation of the cam after clamping force begins, which ensures that adequate skewer-head displacement occurs (pressure). Second, the “parallel-to-dropout” position ensures that the cam is rotated just past its high-point. This ensures that the force required to release the lever will increase slightly before it gets easier, which ensures that the quick-release lever has no tendency to open on its own. In case the above instructions were unclear, the recommended method for using quick-release mechanisms is this: set the adjusting nut so that as the lever is swung from the open position to the closed position, the clamping force begins at the point where the base of the lever is perpendicular to the face of the dropout, then close the lever at least until its base is parallel to the dropout (90° from starting point and perpendicular to the skewer, see figure 18.2). The force that is required to accomplish this can range dramatically, from minuscule, to beyond the capacity of human fingers (in which case the adjustment needs to be compromised). The amount of force that is required to close a properly-set quick-release mechanism is dependent on the surface-smoothness of the cam, the diameter of the cam, the smoothness of the cam-pivot surface, the length of the lever (and its shape and texture), the total surface-area of the cam, and the surface condition of the cam (wear, lubrication, rust, and dirt).



18.2 When properly set, as the lever swings from the open to closed position, clamping force should first be felt when the base of the lever is 80-90° from the closed position (the base of the lever parallel to the dropout face).

(A well-known former bike racer recently infuriated the bicycle industry by testifying that quick-release levers have a tendency to open on their own even when properly *secured*. He says that he has experienced this personally. It is quite probable that he was relying on closing force (palm-imprint method, or variation), not *position*, to determine when the lever was properly set. When the lever is not closed to the “parallel-to-dropout position,” friction alone is resisting its natural tendency to achieve a state of greater relaxation [i.e. open]. When the proper position is achieved, the lever actually *wants* to stay closed, rather than trying to open. Its like the snap on your blue jeans. The moment of highest force is when the snap is halfway together. Once you overcome the point where the snap is halfway on, it actually helps itself go the rest of the way on. When you unsnap your jeans, at first the mechanism resists as much or more than it resisted going together, but once you force the snap to come apart to a certain point, it virtually pops itself apart. Quick-release mechanisms are like snaps, but without as dramatic and obvious a transition. Unlike a snap, it is possible to stop the quick-release at the point where it is halfway on [highest force]; this is not the point of highest security.)

Open-cam and other alternative quick-release mechanisms

The recommended technique for securing quick-release mechanism in this chapter applies to traditional, steel quick-release mechanisms with a cam enclosed inside a housing. There are a number of un-conventional designs in existence today that deviate enough in design that the recommended procedure may not be appropriate. Primarily, these alternative designs incorporate aluminum cams (or no cam at all), and the cam mechanism is exposed, rather than enclosed. Dimensions of these external cams also deviate from convention. Since these alternative quick-release mechanisms are not consistent with each other, or with conventional quick-release mechanisms, there is no general recommended procedure for their use; a mechanic should pursue information from the manufacturer of each of these alternative mechanisms.

Incorrect original wheel installation and brake setup

If the wheel was installed incorrectly, then the brakes may have been mis-adjusted to line up with the rim. On bikes with anything but cantilever brakes, it is a minor correction to center the brakes to the correctly-installed wheel, but on bikes with cantile-

ver brakes, the pads often must be repositioned if the rim position changes. A decision must be made as to whether to put the wheel back in wrong (to match the brake adjustment), or put the wheel in right and adjust the pads for free, or contact the customer and tell them additional brake work will be needed. The best solution is for the service writer to identify the problem and give the customer all the options before checking in the job.

Out-of-true wheels

When wheels are removed for tire or hub work, it may be the case that the rims are out of true and rub the brake pads intermittently. Although this is not the shop's responsibility, if the customer doesn't notice the problem until after getting the bike back, it will reflect poorly on the shop and may lead to a complaint. Usually, it is worth doing a few minutes of complimentary wheel truing before re-installing the wheel. The best solution is to spot the problem before the bike is checked in and to get the customer to agree to getting the wheel trued or to accept that the rim will rub the pads when they get the bike back.

Poor fit to dropouts

It is not unusual for a wheel to be too wide or too narrow for the dropouts, causing awkward removal and installation. Usually the customer would be familiar with the problem and it is nothing the mechanic cannot deal with. Complimentary repair of the problem by giving the stays or fork blades a squeeze or pull is not recommended because it could introduce handling or chainline problems. It is a good idea to contact the customer and see if they would like to pay for the additional work that required to make their existing wheel fit better.

Rear cog position changes

When replacing rear wheels, there is always a possibility that the new wheel will position the rear cogs slightly differently, causing problems with rear-derailleur adjustment. A derailleur adjustment should always be planned as part of a rear-wheel replacement.

Multiple axle thread standards

There are many different thread descriptions for axles. This is only an issue if re-installing an axle-nut-type wheel and a new axle nut is needed. Never use test-mating to determine if a new nut fits. See the **ADJUSTABLE-CONE HUBS** chapter (page 12-4) for information on axle-thread types, or compare inside diameter of new nut and old nut (if not stripped) and then test mate to determine thread compatibility.

Rounded axle nuts

Rounded axle nuts often require a vise-grip tool to remove. They should never be re-installed because a torque wrench should be used for installation.

Stripped axles

Stripped axle threads may be encountered on wheels with axle nuts. Minor damage can be repaired with a thread chaser, but stripped axles must be replaced. This means a simple flat-tire repair can turn into a hub overhaul as well. The customer must be informed and asked to authorize an axle replacement, but under no conditions should the wheel be re-installed with stripped axle threads.

Damaged quick-release skewers

Quick-release skewers can be damaged in several ways. The skewer shaft can be bent or elongated. The cam housing can be cracked or deformed. The cam lever may be bent. The cam lever may get sticky (due to cam-surface wear) and be difficult to close fully from a normal starting position. In all these cases, the quick-release mechanism *must* be replaced.

Different quick-release skewer sizes

Quick releases can differ in length and shaft diameter. Length may be an issue if installing a replacement rear wheel that fits more cogs. Diameter of the shaft may be an issue for some "suspension" front hubs.

Protruding axles

If a quick-release axle protrudes too far from the face of the locknut, it can cause unsafe wheel installation. The axle should not protrude more from the locknut face than the thickness of the dropout it will be installed in. It is the mechanic's responsibility to check *every* wheel being installed for this condition and correct it. Fortunately, it can be corrected adequately by simply removing the skewer and holding the end of the axle up to a grinding wheel.

Broken axles

A broken axle may not show itself until the wheel is removed and the skewer removed from the hub. *Under no circumstances can the wheel be re-installed without replacing the axle!* The customer must agree to axle replacement, or accept the bike back in pieces. A broken axle is usually a symptom of a mis-aligned dropout.

Bent axles

Bent axles are broken axles in the making. They should never be bent back because it just causes further weakening. Even re-installing the wheel with a

18- WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

bent axle is a questionable choice. The customer should be advised of the problem and encouraged to agree to axle replacement.

Poor hub adjustments

When the wheel is removed, a tight adjustment, a loose adjustment, or loose cone locknuts may be discovered. Adjustments should not be altered, but the customer should be advised of the condition. Loose adjustments may interfere with installing the wheel in a fashion that the rim will not rub the brake pads.

Mis-adjusted brake pads

Mis-adjusted brake pads are a problem if they end up rubbing the tire or are at risk of deflecting below the rim when braking hard. Since it could appear that the shop was responsible if a problem relating to these conditions occurred after the wheel was installed, these conditions must be dealt with. In some cases it is simple, but the amount of work involved with some brakes ends up being almost a full brake job. In these cases, it would be best to contact the customer and get authorization to perform the additional work. The best solution is to look for problems with brake pads missing the rim whenever checking in a bike for any service that involves wheel removal.

ABOUT THE REST OF THIS CHAPTER

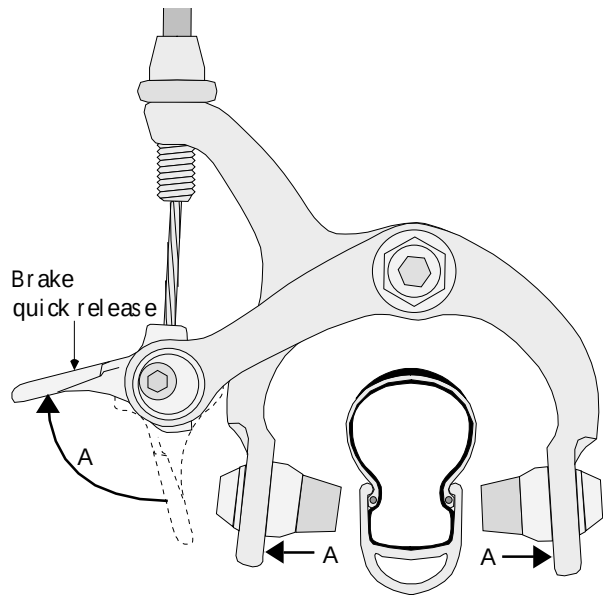
The rest of this chapter is divided into three parts. The first part is about wheel removal. The emphasis here will be on following a procedure that not only makes wheel removal easy, but on getting the right information before removing the wheel, which makes wheel installation easier. The second part is about the fit of the wheel to the bike and additional considerations when replacing a wheel. The third part is about installation of a wheel so that it ends up properly aligned and secure.

REMOVING A FRONT OR REAR WHEEL

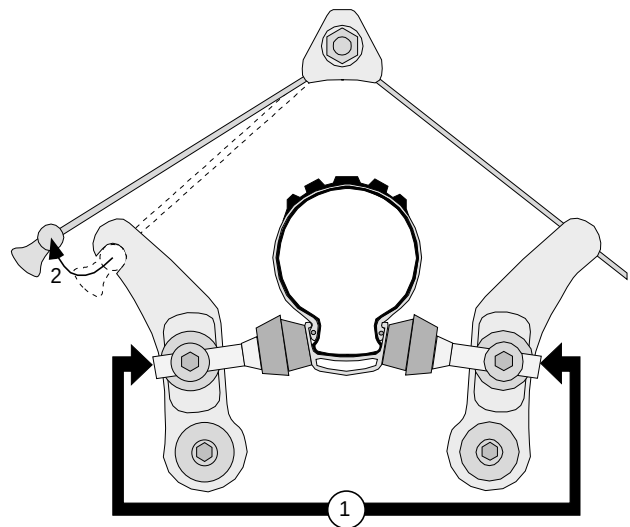
PREPARING ALL WHEELS FOR REMOVAL

1. [] Put bike in bike stand.

2. [] Operate brake once or twice, spin wheel, and observe whether rim or tire is rubbing on brake pads.
3. [] Observe whether rim appears centered between fork blades or seat stays (frame tubes from below seat to rear axle).
4. [] Spread brake pads by operating quick release on sidepull caliper or unhooking straddle wire on cantilever/U-brake/center-pull brake. If neither is possible, deflate tire if it is too fat to pass through brake pads.



18.3 By flipping the quick release in direction A, the pads will move in direction A so that the tire will clear the pads more easily.



18.4 To release a straddle wire to improve brake-pad clearance, 1) squeeze the calipers in toward the rim, 2) then pull the end of the straddle wire out of the caliper arm.

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5. [] Some front wheels have safety-retention mechanisms that hold wheel in place if quick release fails. Look for plates of metal sandwiched between quick release and dropout face and remove any screw/bolt that goes through plate.

NOTE: Skip to step 8 if removing a front wheel.

PREPARING A REAR WHEEL FOR REMOVAL

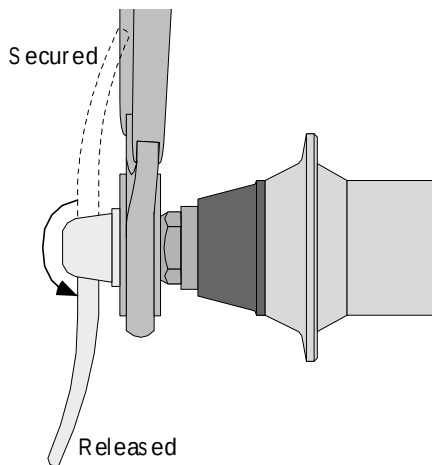
6. [] Shift chain to innermost chainring in front and outermost cog in rear so that chain has as much slack as possible.
7. [] Observe whether tire appears centered between chain stays just behind the bottom bracket.

LOOSENING QUICK RELEASES OR AXLE NUTS

NOTE: If wheel is held to bike by axle nuts, skip to step 10.

If the wheel is held to bike by a quick release

8. [] Locate quick-release lever (generally on left side of bike) and flip lever (do not rotate) 180°.



18.5 Opening a quick-release lever.

9. [] If wheel does not want to easily slide out of dropouts, hold conical-nut end of quick-release mechanism on side opposite lever and rotate lever counterclockwise to loosen mechanism further, or simply loosen conical nut further.

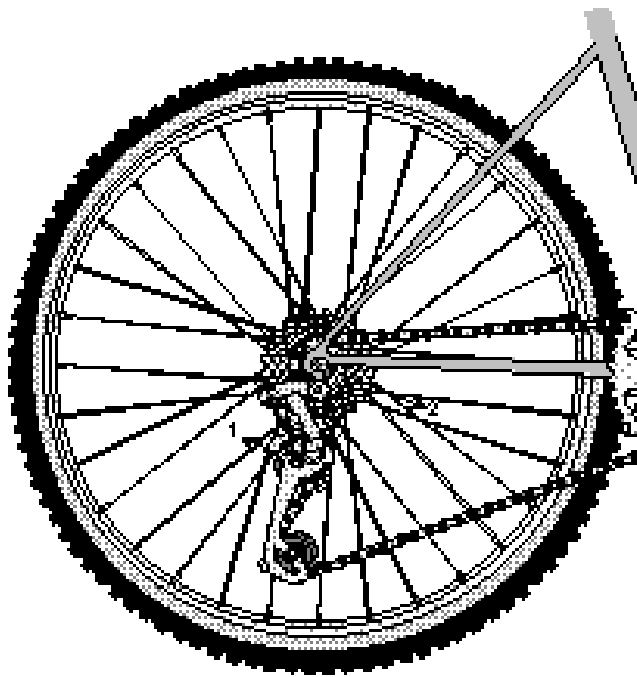
If the wheel is held to bike by axle nuts

10. [] Turn either axle nut counterclockwise to loosen.
11. [] Turn second axle nut counterclockwise to loosen. If axle tends to turn with axle nut, re-tighten first axle nut just enough to fix axle while breaking loose second axle nut, then break loose first nut again.
12. [] If wheel does not slide out easily, loosen either or both axle nuts further.

NOTE: If removing a front wheel, wheel removal is done. Ignore remaining steps.

CLEARING FREEWHEEL FROM DERAILLEUR AND CHAIN

13. [] If removing rear wheel, it probably has come to a rest on top of rear derailleur. Rotate derailleur back (clockwise viewed from right side of bike) around its mounting bolt while pushing wheel forward and down.



18.6 Rotate the derailleur back so it will clear the wheel when the wheel is removed.

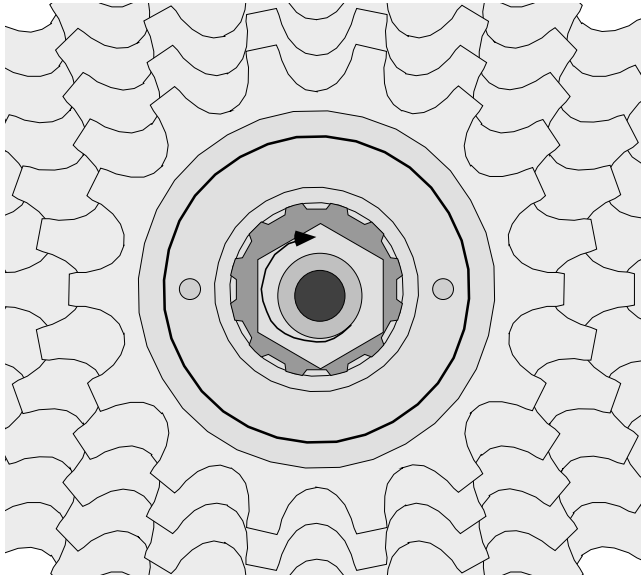
14. [] Once freewheel clears rear derailleur, drop wheel down and to bike's left to get rear cogs and right end of axle to clear lower section of chain.

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INSPECTING AXLE FOR BENDS

A number of the following steps might require hub work. Inspect now for whether the axle is bent. *A bent axle often indicates that the dropouts need alignment.*

- 15. [] Looking into each end of axle, rotate axle and observe whether there is any oscillation that would indicate either end of axle is bent.**



18.7 *Inspect the end of the axle for oscillation when rotated.*

FITTING WHEELS, ORIGINAL AND REPLACEMENT

Whether reinstalling an existing wheel or installing a replacement wheel, check whether it fits. The following is a short list of fit aspects common to all wheels:

- Fit of axle length to dropout thickness

- Fit of hub width to width between dropouts

For replacement wheels the following additional aspects of fit should also be considered:

- Fit of axle to dropout-slot width (particularly if replacing front solid-axle wheel with quick-release wheel)

- Fit of thread-on freewheel or freehub-cog cassette to hub (if replacing rear wheel)

For replacement wheels and rebuilt wheels, these additional aspects of fit should also be considered:

- Fit of rim width to brake-pad width

- Fit of rim diameter relative to brake-pad height

- Centering of rim to brakes

- Fit of rim to existing-tire size

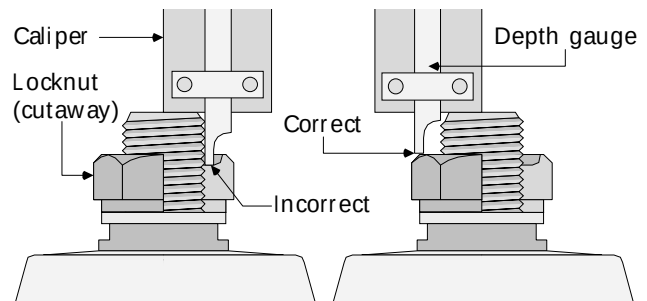
FIT OF AXLE LENGTH TO DROPOUT THICKNESS

The amount that the axle protrudes past the locknut on the hub is important. If the wheel is a quick-release type and the axle is too long, it may prevent the wheel from securing properly. Simply, a quick-release axle should never protrude past the locknut by more than the thickness of the dropout that the axle will insert into. If the wheel is the type held on by axle nuts, the axle protrusion should be at least equal to the sum of the dropout thickness, the thickness of the axle washer (if any), and the thickness of the axle nut, or the axle nut may not engage the axle adequately.

- 1. [] Measure axle protrusion on each side of hub and record here:**

Right-side protrusion: _____

Left-side protrusion: _____

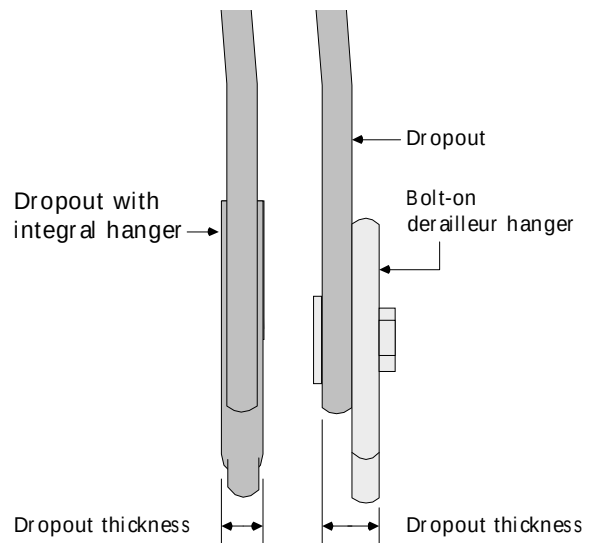


18.8 *Measuring axle protrusion.*

- 2. [] Measure dropout thickness and record here.**

Right side (include derailleur-mounting plate that bolts on to the face of the dropout, if any): _____

Left side: _____



18.9 *Measuring dropout thickness.*

NOTE: If wheel is held on by axle nuts, skip to step 5.

If wheel is quick-release type

Axle-length protrusion can be too long, resulting in the quick-release mechanism clamping against the end of the axle instead of against the dropout. Axle-length protrusion cannot be functionally too short, it simply makes alignment of the wheel more awkward if there is no protrusion (wheel security is unaffected by axle-to-dropout engagement).

3. Subtract right-side axle protrusion from right-side-dropout thickness.

Record answer here: _____

- ☐ If answer is a negative value, shorten axle by filing, cutting, or replacing. Excess length can also be shifted to other side if other side is too short.

- ☐ If answer is ≥ 0 , axle protrusion is acceptable.

4. Subtract left-side axle protrusion from left-side-dropout thickness. Record answer here:

- ☐ If answer is a negative value, shorten axle by filing, cutting, or replacing. Excess length can also be shifted to other side if other side is too short.

- ☐ If answer is ≥ 0 , axle protrusion is acceptable.

If wheel is solid axle type

Axle-length protrusion can be too short, resulting in inadequate engagement of the axle nut. Axle-length protrusion cannot be functionally too long, it is simply unsightly and hard on shins.

5. Subtract right-side axle protrusion from sum of right-side-dropout thickness, axle-nut thickness, and axle-nut-washer thickness. Record answer here: _____

- ☐ If answer is a positive value, axle must be replaced unless enough excess length is found on left side.

- ☐ If answer is ≤ 0 , axle protrusion is acceptable. Extra length can also be shifted to other side if other side is too short.

6. Subtract left-side axle protrusion from sum of left-side-dropout thickness, axle-nut thickness, and axle-nut-washer thickness. Record answer here: _____

- ☐ If answer is a positive value, axle must be replaced unless enough excess length is found on right side.

- ☐ If answer is ≤ 0 , axle protrusion is acceptable. Extra length can also be shifted to other side if other side is too short.

FIT OF HUB WIDTH TO WIDTH BETWEEN DROPOUTS

A good fit between the hub and the dropouts ensures that the wheel is easy to remove and install. In the case of suspension forks, a good fit is essential to keep the suspension working properly.

Tolerance for error

If the hub width differs from the dropout width by 2mm or more, awkward wheel installation or removal will probably be experienced.

If the hub is too wide, the wheel will always be difficult to install, regardless of how much the axle nuts or quick-release adjustment is loosened.

If the hub is too narrow, the wheel will come out relatively easily when the quick-release mechanism is released or the axle nuts are un-torqued; however, the frame will expand to a wider state after the wheel is removed. The expanded frame makes reinstalling the wheel a struggle without additional loosening of the quick-release mechanism or axle nuts, because otherwise the frame will need to be compressed to fit back between the quick-release parts or the axle nuts.

Modern front dropouts often have a recess in their faces or tabs that protrude from the tips so that the wheel is trapped even when the quick release is released. These require that the quick-release adjusting nut (on the non-lever end) be loosened further just so that the quick-release will clear these safety mechanisms. In this case, needing to loosen the quick release further to remove the wheel is not necessarily a sign that there is a problem with wheel fit. To adjust and readjust the quick release every time because of these safety devices is a pain. Every millimeter the dropouts are too wide adds to the pain.

With regard to the fit of the hub to a suspension fork, the tolerance for error is even less. The hub must be *less* than 1mm wider or narrower than the width between the dropouts on the suspension fork. If the fit is worse than 1mm, then the tubes sliding in and out of each other (as the suspension compresses and extends) tend to bind.

Quantifying error

To quantify of the width error between the hub and the dropouts, two measurements must be taken and a difference must be calculated. First, use a caliper to measure the width from the face of one hub locknut (the surface that presses against the inside face of the dropout) to the face of the other hub locknut. For rear hubs it will usually be necessary

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to remove the freewheel or freehub cogs (see the **FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS** chapter, page 25-9 and 25-16). Next, use a caliper to measure the distance between the inside faces of the two dropouts (the parts of the frame that the wheel attaches to). The width error is the difference between these two measurements.

Correcting error

To correct a width error, there are two basic approaches. It is possible to spread or compress the width between the dropouts. This is not an option with aluminum frames or forks, carbon-fiber frames or forks, or suspension forks (unless the suspension system is not part of the fork blades). The other option is to change the width of the hub. This is not an option with many cartridge-bearing hubs, which often do not have means to add or subtract spacers from the axle. In these cases, a new axle set may need to be installed.

Assuming that the hub is an adjustable-cone hub with a threaded axle, re-spacing the axle is simply a matter of adding, subtracting, or substituting spacers behind the locknuts on each end of the axle.

Consequences of hub re-spacing

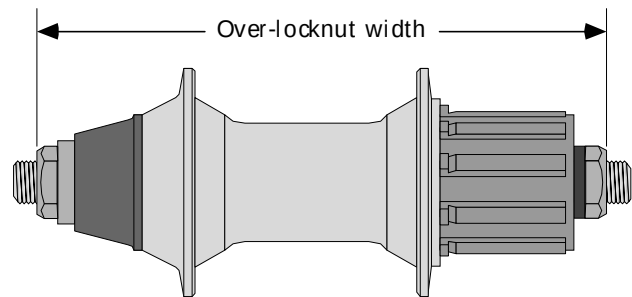
Although the process of adding or subtracting space from the axle is relatively simple, the consequences can be quite complex. When adding, subtracting, or substituting spacers from either end of the axle, it will be necessary to re-adjust the hub bearings (see the **ADJUSTABLE-CONE HUBS** chapter, page 12-12). As long as changes made are equal on both sides of the axle, then there is no concern about wheel dish (centering of the rim to the hub). If at any time unequal spacing changes occur on the two ends of the axle, then the wheel will need to be re-dished (see the chapter **WHEEL TRUING AND REPAIR**, page 17-15).

As long as spacers are being added to the right end of a rear hub, there is no concern about the fit of the freewheel cogs, but if subtracting space from the right end there is a possibility that the outermost cog may end up too close to the frame and that the chain might jam against the frame, either while on the outermost cog or while shifting on to or off of it. *Anytime* spacers are being added *or* subtracted from the right side of the rear hub, it *will* affect the rear-derailleur limit-screw settings and the index-cable-tension adjustment. See the **REAR DERAILLEURS** chapter (page 32-10) in order to adjust the rear derailleur.

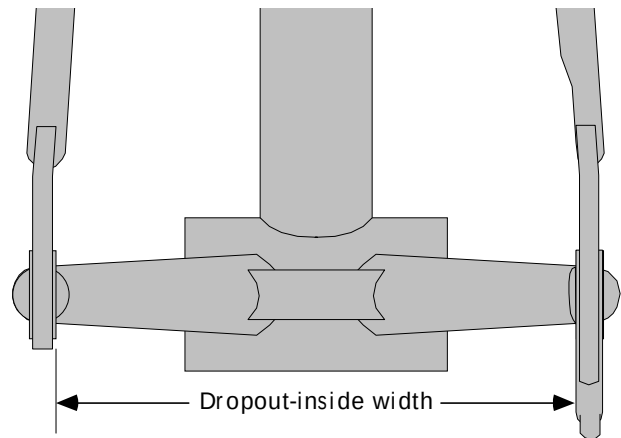
The following steps enable calculation of the total change necessary to make the hub a perfect fit to the dropouts. To make the necessary corrections to

the hub, the wheel dish, the freewheel fit, or the rear-derailleur adjustment, refer to the appropriate chapters on these components.

7. [] Measure over-locknut width of hub and record here: _____



18.10



18.11

8. [] Measure width between dropout inside faces, record here: _____

9. [] Subtract smaller number from steps 7 or 8 from larger number from steps 7 or 8 and record answer here: _____

10. Check one of following depending on answer in step 9:

[] Hub width needs to be increased by amount in step 9.

[] Hub width needs to be decreased by amount in step 9.

[] Hub width is acceptable (step 9 is <1mm for suspension forks or £2mm for others).

NOTE: If just re-installing a wheel, skip following section FITTING WHEELS, REPLACEMENT ONLY and go directly to INSTALLING THE WHEEL.

FITTING WHEELS, REPLACEMENT ONLY

NOTE: Skip to **FIT OF BRAKE-PAD WIDTH TO RIM WIDTH** (following step 21) if re-installing an original hub built up with a new rim.

FIT OF AXLE TO DROPOUT-SLOT WIDTH

NOTE: Use this section only if replacing front solid-axle wheel with quick-release wheel.

If upgrading a front solid-axle wheel to a quick-release wheel, there may be a problem fitting the axle to the slots in the fork dropouts. Most road-bike front axles that use axle nuts are 5/16" diameter (7.95mm), and all quick-release front axles are at least 9.5mm diameter. Some forks are made with dropout slots just wide enough to accommodate the axle-nut-type axles. If upgrading to quick-release front axle, do the following steps. If the dropout axle slots are too narrow, they will need to be enlarged with a file. MTB front axles that use axle nuts are usually fatter, so the dropouts may not need this modification to accommodate a quick-release axle.

If replacing an axle-nut-type front wheel with a quick-release wheel

11. Measure width of slot in fork dropout and conclude one of following:

- [] Slot width is $\geq 9.5\text{mm}$, quick-release axle will fit without filing axle slots.**
- [] Slot width is $< 9.5\text{mm}$, axle slots must be filed to fit quick-release axle.**

FIT OF FREEWHEEL TO HUB

NOTE: Use this section only if replacing a rear wheel equipped with a thread-on freewheel.

Rear wheels that fit thread-on freewheels (as opposed to freehubs, which have the freewheel built in) are not all made with the same space for the freewheel to fit (called freewheel space). Also, in rare cases, there is a possibility that the threads on the freewheel are not compatible to the threads on the hub. Even when the hub has adequate freewheel space, if it is not the identical amount as the original hub, it will be necessary to re-adjust the rear-derailleur limit screws and cable.

For every type of freewheel (five-speeds, narrow six-speeds, wide six-speeds, and seven-speeds), there is a minimum-freewheel-space value. In certain cases where the seat stay (tube from below the seat to the

rear dropout) is bulky where it attaches to the dropout, the minimum freewheel space may not be adequate (the chain may rub against the end of the seat stay while on the outermost cog or shifting on and off of the outermost cog).

To determine whether the new rear hub has adequate freewheel space, take two measurements on the hub, add them together, and see if the answer is equal to or more than the space requirement for the specific freewheel. In the case of a six-speed freewheel, it will also be necessary to take a measurement on the freewheel to determine whether it is a narrow- or wide-spaced six-speed. An alternate approach is to compare the new hub's freewheel space to the old hub's freewheel space. As long as the new hub has equal to or greater space than the old hub, the freewheel space should be adequate. It is also possible to calculate the difference between the new and old hub's freewheel spaces to determine how much space to add or subtract from the right side of the new hub's axle set, in order to get an identical match and avoid having to re-adjust the rear derailleur.

If the freewheel space on the new hub needs to be modified, then it will affect the wheel dish and the fit of the hub to the dropouts (see above). See the chapter **WHEEL TRUING AND REPAIR** (page 17-15) to adjust the wheel dish. If the hub's fit into the dropouts is good, then whatever amount of spacing will be removed from the right side of the axle should be added to the left side of the axle. If adding spacers to the right side of the hub, the equivalent amount should be subtracted from the left side of the hub. If the freewheel space is wrong and the hub width is also wrong, try to fix both at the same time. See the **ADJUSTABLE-CONE HUBS** chapter (page 12-12) to add and subtract spacers from the axle and adjust the hub after doing so.

Older French bikes (before 1985) occasionally had freewheel threads that were a 1mm pitch. Just about any replacement wheel will have freewheel threads that are a pitch of 24tpi. These two pitches are not compatible. In such a case, the freewheel will need to be replaced along with the wheel.

If replacing a rear wheel equipped with a thread-on freewheel with a new wheel

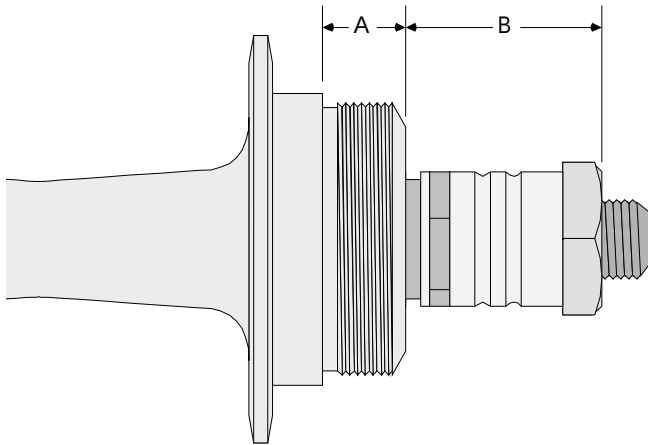
12. [] Measure pitch of freewheel threads on free-wheel and hub and make sure they match.

13. [] Measure distance from shoulder at bottom of hub's freewheel threads to end of hub shell and record:

(new hub) _____
(old hub) _____

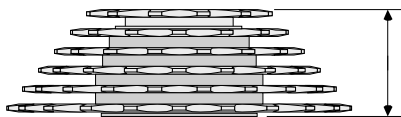
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14. [] Measure from end of hub shell to face of locknut and record: (new hub) _____
(old hub) _____



18.12 Measure these two dimensions to determine freewheel space.

15. [] Add both *new* hub numbers from steps 13 and 14 and record answer here: _____
16. [] Add both *old* hub numbers from steps 13 and 14 and record answer here: _____
17. [] If freewheel has six cogs, measure distance from outer face of outermost cog to inner face of innermost cog and record measurement here: _____



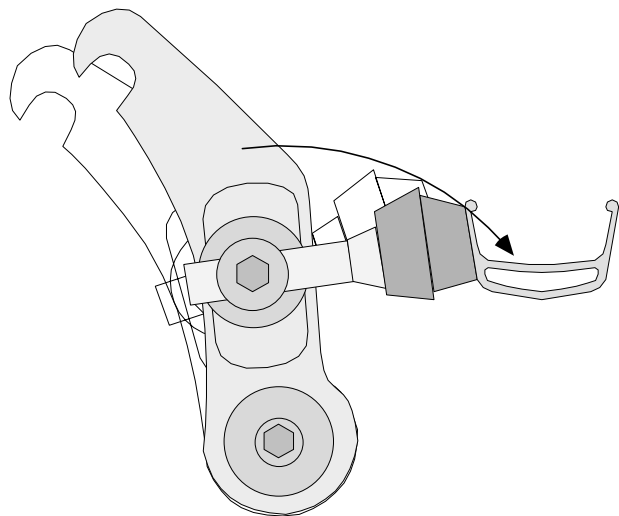
18.13 If freewheel is a six-speed, measure the freewheel width.

18. Check appropriate choice below, depending on freewheel to be installed on new wheel:
- [] Five-speed freewheel, minimum freewheel space is 29mm.
 - [] Six-speed freewheel width is <28mm, minimum freewheel space is 31mm.
 - [] Six-speed freewheel width is >28mm, minimum freewheel space is 35mm.
 - [] Seven-speed freewheel, minimum freewheel space is 37mm.
19. [] If new hub freewheel space (step 15) is less than minimum-freewheel-space requirement (step 18), add necessary spacers to right side of axle so that it equals minimum-freewheel-space requirement (derailleur adjustment will be required unless step 18 amount also equals step 16), or add or subtract necessary spacers on right side of axle so that new freewheel space equals step 16 (no derailleur adjustment will be required). (See ADJUSTABLE-CONE HUBS chapter, page 12-12.)

20. [] If necessary, subtract or add spacers to left side of rear axle so that over-locknut width equals step 8 ($\pm 2\text{mm}$). (See ADJUSTABLE-CONE HUBS chapter, page 12-12.)
21. [] Re-dish wheel if spacers have not been added or subtracted equally on right and left sides of wheel. (See WHEEL TRUING AND REPAIR chapter, page 17-15.)

FIT OF RIM WIDTH TO BRAKE-PAD WIDTH

In many cases, if a replacement wheel has a different rim width than the original wheel, then nothing is needed other than a minor cable adjustment to change the brake pad-to-rim clearance. If the bike has cantilever brakes, U-brakes, centerpull brakes, or Shimano dual-pivot brakes, then even minor changes in rim width can have a major effect on brake-pad-height adjustment. The reason for this is that the above-listed brakes (all brakes other than conventional sidepull brakes) have a very short caliper-arm length. When the caliper arm is short, the pads move almost an equal amount up and down for the amount they move in and out. For example, a 21mm-wide mountain-bike rim might be replacing a 27mm-wide mountain-bike rim. Each pad will need to move 3mm further in to reach the rim. When a cantilever arm moves a pad 3mm further in, the pad ends up 1–2mm further down. This might end up with the pad partially below the rim. All this means is that the brake-pad height on the caliper arm needs to be adjusted, not that the narrower rim cannot be used.

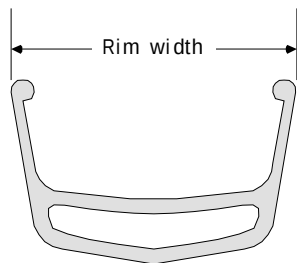


18.14 Brake pads change height as they move laterally.

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With sidepull and cantilever brakes, pads move down as they move in. If the replacement rim is narrower, inspect for pads that end up too low on the rim. If the replacement rim is wider, inspect for pads that end up too high on the rim. With centerpull and U-brake calipers, the pads move up as they move in. If the replacement rim is narrower, inspect for pads that end up too high on the rim. If the replacement rim is wider, inspect for pads that end up too low on the rim.

22. [] Measure and compare old and new rim widths.



18.15 Measuring rim width.

23. If new rim width is narrower, check one of following choices:

- [] Brakes are cantilever or sidepull brakes, check if brake pads hit too low on new rim.
- [] Brakes are U-brake or centerpull, check if brake pads hit too high on rim.

24. If new rim width is wider, check one of following choices:

- [] Brakes are cantilever or sidepull brakes, check if brake pads hit too high on new rim.
- [] Brakes are U-brake or centerpull, check if brake pads hit too low on rim.

FIT OF RIM DIAMETER RELATIVE TO BRAKE-PAD HEIGHT

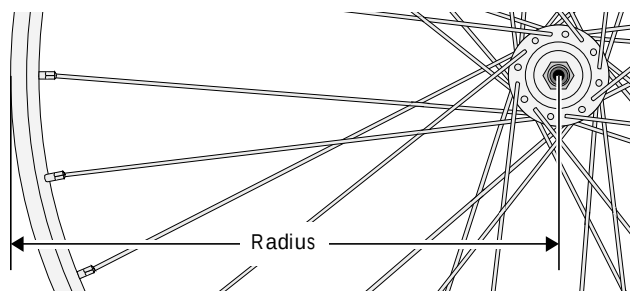
In almost every case, a wheel must be replaced with one of an identical size or the brakes will not reach the rim. The only exception to this is the 700C and the 27" sizes, which differ in radius by approximately 4mm. In most cases, even this small difference would mean that the brakes will not fit. If replacing a 27" wheel with a 700C wheel, and the brake pads are currently at the top of their height-adjustment range, then there is a possibility the 700C wheel will fit. If replacing a 700C wheel with a 27" wheel, and the brake pads are currently at the bottom of their height-adjustment range, then there is a possibility the 27" wheel will fit. (This example assumes the brakes are sidepull, not cantilever.)

If replacing a smaller wheel size with a larger size (for example replacing 700C with 27") there is also a question as to whether the tire tread will clear the frame or fork. If the new tire is of a similar fatness as the old one, then it is simply a matter of checking the old tire to see if there is at least 8mm clearance. If the new tire is skinnier or fatter than the old tire, factor in that difference as well as the wheel-radius difference. Ideally, try to end up with about 6mm clearance (without fenders), and 12mm clearance if fenders will be used.

NOTE: If replacing a wheel with one of the same size, skip to CENTERING OF RIM TO BRAKES.

If replacing a wheel with one of another size

25. [] Measure radius of old wheel, and write answer here: _____



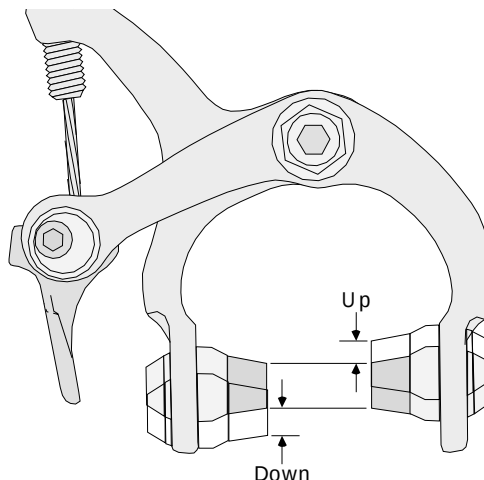
18.16 Measure the rim radius.

26. [] Measure radius of new wheel, and write answer here: _____

27. [] Subtract smaller of steps 25 and 26 from larger of steps 25 and 26 and write answer here: _____

This is amount brake pads will need to be adjusted up or down to reach new rim.

28. [] Measure amount brake pad can move down (if step 26 is smaller than step 25), or up (if step 26 is larger than step 25,) and write answer here: _____



18.17 Vertical pad adjustment of a sidepull brake.

18- WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

29. Choose one of following choices:

☐ Step 28 is larger than step 27, so brakes will accommodate new wheel size.

☐ Step 28 is smaller than step 27, so brakes will not accommodate new wheel size.

30. ☐ If replacing a smaller wheel with a larger one, check clearance between tread and frame to make sure there will be room for a larger tire.

CENTERING OF RIM TO BRAKES

Assuming the wheel is correctly dished initially (and this may prove false later), if the axle spacing was modified in any way, dish should be checked and corrected. Assuming the original wheel centered correctly between the brake pads, if the new wheel does not center up well, either the brakes were mis-adjusted to a poorly-dished old wheel, or the new wheel is not correctly dished. When installing the new wheel, if it does not center to the brake pads, there is either a problem with the wheel dish or the brake adjustment. Use a dish gauge to check the dish of the new wheel (see page 17-15) before centering the brakes to the new wheel.

31. ☐ Install wheel temporarily and check if rim is centered between brake pads. If centered, skip steps 32 and 33.

32. ☐ If not centered, check and correct wheel dish if necessary.

33. If wheel dish is correct, brakes need centering.

FIT OF RIM TO EXISTING TIRE SIZE

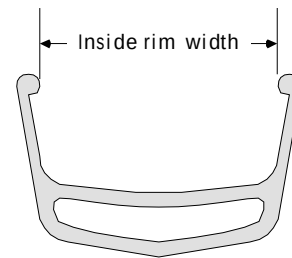
Assuming the replacement wheel is the same size category as the original and the plan is to re-use the old tire, check that the new rim width is compatible with the old tire. In a perfect world, it would be a matter of matching the named width of the rim to the named width of the tire, and all 26" MTB tires would be compatible with all 26" MTB rims. Unfortunately, the world isn't perfect, at least not as far as tires and rims are concerned. For any size (such as 26" MTB), there are a variety of rim widths and a variety of tire widths. To complicate matters, the actual width for two rims that are named the same can actually be quite different. The same holds true of tires. If combining the narrowest of rims with the widest of tires in a given size group, or vice versa, then there may be a problem. There are a few simple measurements that can be taken and calculations to make to determine whether the tire width is acceptable to use with the new wheel.

If the tire is too narrow for the new rim, there are several consequences. The height profile of the tire will be too low, which can lead to more rim damage and

more pinch flats. Also, the shape of the tire will be deformed in a way that reduces cornering performance (particularly on road bikes). If the tire is too wide for the new rim, there is some risk of different consequences. If the tire is too wide for the rim and the bike has cantilever brakes, the brake pads often end up rubbing on the tire — resulting in its premature demise. If the bike in question has sidepull brakes, the pads probably will not spread wide enough to clear an oversize tire. Also, on road bikes where the tire is too wide for the rim, a squirmy feel in the handling might be experienced — depending on the tire design and the air pressure.

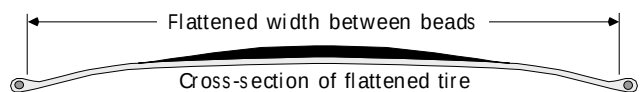
The following steps determine whether the existing tire is within the range of widths that is acceptable on the new rim.

34. ☐ Use a caliper to measure inside width of rim.
Record measurement here: _____



18.18 Measure inside width of rim.

35. ☐ Measure width from bead-to-bead (edge-to-edge) of tire (flattened) and record width here: _____



18.19 Measure flattened width of tire between the beads.

36. ☐ Divide answer in step 35 by 2.5 to determine "section width" and record answer here: _____

37. ☐ Multiply rim-inside width from step 34 by 1.4 to determine the narrowest acceptable "section width" and record answer here: _____

38. ☐ Multiply rim-inside width from step 34 by 2.0 (road bikes) or 3.0 (MTBs) to determine the widest acceptable "section width" and record answer here: _____

39. Check one of following choices:

☐ Step 36 is included in range of steps 37 and 38, so tire width is ideal for rim.

☐ Step 36 is outside of range of steps 37 and 38, so tire width is potentially unacceptable for rim. (See preceding text for description of possible problems.)

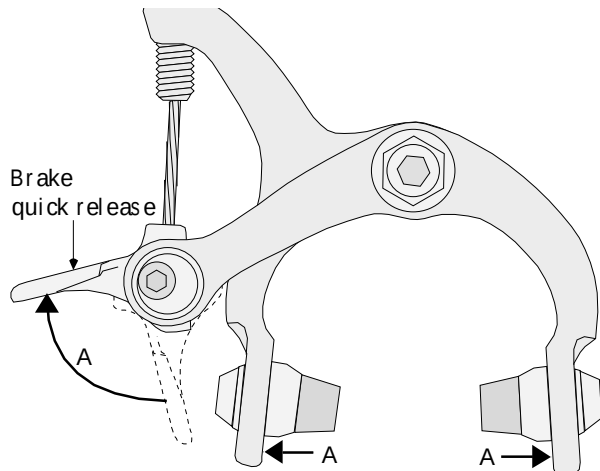
INSTALLING THE WHEEL

NOTE: If installing a rear wheel, skip to **REAR WHEELS**.

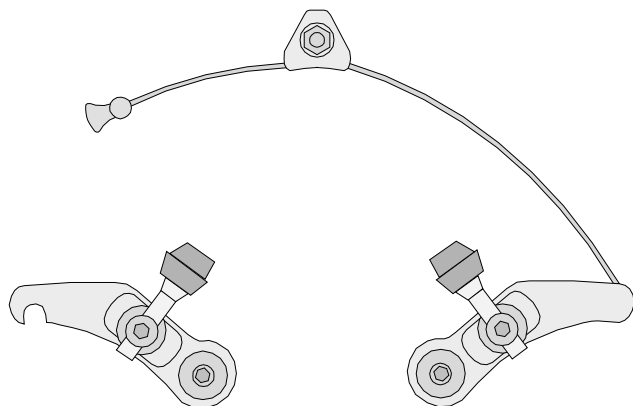
FRONT WHEELS

Installing a front wheel is relatively simple, but don't let the simplicity lead to carelessness. Nothing is more disastrous than a front-wheel-mounting failure!

1. [] **Check that sidepull-brake quick-release mechanism is released, or cantilever/U-brake/centerpull straddle wire is unhooked.**

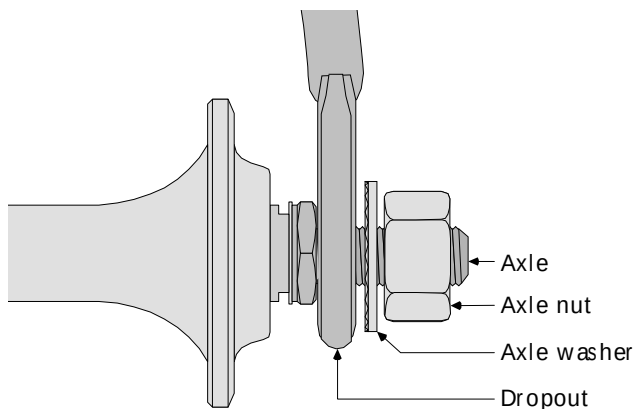


18.20 A sidepull brake should be released before installing the wheel.



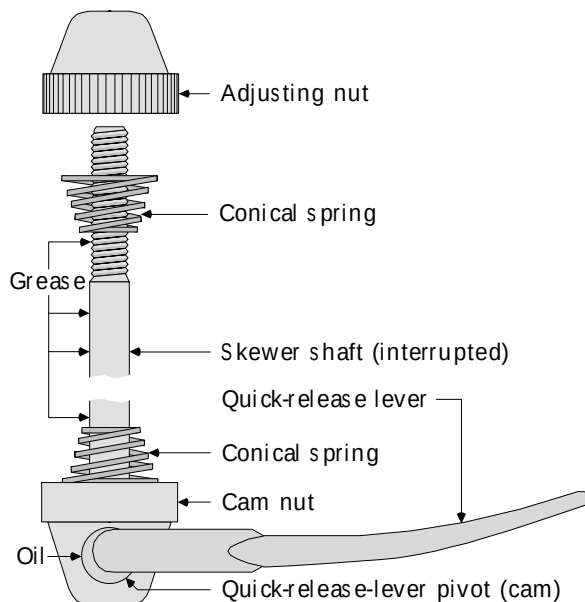
18.21 A cantilever brake should be released before installing the wheel.

2. Check one of following choices, then perform lettered steps that follow checked choice:
 - [] If wheel is retained with axle nuts:
 - a) Remove axle nuts and washers, grease axle threads.
 - b) Install axle washers (textured face, if any, toward dropout).
 - c) Thread on axle nuts (any flange on axle nut faces toward dropout).



18.22 Orientation of axle nut, washer, and dropout.

- [] If wheel has quick-release mechanism and quick-release mechanism has been removed from axle:
 - a) Lubricate skewer shaft and threads.
 - b) Lubricate pivot of quick-release lever.
 - c) Install conical spring so that small end points to threaded end of skewer (OK to omit both springs, but not one).
 - d) Install skewer in axle so that lever ends up on wheel's left side.
 - e) Install second spring over threaded end of skewer so that small end points inward (unless using no springs).
 - f) Thread on skewer adjusting nut.



18.23 Parts identification and lubrication points of a quick-release mechanism.

18- WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

[] If skewer is already installed:

- a) Lubricate quick-release lever pivot.
- b) Check that there are two conical springs, or no conical springs (one is worse than none).
- c) Check that small ends of conical springs point toward center.

- 3. [] Slip wheel between fork blades and axle ends into dropout slots. For quick-release wheels, convention is that Q.R. lever is on bike's left.
- 4. [] Close sidepull quick-release mechanism or hook up cantilever/U-brake/centerpull straddle wire.

In the next step, make sure that the wheel is centered between the fork blades. This is not achieved automatically by shoving the axle fully into the dropout slots. Few manufacturers make forks so precisely that a properly-dished wheel will automatically center. It is possible to use a round file to extend the length of the axle slot in the dropout that is on the side of the fork that the rim ends up too close to. In most cases, this is not worth the trouble. A more practical approach is to make sure the wheel is dished, and install the wheel so that it is centered to the fork blades, center the brake to the rim, and from then on for all further wheel installations just install the wheel so that it ends up centered between the brake pads.

- 5. Check one of following choices, depending on whether brake was centered to correctly dished wheel previously or not:

[] If brake was not centered to correctly dished wheel previously, position rim so that it is centered between fork blades. Secure wheel temporarily and recheck centering.

[] If brake was centered to correctly dished wheel previously, position rim so that it is centered between brake pads. Operate brake several times to ensure pads are returning to their natural positions. Secure wheel temporarily and recheck centering.

- 6. [] If quick-release wheel has safety-retention plates, install screws and tighten screws now.

In the next step, the wheel is secured. There are few errors a mechanic can make that are more catastrophic than a wheel-mounting failure. If the wheel is retained by axle nuts, there is a simple procedure that guarantees a secure wheel: use axle washers, make sure the clamping surfaces of the axle fully engage the dropout surface, then use a torque wrench to tighten the axle nuts to the recommended torque.

If the wheel is retained by a quick-release mechanism, the solution is not so simple. Few manufacturers provide guidelines for use of the quick-release mechanisms; some of the manufacturers that do are simply quoting existing lore, rather than techniques

that have been proven by research. "Existing lore" is the cause of many of the problems with quick-release mechanisms. It is strongly recommended that you read the earlier section, *wheel-mounting failure* (page 18-2), before proceeding with wheel installation.

- 7. Select one of following steps depending on whether wheel is retained by axle nuts or quick-release mechanism:

[] If wheel has axle nuts, secure nuts to a torque of 180–240in-lbs (30–40lbs@6") and check that rim is still centered as in step 5. If axle tends to rotate while securing axle nut, alternate tightening nuts on each side a little at a time.

[] If wheel has quick-release mechanism:

a) Flip lever from open position toward closed position and check if clamping force is first encountered when lever is close to pointing straight out (base of lever perpendicular to dropout face). If dropouts are wider than hub width, clamping force does not begin until both dropouts are contacting faces of axle hardware.

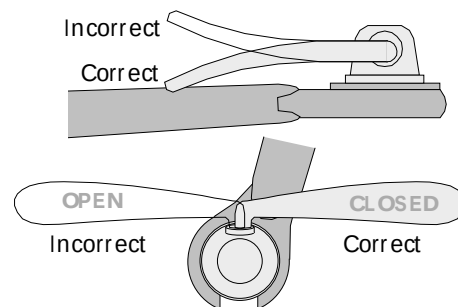
b) If necessary, tighten or loosen adjusting-nut so that clamping force is first encountered when lever is close to pointing straight out (base of lever perpendicular to dropout face).

c) Flip lever to open position and rotate skewer so that when lever is flipped to closed position, lever will end up adjacent to, but not overlapping, fork blade.

d) Close lever so that base of lever ends up at parallel to dropout, or past point where it is parallel.

e) If unable to close lever fully (base of lever parallel to dropout), open lever enough to be able to turn adjusting nut and loosen adjusting nut by very small increments until just able to close lever to parallel-to-dropout position.

f) Check that rim is still centered as in step 5.

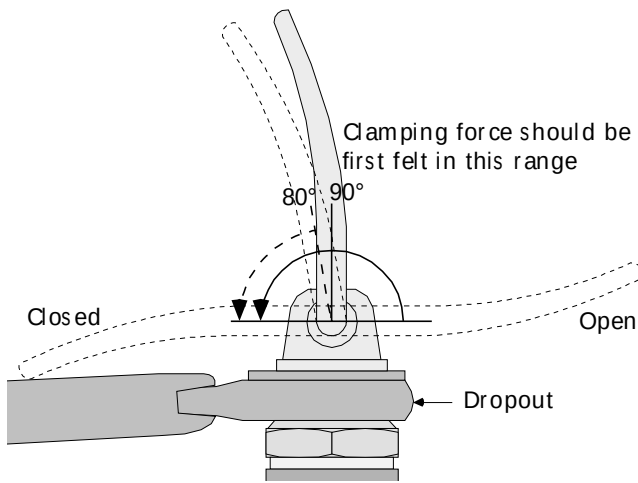


18.24 The solid images are quick-release mechanisms as they appear when they have been closed properly by utilizing the cam (flipping the lever). The outlined levers are quick-release mechanisms as they appear when they have been secured incorrectly (as though the lever was a wing-nut).

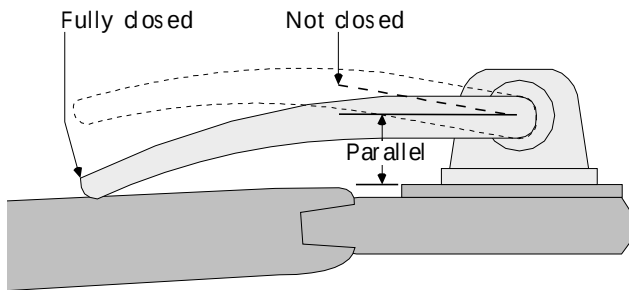
REAR WHEELS

Installing a rear wheel is relatively simple, but compared to a front wheel it is complicated by the chain and the fact that the wheel needs to be aligned between the chain stays (frame tubes between the crank set and rear axle) and the seat stays (frame tubes between the seat and the rear axle).

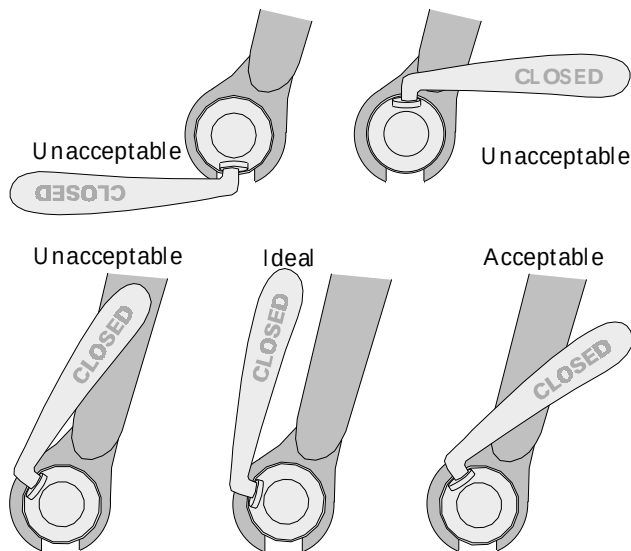
9. [] Check that sidepull-brake quick-release mechanism is released, or cantilever/U-brake/centerpull straddle wire is unhooked.



18.25 When properly set, as the lever swings from the open to closed position, clamping force should first be felt when the base of the lever is 80-90° from the closed position (with the base of the lever parallel to the dropout face).

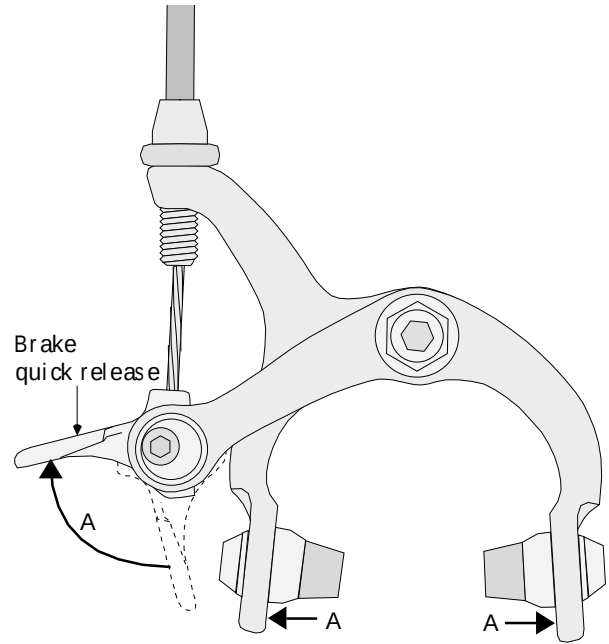


18.26 When closed, the base of the lever **must** be parallel to the dropout.

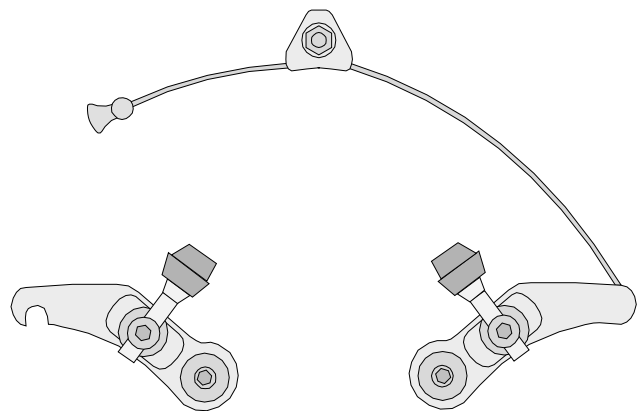


18.27 When closed, the lever should be adjacent to, but not overlapping, the fork blade.

8. [] Center brake pads as necessary (see chapter on brakes).



18.28 A sidepull brake should be released before installing the wheel.



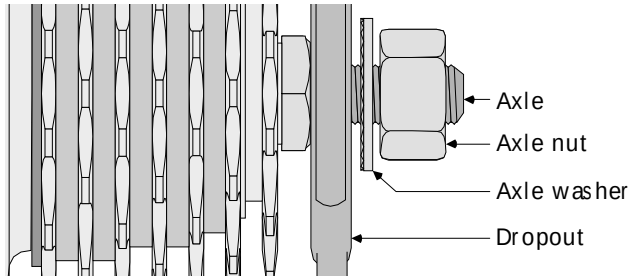
18.29 A cantilever brake should be released before installing the wheel.

18- WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

10. Check one of following choices, then perform lettered steps that follow checked choice:

☐ If wheel is retained with axle nuts:

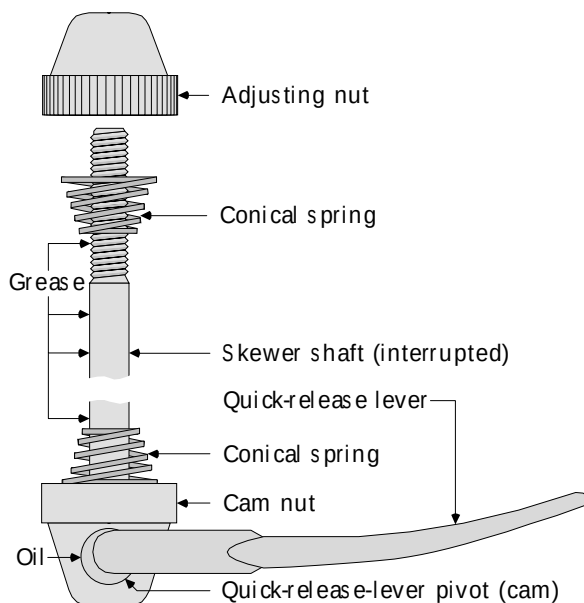
- Remove axle nuts and washers, grease axle threads.
- Install axle washers (textured face, if any, toward dropout).
- Thread on axle nuts (any flange on axle nut faces toward dropout).



18.30 Orientation of axle nut, washer, and dropout.

☐ If wheel has quick-release mechanism and quick-release mechanism has been removed from axle:

- Lubricate skewer shaft and threads.
- Lubricate pivot of quick-release lever.
- Install conical spring so that small end points to threaded end of skewer (OK to omit both springs, but not one).
- Install skewer in axle so that lever ends up on wheel's left side.
- Install second spring over threaded end of skewer so that small end points inward (unless using no springs).
- Thread on skewer adjusting nut.

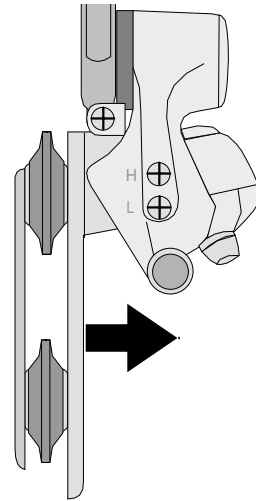


18.31 Parts identification and lubrication points of a quick-release mechanism.

☐ If skewer is already installed:

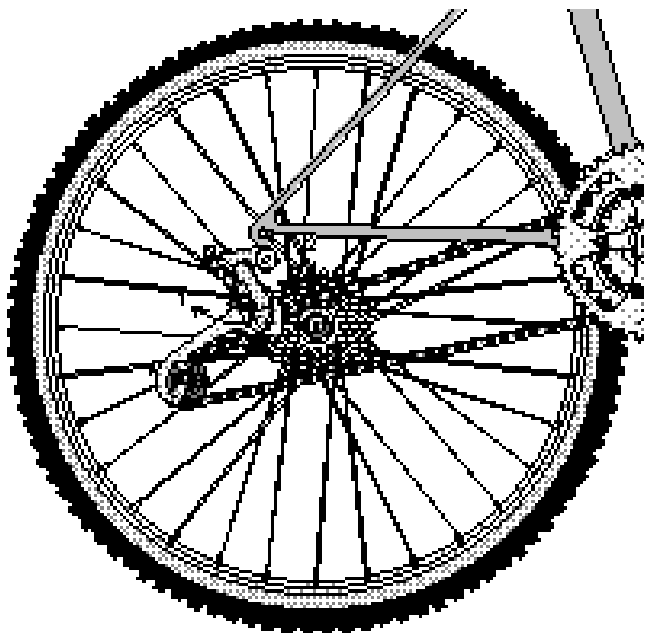
- Lubricate quick-release lever pivot.
- Check that there are two conical springs, or no conical springs (one is worse than none).
- Check that small ends of conical springs point toward center.

11. ☐ Use right shift control to make sure rear derailleur is moved out as far as it will go.



18.32 Use the shift-control mechanism to position the rear derailleur fully out before installing rear wheel.

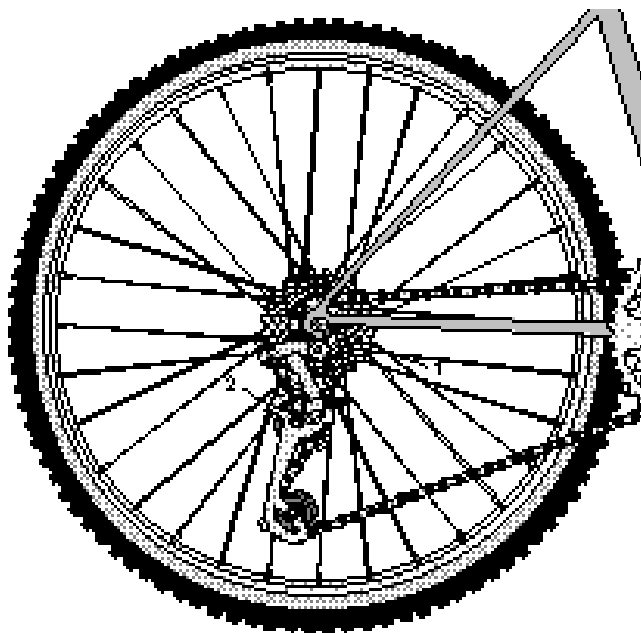
12. ☐ Position wheel so that cogs are above section of chain running from bottom of crankset to bottom of derailleur and below section of chain running from derailleur to top of crankset.



18.33 Rotate derailleur back, then place outermost cog of wheel between upper and lower sections of chain and engage outermost cog to upper section of chain.

18- WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

13. ☐ Pull back on derailleur and pull wheel up into dropout axle slots, making sure top of outermost cog engages chain.



18.34 Pull wheel back and up so that axle seats in axle slots, then allow derailleur to swing forward.

14. ☐ Temporarily secure wheel with quick release or axle nuts.
15. ☐ Close sidepull quick-release mechanism or hook up cantilever/U-brake/centerpull straddle wire.

In the next step, make sure that the wheel is centered between the seat stays and chain stays. This is not automatically achieved by shoving the axle fully into the dropout slots. Few manufacturers make frames so precisely that a properly-dished wheel will automatically center.

If the dropouts have horizontal axle-slots, then there will be ample adjustment to center the rim between the chain stays and a limited range of adjustment to center the wheel between the seat stays.

If the dropouts have vertical axle-slots, then there will be limited adjustment to center the rim between the chain stays and ample range of adjustment to center the wheel between the seat stays.

Because axle slots are often wider than the axle, it is usually possible to center the rim by moving the end of the axle at right angles to the direction of the slot. The slot may be filed wider to increase the amount of adjustment available. In most cases, this is not worth the trouble. A more practical approach is to make sure the wheel is correctly dished, then install the wheel so that it is centered as best as possible between the seat stays

and between the chain stays. If the dropouts have vertical axle-slots, precise centering between the seat stays should be possible, but the potential to center the wheel between the chain stays may be limited; if the dropouts have horizontal axle-slots, precise centering between the chain stays should be possible, but the potential to center the wheel between the seat stays may be limited. After installing the wheel as best as possible, then center the brake to the rim. On subsequent wheel installations, the wheel should be installed so that it ends up centered between the brake pads.

Some dropouts with horizontal axle-slots have positioning screws in the dropouts that butt against the axle. Once the wheel is properly positioned, these screws can be adjusted so that both butt against the axle. To position the wheel when installing it at a later time, then just pull it back until both ends of the axle are against the positioning screws.

16. Check one of following choices, depending on whether the brake was centered to correctly dished wheel previously or not:

- ☐ If brake was not centered to correctly dished wheel previously, position rim so that it is centered between seat stays and chain stays. Secure wheel temporarily and recheck centering.
☐ If brake was centered to correctly dished wheel previously, position rim so that it is centered between brake pads and chain stays (unless brake is under chain stays, in which case rim should be centered between brake pads and seat stays). Operate brake several times to ensure pads are returning to their natural positions. Secure wheel temporarily and recheck centering.

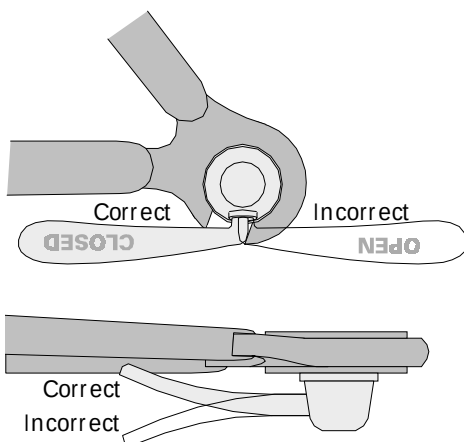
In the next step, the wheel is secured. There are few errors a mechanic can make that are more catastrophic than a wheel-mounting failure. If the wheel is retained by axle nuts, there is a simple procedure that guarantees a secure wheel: use axle washers, make sure the clamping surfaces of the axle fully engage the dropout surface, then use a torque wrench to tighten the axle nuts to the recommended torque.

If the wheel is retained by a quick-release mechanism, the solution is not so simple. Few manufacturers provide guidelines for use of the quick-release mechanisms; some of the manufacturers that do are simply quoting existing lore, rather than techniques that have been proven by research. "Existing lore" is the cause of many of the problems with quick-release mechanisms. It is strongly recommended that you read the earlier section, ***wheel-mounting failure*** (page 18-2), before proceeding with wheel installation.

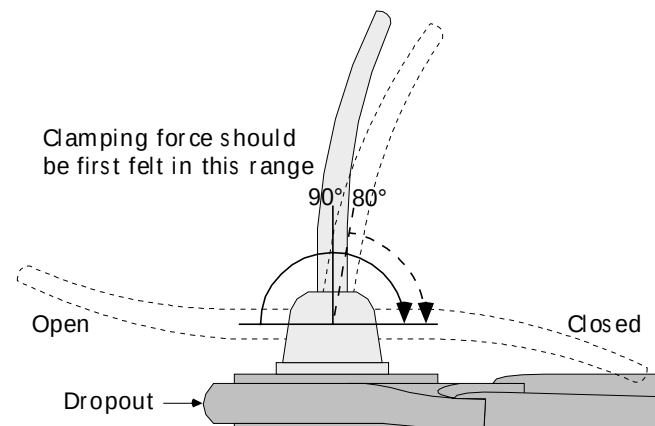
18- WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

17. Select one of following steps, depending on whether wheel is retained by axle nuts or quick-release mechanism:

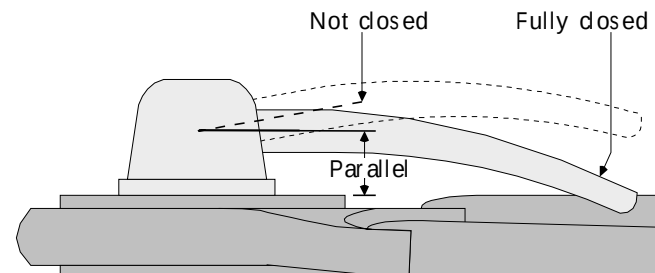
- [] If wheel has axle nuts, secure nuts to a torque of 240–300in-lbs (40–50lbs@6") and check that rim is still centered, as in step 16. If axle tends to rotate while securing axle nut, alternate tightening nuts on each side a little at a time.
- [] If wheel has quick-release mechanism:
 - a) Flip lever from open position toward closed position and check if clamping force is first encountered when lever is close to pointing straight out (base of lever perpendicular to dropout face). If dropouts are wider than hub width, clamping force does not begin until both dropouts are contacting faces of axle hardware.
 - b) If necessary, tighten or loosen adjusting-nut so that clamping force is first encountered when lever is close to pointing straight out (base of lever perpendicular to dropout face).
 - c) Flip lever to open position and rotate skewer so that when lever is flipped to closed position, lever will end up adjacent to, but not overlapping, seat stay or chain stay.
 - d) Close lever so that base of lever ends up at parallel to dropout, or past point where it is parallel.
 - e) If unable to close lever fully (base of lever parallel to dropout), open lever enough to be able to turn adjusting nut and loosen adjusting nut by very small increments until just able to close lever to parallel-to-dropout position.
 - f) Check if rim is still centered as in step 16.



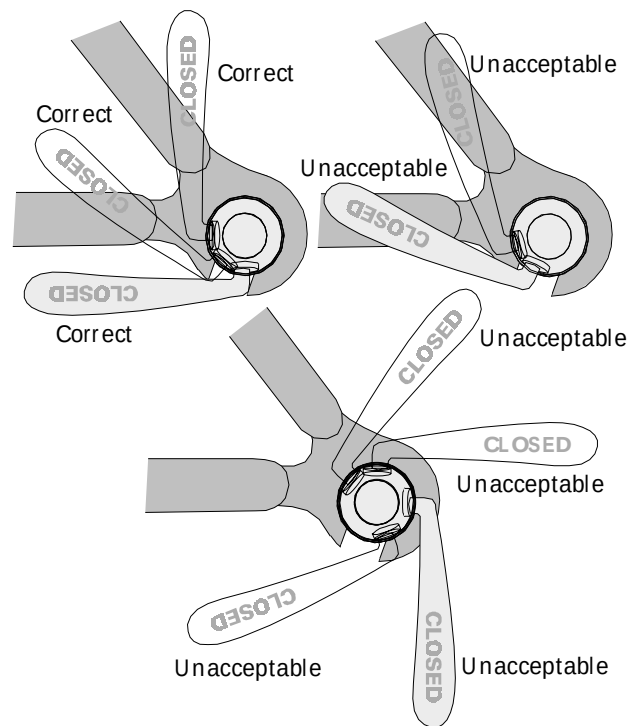
18.35 The solid images are quick-release mechanisms as they appear when they have been closed properly by utilizing the cam (flipping the lever). The outlined levers are quick-release mechanisms as they appear when they have been secured incorrectly (as though the lever was a wing-nut).



18.36 When properly set, as the lever swings from the open to closed position, clamping force should first be felt when the base of the lever is 80-90° from the closed position (the base of the lever parallel to the dropout face).



18.37 When closed, the base of the lever **must** be parallel to the dropout.



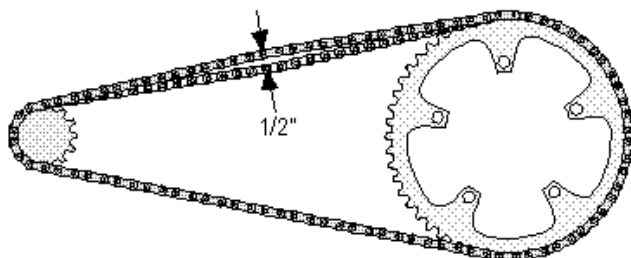
18.38 When closed, the lever should be adjacent to, but not overlapping, the chain stay or seat stay.

18- WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

18. [] Center brake pads as necessary (see chapter on brakes).
19. [] Pedal cranks to make sure chain is running smoothly through derailleur and over free-wheel cogs, and shift chain to more inner freewheel cog so that the bike will be in an easier gear to get started in.

NON-DERAILLEUR-CHAIN TENSION

If the chain tension is too tight, it will not operate smoothly. If it is too loose, it will fall off. Because gears are not perfectly round, chain tension will vary depending on the point of rotation of the crank. Find the point at which the chain is tightest and adjust the wheel forward or backward until the chain will move up and down 1/2" at the point halfway between the front and rear gears.



18.39 The chain should have 1/2" of free play when the crank has been rotated to the point that puts the chain under the most tension.

WHEEL-REMOVAL AND INSTALLATION TROUBLESHOOTING

Cause	Solution
SYMPTOM: Axle nuts or quick-release mechanism must be loosened further for wheel installation than was required for removal.	
Dropout spacing is too wide for hub width.	Add spacers to axle set, or re-space the rear triangle or fork blades.
SYMPTOM: Hands are needed to spread the dropouts in order to install the wheel.	
Dropout spacing is too narrow for hub width.	Remove spacers from axle set, or re-space the rear triangle or fork blades.
SYMPTOM: Wheel will not center automatically between fork blades when installed fully.	
Axle is bent.	Remove wheel and inspect for bent axle.
Wheel is not properly dished.	Remove wheel and inspect wheel dish.
Dropouts are different height.	Live with the problem or use a file to change the axle slot in the dropout until the wheel centers properly.

Continued

WHEEL-REMOVAL AND INSTALLATION

TROUBLESHOOTING *(continued)*

Cause	Solution
SYMPTOM: <i>Wheel cannot be centered between chain stays on bike with rear-dropout vertical axle-slots.</i>	
Axle is bent.	Remove wheel and inspect for bent axle.
Wheel is not properly dished.	Remove wheel and inspect wheel dish.
Chain stays are different lengths.	Live with the problem or use a file to change the axle slot in the dropout until the wheel centers properly.
SYMPTOM: <i>Wheel does not center between seat stays when installed fully in rear-dropout vertical axle-slots, or cannot be centered between seat stays at all (regardless of dropout type).</i>	
Axle is bent.	Remove wheel and inspect for bent axle.
Wheel is not properly dished.	Remove wheel and inspect wheel dish.
Dropouts are different height.	Live with the problem or use a file to change the axle slot in the dropout until the wheel centers properly.
SYMPTOM: <i>When axle is rotated, wheel changes position between fork blades or rear stays.</i>	
Axle is bent.	Remove wheel and inspect for bent axle.
SYMPTOM: <i>Wheel changes position after being installed.</i>	
Quick-release axle protrudes past axle locknut too far.	Remove wheel and make sure that axle protrusion is less than dropout thickness.
Quick release or axle nuts not adequately secure.	Secure quick release or axle nuts properly.
Axle nuts need washers.	Install washers between axle nuts and dropouts.
SYMPTOM: <i>Wheel is difficult to install when dropout width is good and wheel-retention mechanisms are adequately loose.</i>	
Dropouts badly misaligned.	Check and align dropouts.

19 – TIRES AND TUBES

ABOUT THIS CHAPTER

This chapter is about removing and installing tires and tubes, fixing a punctured inner tube, as well as installing a replacement tire and/or tube.

GENERAL INFORMATION

TERMINOLOGY

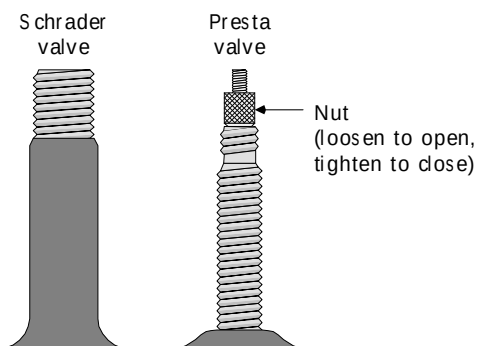
Tire: The rubber, cloth, and wire construction that touches the ground as you roll. A common misuse of the term is to use “tire” to refer to the entire wheel, including hub, spokes, rim, and tire.

Inner tube: The rubber air bladder that is inside the tire.

Valve: The stem on the inner tube that air is pumped through to fill the inner tube. When the inner tube is installed in the tire and the tire is installed on the rim, the valve may appear to be attached to the rim, as it is on automotive wheels, but it is always part of an inner tube.

Schrader valve: The correct name for the common bicycle inner-tube valve that is the same design as the one used on cars.

Presta valve: A valve that is narrower than a Schrader valve and has a built-in nut that must be loosened or tightened to open or close the valve. The Presta valve is sometimes called a “European valve” or “French valve.”



19.1 Schrader valve and Presta valve.

Tread: The textured or smooth rubber on the outer perimeter of the tire where the tire contacts the road.

Sidewall: The portion of the tire that starts at the outer perimeter of the rim and ends where the tread begins. It may be fabric that is coated with so little rubber that the coating is not apparent, or it may be covered with an obvious layer of rubber such as: a natural gum color, black, or other assorted colors.

Carcass: The structural body of the tire. The carcass consists primarily of a fabric of cloth threads that stretch from one edge of the tire to the other. This fabric is generally impregnated with rubber.

Threads: The individual cloth fibers that make up the carcass.

Tire bead: The edge of the tire that attaches to the rim. The tire bead is usually metal wire, but could be a Kevlar cord. The wire or cord is wrapped in the hem of the tire carcass.

Seating line: About 1/4" to 3/8" above the bottom edge of the tire is the seating line. This is usually a molded rubber line, but may be nothing more than a color change between the edge of the carcass hem and the sidewall of the tire. The color change might be because a portion of the tire bead has been dyed, or because a coating on the sidewall of the tire begins or ends at this point.

Rim strip: The tape-like strip that mounts between the inner tube and the rim. The rim strip's function is to protect the inner tube from damage by the rim and the spokes. Rim strips come in many forms; they may be rubber, plastic, cloth, or an adhesive cloth tape.

Tire liner: This tape-like strip that inhibits punctures is an optional protective liner that goes between the inner tube and the tire. The tire liner is always plastic, and is approximately as wide as the tread.

PREREQUISITES

Wheel removal and installation

In order to replace or service a tire or a tube, the wheel should be removed from the bike. See the **WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION** chapter, if unsure about wheel removal (page 18-6) and installation (page 18-15).

INDICATIONS

Flat-tire repair

The tire and tube will need to be removed and re-installed in order to fix a flat. It is important to keep in mind that all tires lose air gradually, even without a puncture. The fact that the tire has lost pressure does not always indicate that it is flat. Depending on the type and weight of rubber that the tube is made of, this loss could amount to just a few pounds a week, or as much as 20 pounds a day (lightweight latex tubes). Shops should have a policy of airing virtually all tires to the recommended pressure when a repair is checked in. This way, the mechanic can check for pressure loss when starting the job. However, there is little point in attempting to inflate a tire that has an obvious object sticking out of it.

There is another reason that tires might lose pressure and not be punctured. This is because some valves come loose from the factory, or develop looseness from age. In these cases, the valve just needs to be tightened. The **TIRE AND TUBE REMOVAL** procedure (page 19-3) starts with a check for a loose valve before going to the trouble of removing the wheel and tire.

Worn and damaged tires

The following list covers several of the symptoms that might be detected and would lead to replacing a tire:

- Tread on road-bike tires worn to the point that carcass threads are showing, or are about to show

- Knobs on off-road-bike tires worn to the point that they cause loss of traction

- Tread develops cracks from age and exposure to the elements

- Cuts in the tire that are through the rubber and have damaged threads in the carcass

- Abrasions in the tire's sidewall that have damaged threads in the carcass

- Bulges or distortions in the tire's shape (when inflated) that indicate hidden carcass damage

Wheel truing, replacement, and rebuilding

The tire needs to be removed and re-installed to do any wheel truing, wheel rebuilding, or wheel replacement.

TOOL CHOICES

The only tools required are tire levers, pump or compressor, and pressure gauges. All choices are adequate and any personal preference is fine.

TIME AND DIFFICULTY

Tire removal and re-installation is a 4–6 minute job of little difficulty. Patching a tube might take additional 1–3 minutes.

COMPLICATIONS

Difficult tire removal

Tires may be difficult to remove because of a tight fit or because of tire adhesion to the rim. If you are having trouble getting a tire off the rim, deflate the tube fully by squeezing the tire while the valve is open. Push the tire away from the rim bead all the way around on both sides to eliminate adhesion.

Difficult tire installation

Tires can be difficult to install for several reasons: the tire may simply be too tight a fit, there may be too much air in the tube, the tube or rim strip may be caught under the tire bead, the rim strip may be too bulky for a tight-fitting tire, or the tube may be too large for the tire cross-section.

Pinch flats on installation

Pinch flats can occur during installation when tire levers are used incorrectly.

Directional tread patterns

Many tires have directional tread designs. Look for directional arrows and notations to avoid installing the same tire twice.

High-seating bead section

Sometimes a portion of the tire bead seats higher on the rim than the rest of the tire. When you spin the wheel, you may see what appears to be a lump in the tire. Chances are this condition will lead to a blow-out. Newly-installed tires should be checked carefully for this condition. Causes may be the tube or rim strip caught under the tire bead, the valve-stem base caught under the tire bead, a damaged bead, poor fit, or a low-seating area elsewhere on the same side.

Low-seating bead section

When a portion of the tire bead sits too low on the rim, the tire has a flat spot. The low spot encourages a high spot elsewhere, which can lead to a blow-out. The causes usually are low inflation, or a high-seating area elsewhere.

Tire will not stay mounted

If the tire is seated properly at full inflation, and then develops high-seating areas or blows off the rim, the tire bead is probably damaged. Check for damage and replace the tire if the bead is damaged.

ABOUT THE REST OF THIS CHAPTER

The next part of this chapter assumes the most complex variation of the job being done, including removing a tire, patching an inner tube, replacing the tube (perhaps because the patch failed), solving problems with the rim strip, replacing the tire with a non-identical tire, installing a tire liner, and installing the tire. The following procedures for tire and tube service are divided into clear sections for each of these, so if doing a less complex job (removing and re-installing a tire in order to true a wheel, for example), then simply skip over the inappropriate sections.

At the end of the chapter is a table of rim and tire sizes and a troubleshooting chart.

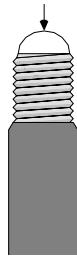
TIRE AND TUBE REMOVAL

PRE-REMOVAL INSPECTION

Inspecting for leaks, rubbing tires, and damaged tires

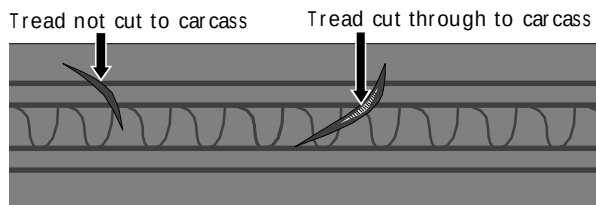
- 0a. [] If tire will hold air, inflate and inspect valve core for leaks. Tighten (Schrader valve only) if leaking.

Soap bubble indicates valve leak



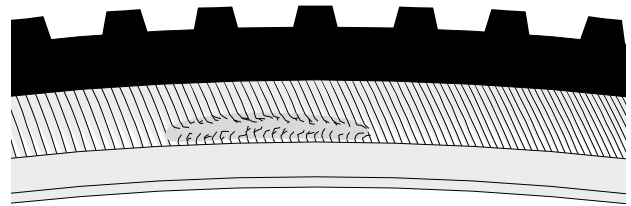
19.2 Smear a liquid (liquid soap) on top of the valve. If it bubbles up, the valve core needs to be tightened.

- 0b. [] If tire will hold air, inflate and inspect tread for cuts that have damaged threads in carcass. Replace tire if damaged threads are found.



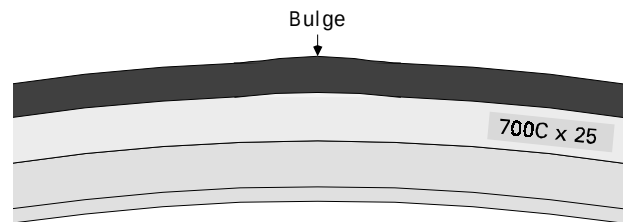
19.3 Cuts in the rubber are no problem, but cuts that go through the rubber into carcass threads mean the tire should be replaced.

- 0c. [] If tire will hold air, inflate and spin wheel to check for tire rubbing on brake pads or frame tubes. Replace tire if damaged threads are found.



19.4 This sidewall was damaged by a brake pad.

- 0d. [] If tire will hold air, inflate and check for bulges or deformations in tire's shape that would indicate there are cut or ruptured tire-carcass threads, hidden or not. Replace tire if damaged threads are found.



19.5 The bulge in this tire indicates that the carcass threads are damaged and separating.

Inspecting treadwear

Determining if the tread is worn out is a subjective process. It differs for tires used on pavement and tires used off-road.

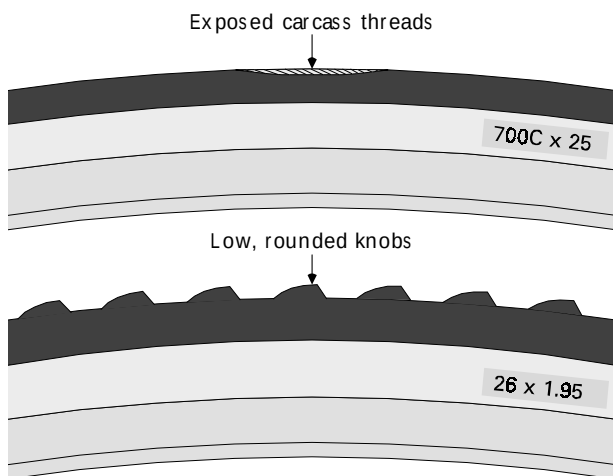
Road tires come with textured-tread and smooth-tread (bald or slick) designs. In either wet or dry conditions, the texture pattern is non-essential for traction, because bicycle tires do not hydroplane. The function of a tread pattern on an auto tire is to reduce hydroplaning. (Hydroplaning happens when a tire floats on the surface of the water; grooves in the tread allow the water to escape from under the tire. Automobile tires hydroplane because they have *less* load-per-square-inch of road contact than bicycle tires. This is not to say that a bicycle is not more likely to slide on wet pavement than on dry pavement; wet pavement causes bicycles to slide simply because the water changes the coefficient of friction of the pavement and the tire, not because of hydroplaning.) It is quite normal for a tire with a tread pattern to develop a smooth strip down the middle before the tire has seen many miles. The fact that the texture has worn off is not in itself an indication that the tire is shot. However, when the wear is getting bad, the bald section will become noticeably

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wider. If the tire has an obvious “flat top” that covers the majority of the tread width (seen when looking in-line with the tire, sighting across the top of the tire), then it’s time for a new tire. Looking for this wide “flat top” is the best way to determine whether a treadless tire is getting worn out. When the tire is off, feel the thickness and flexibility at the center of the tread. If the tire is obviously thinner and much more flexible in the center of the tread than at the edges, wear is advanced.

The issues are different with knobby off-road tires. The height and definition of the knobs create traction. When knobs are worn in the center of the tread, it affects braking and climbing traction. When knobs are worn on the outer portion of the tread, it affects cornering traction. Knobs wear two ways, they get shorter and they get rounded off. With the wheel on the bike and looking at the *top* of the wheel, check whether the center knobs are rounded on the front or back edges. If the tire shows wear on the leading edges (rear wheel only), climbing traction is affected. If worn on the trailing edges, braking traction is affected. If the center section knobs just appear short compared to the others, then they are simply worn out from miles, and all types of traction are affected. If the knobs on the outer portion of the tread appear worn, cornering traction is affected.

If the tread does not appear worn out, and there are no damaged carcass threads, it does not necessarily mean the tire is fine. Later, when the tire is removed, it should be inspected for age rot, one of the most common reasons for tire replacement.



19.6 The exposed carcass threads indicate this road tire is worn out, and the rounded knobs indicate this MTB tire is worn out.

0e. [] Rotate wheel slowly and inspect tread wear around whole tire.

0f. [] Inspect for and remove foreign objects in tread such as thorns, glass, tacks, wire, etc. Replace tire if damaged threads are found.

WHEEL REMOVAL

0g. [] See *WHEEL REMOVAL, RE-INSTALLATION, AND REPLACEMENT WORKSHEETS: REMOVING A FRONT OR REAR WHEEL*, steps 1–16.

TIRE REMOVAL

In the next step, mark the tire and valve in a specific way before removing them. By laying the tube on the tire in the orientation they had when both were mounted on the wheel, then it will be clear which section of the tire is likely to have the cause of the flat. Since a large part of successful flat repair is preventing the next flat, this localized cause-search is valuable in and of itself.

However, after searching the specific area of the tire, a thorough inspection of the tire is recommended. For example, if the reason for the flat was a piece of glass, then the rider probably ran through a patch of glass. It is quite likely that there are several pieces of glass in the tire, but only one has penetrated far enough to cause a flat, so far. A grease pencil/crayon or a regular ball-point pen can be used to mark on rubber.

1. [] Use a crayon or felt marker to mark tire sidewall on right side at valve and also mark valve stem on right side.

There are two basic valve types, Schrader (same as valve on car tires), and Presta (European style, narrower).

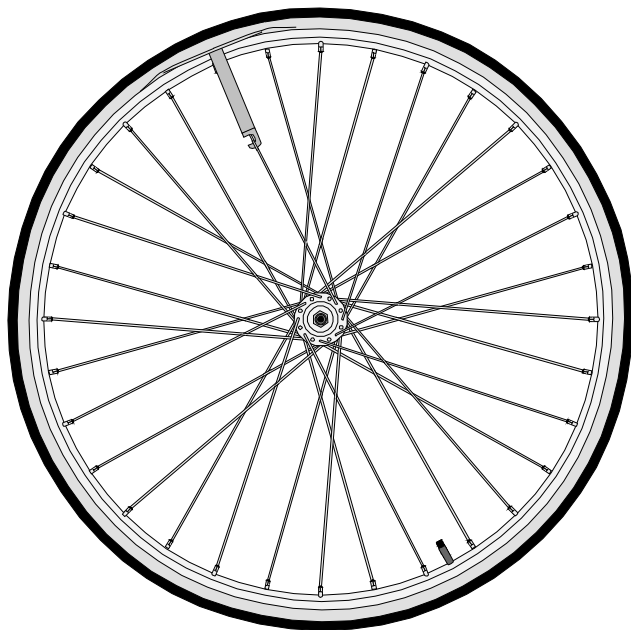
The Schrader valve has a small plunger in the top that must be depressed for air to escape. This plunger is pushed up by a spring (hidden beneath the plunger), which is what keeps the valve closed, even when there is no air pressure in the tube. This plunger, the spring, and the piece they are both built into are collectively called the valve core. The valve core can be threaded in and out of the valve stem, using a valve-core tool.

The Presta valve also has a little plunger, but no spring hidden inside to keep the valve closed. Instead, there is a small knurled nut on top of the plunger. When this nut is threaded down (with fingers), the plunger is pulled up and the valve is held closed. When the nut is threaded up, then the plunger can be pushed down with a finger to release air from the tube. Just below the plunger nut are the valve threads, which the valve cap screws onto. On rare occasions, there will be two wrench flats in these threads. In this case, the valve core

is removable, and it may need to be tightened to prevent the valve core from leaking. A small adjustable wrench is adequate to tighten a Presta-valve core.

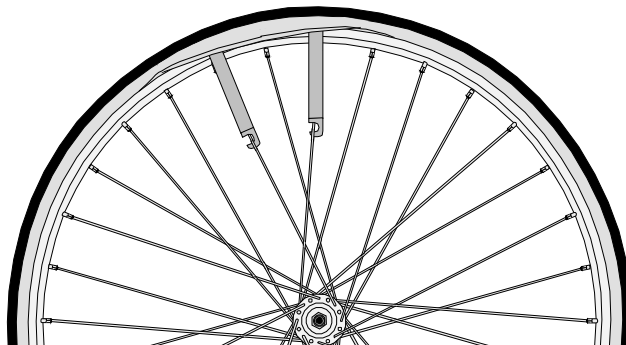
Either valve type may be partially rubber coated, or either may be an exposed threaded metal shaft that is threaded all the way to the rim. When the valve is threaded, then a valve-retaining nut is often used. This nut is threaded (by fingers only) down against the rim. The only function of the valve-retaining nut is to keep the valve from escaping into the rim when trying to press a pump head onto the valve. Valve-retaining nuts are also reputed to prevent movement between the tire and tube under hard braking conditions (and thus prevent the valve from separating from the tube), but the real cause of this problem is under-inflation, and nothing will reduce the problem other than higher inflation pressures.

2. [] **Remove valve cap (if any), valve-stem-retaining nut (if any), and loosen valve nut (if Presta valve).**
3. [] **Deflate tire, if not already deflated.**
4. [] **On right side of wheel, 180° away from valve (at a point where a right-side spoke joins rim), insert tire lever under edge of tire and lever tire out of rim, hooking tire lever onto spoke.**



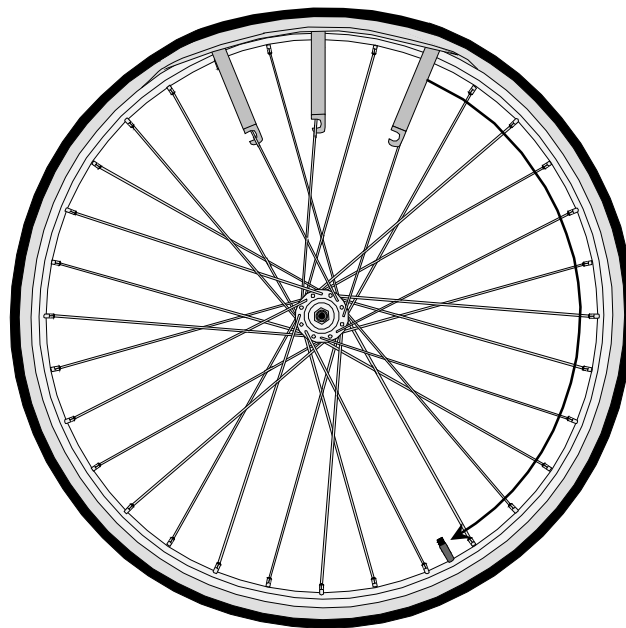
19.7 Insert a tire lever under the right tire bead and lever down until the lever can be hooked onto a right-side spoke.

5. [] **Two spokes clockwise from first tire lever, insert second tire lever under edge of tire, lever tire out of rim, and hook tire lever onto spoke.**



19.8 Insert a second tire lever two spokes away from the first and hook it onto a spoke.

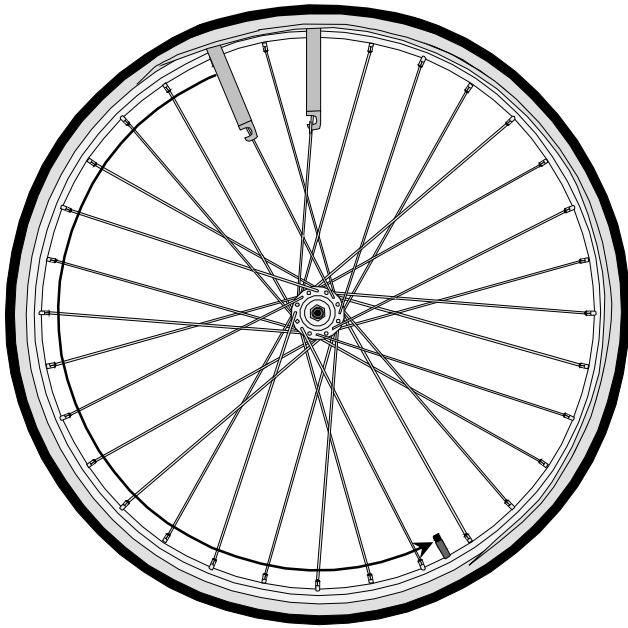
6. [] **Two spokes clockwise from second tire lever, insert third tire lever under edge of tire, lever tire out of rim, and slide tire lever clockwise around rim to unseat tire bead from rim. If tire lever will not slide, hook it to spoke, remove second tire lever, and insert second lever two spokes past third lever and try sliding it. Continue to leapfrog second and third levers in this fashion until a lever can be inserted and slid around rim.**



19.9 Insert a third tire lever about two spokes away from the second, lever it down, and attempt to slide the tire lever around the rim away from the second tire lever, all the way to the valve.

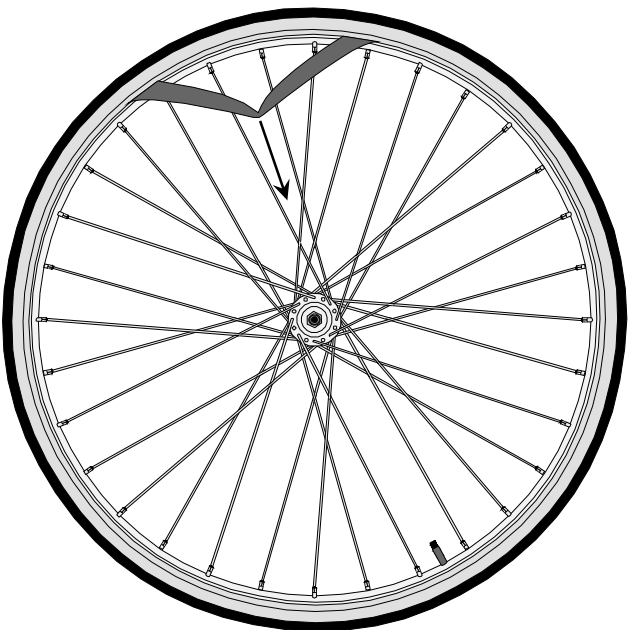
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7. [] Unhook first tire lever from spoke and slide counterclockwise around rim back to valve.



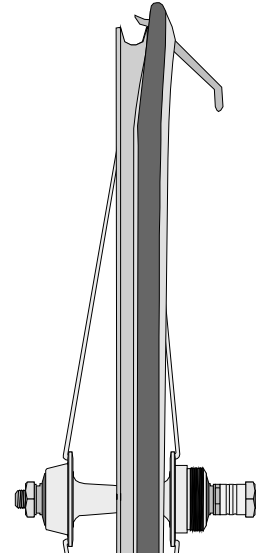
19.10 Unhook the first tire lever from the spoke and slide it around the rim the opposite way back to the valve.

8. [] 180° away from valve, pull inner tube out of tire and continue to pull until all of inner tube is out of tire. Finish by pulling valve out of rim.



19.11 Opposite the valve, pull the tube out of the tire.

9. [] Use tire lever to lift second bead over same side of rim as first bead.



19.12 Use a tire lever to lift the second bead over the same side of the rim as the first bead.

INSPECTION, REPAIR, AND FIT

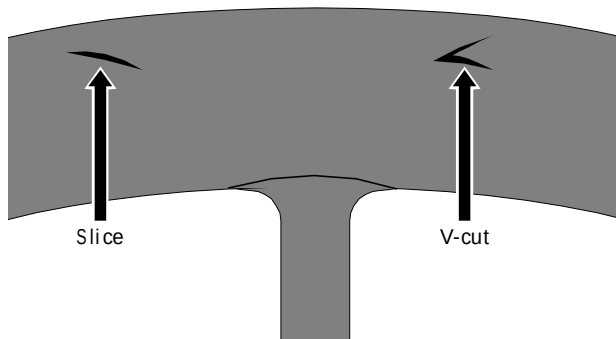
TUBE INSPECTION

Many bike shops do not do tube repair. The reason they give is that it is more economical to just replace the tube. It is possible that they reach this conclusion by taking short cuts that should not be taken when installing a new tube. The process of putting a patch on a tube is not time consuming, in itself. It takes a mechanic that knows what to do less than 1 minute to apply the glue and the patch, and then inspect whether the patch is good. The real time that is required comes from searching for the hole in the tube. When shops don't patch tubes (citing the economy), it is a good bet that they don't inspect the old tube. Inspecting the old tube should *never* be skipped, because this is one of the best ways to determine the cause of the flat (and prevent its re-occurrence). Regardless of whether your shop does or doesn't patch tubes, don't skip inspecting the old tube. (While we are on this subject, patching tubes is a highly efficient form of recycling of a product made from a non-renewable resource.)

- 10. Perform following steps (in order) until leak is found, then ignore remaining steps:**

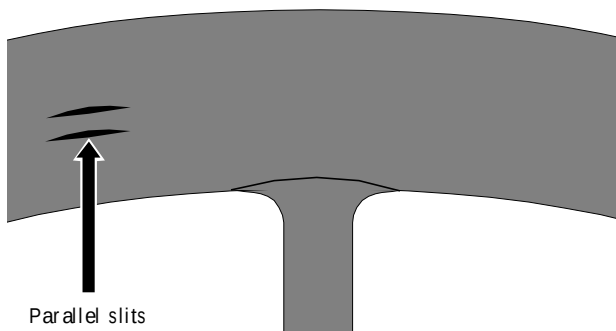
- [] Attempt to inflate tube and listen for leaking air to find hole.

- [] If tube is holding air easily, over-inflate tube to enlarge puncture and make it easier to find. Tubes can easily be over-inflated until they are twice as fat as their inflated and un-expanded size.
 - [] If leak is not audible, rotate tube with outer perimeter close to cheek or tip of nose to feel for fine streams of air that cannot be heard.
 - [] Submerge tube in water to look for bubbles rising from tube to find hole if all other techniques have failed to find hole.
11. [] Mark hole (with crayon or ball-point pen) with an X or cross that extends an inch in every direction from middle of hole.
12. Inspect hole and check off one or more of following choices to find and eliminate cause of puncture:
- [] Puncture is a single or multiple pin hole in outer perimeter of tube. Inspect tire for thorns, tacks, or small wires.
 - [] Puncture is a cut or slit on outer perimeter. Inspect tire for glass, nail, or other large foreign objects.



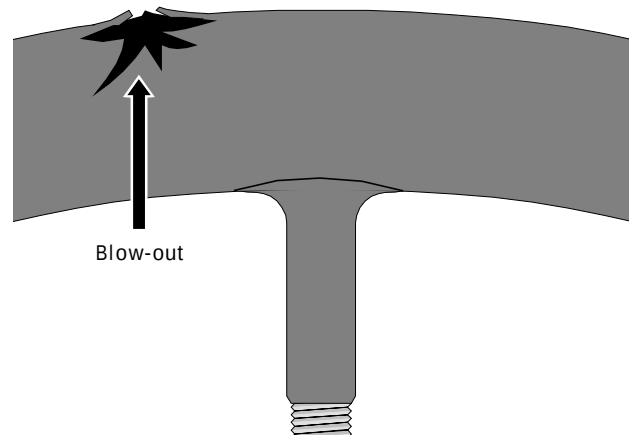
19.13 Cuts like these should mean inspect the tire for glass, a nail, or some other large foreign object.

- [] Puncture is a pair of horizontal, parallel slits on side of inner tube. Inspect for rim bead damage. Keep tires better inflated and avoid hitting obstacles on riding surface.

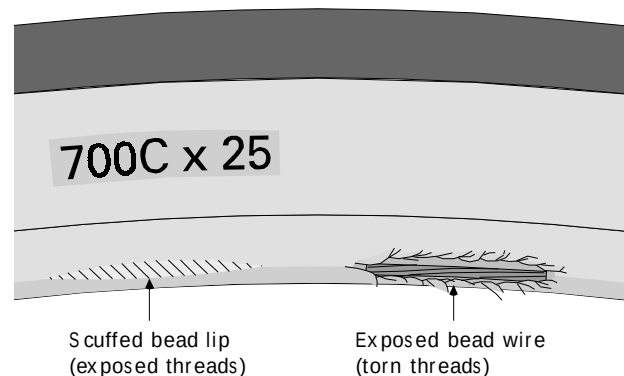


19.14 Two parallel slits on the side of the tube indicate that the tire has been bottomed out and the tube has been pinched between the rim and the riding surface, or that a tire-removal tool has been used improperly.

- [] Puncture is a large shredded hole. Inspect tire for large holes and tire bead for damage from being blown off rim.
- [] Puncture is a pin hole or slit on inner perimeter of tube. Inspect rim strip for position problem or failure. Inspect inside of rim for sharp burrs. Inspect spokes for protruding through nipple heads.
- [] Puncture is a cut in rubber at base of valve. Install tube so valve is straight, and keep tire fully inflated to prevent tire creep around rim.
- [] Puncture is a failure of seam where the ends of tube are joined together to make a circle. Inspect whether tube size is too small for fatness or diameter of tire.



19.15 This blown-out tube was caused by either a large hole in the tire or a tire-mounting failure.



19.16 These abrasions and tears on the tire bead could lead to another blowout.

NOTE: If tube will be replaced, go to **CHECKING NEW INNER-TUBE FIT** (page 19-8). If not repairing or replacing inner tube, go to **TIRE INSPECTION** (page 19-9). If not repairing or replacing inner tube, but installing a new tire, go to **TIRE FIT AND COMPATIBILITY** (page 19-10). If simply re-installing the original tube and tire, go to **INSPECTING AND INSTALLING RIM STRIPS** (page 19-12).

TUBE REPAIR

Many bike shops do not patch tubes. The usual excuse is that it is not financially sensible. Although this argument has some holes in it, there is a more important issue at stake. The variety of tubes out there in the real world usually exceeds the variety of stock of tubes that a bike shop has on hand. Given the choice between installing a tube that is not a good match, or patching a tube that has a minor puncture, it is preferable to patch the tube. For this reason, a mechanic should know how to patch tubes in a way that will make the patched tube as reliable as a replacement tube. A well-done patch job will successfully repair a simple puncture. Slits, tears, multiple punctures, and seam failures cannot be reliably patched.

There are several brands of good patch kits on the market, and they all have one thing in common: the patches have feathered edges. This is easy to see, because the perimeter of the patch will be a different color than the center of the patch. Feathered patches are not only better quality and more suited to lightweight bicycle tubes, they are a lot easier to use. This is because the patch is laminated between a layer of foil and a layer of cellophane. The foil protects the adhesive side of the patch and the cellophane provides something to hold onto without touching the adhesive once the foil has been peeled. The old standby brand is REMA, but several other companies now make feathered patches.

Keep these following tips in mind to insure a successful patch job:

Don't miss the hole. If the hole is well marked by an X or cross that is larger than the size of the patch, then it is less likely the hole will be near the edge of the patch.

Roughing the tube up eliminates surface contamination and creates a rough surface, which helps the glue adhere to the tube. Do a thorough job.

Gluing needs to be thorough, but don't overdue it. Use a *thin* layer that evenly extends slightly past the area the patch will cover. A lumpy buildup creates a greater likelihood of patch failure. Starting with plenty of glue and smearing it around quickly as far as necessary to get the covering thin will achieve the best result. Putting on a little, finding that it's not enough, then adding more after the first application has partially dried is asking for trouble.

13. [] Use emery cloth (usually comes with patch kit) to rough up an area around hole that is slightly larger than the patch.

14. [] Use rubber buffer to clean roughed area.

15. [] Put dime-sized blob of glue on hole and use finger to spread glue out thoroughly. Glued area must be at least slightly larger than patch to be applied.

16. [] To speed glue drying, inflate tube if possible until it is expanded.

17. [] Deflate tube if it was expanded in previous step.

18. [] When glue is dry, peel foil-back off patch, being careful not to touch exposed surface of patch, and apply to tube. Center patch over hole.

19. [] Roll a screwdriver handle back and forth over patch, or apply pressure in some other way to get patch to stick well. Cellophane on patch (if any) can be left in place, or may be removed.

20. With tube mostly inflated, check for:

[] Patch for security (edges not peeling up)

[] Leaks coming from edge of patch

[] Other leaks elsewhere in tube.

21. [] Deflate tube just enough so that it still has shape, but is not expanded at all.

22. [] Optional: use talcum powder, tire talc, or cornstarch on patched area to neutralize glue past edges of patch, so tube will not stick to inside of tire.

NOTE: If inner tube has been patched, go to *TIRE INSPECTION* (page 19-9). If installing a new tire, go to *TIRE FIT AND COMPATIBILITY* (page 19-10). If simply re-installing the original tube and tire, go to *INSPECTING AND INSTALLING RIM STRIPS* (page 19-12).

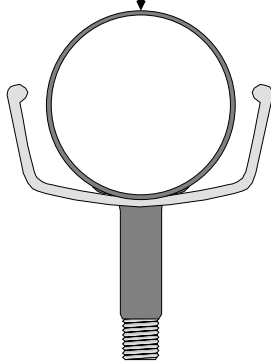
CHECKING NEW INNER-TUBE FIT

It would seem that tube fit would simply be a matter of putting a tube inside a tire of the same nominal size. Because tire nominal sizes are not exact measurements, and because tire manufacturers "play" with reality for marketing reasons, the marking on the tire does not accurately say how wide the tire is. The size number (27", 700C, 26") is generally accurate, but there are several sizes that are easily confused and not interchangeable, and there are dissimilar-named sizes that are interchangeable. The 26"×1-3/8" size sounds similar to a tube that might be marked 26"×1.5" & 1.75", but these numbers come from completely different sizing systems and the two 26" are not at all the same. On the other hand 27" and 700C don't sound at all alike, but with regards to tube fit, they are fully interchangeable.

Another factor that further complicates tube fit is that tubes are simply inconsistent. I have seen two brands of tubes marked 700C×25 vary in width by as much as 50%. Use the marked designation of the tire to determine which tube to use, but then perform these simple tests to confirm that it is a good fit.

23. [] Inflate tube until it has shape *but is not expanded*.
24. Place tube on rim and check for following symptoms that tube is too small:
- [] If tube needs to be stretched to fit on rim it is too small.
 - [] If tube is skinnier than inside width of rim, tube is too small.

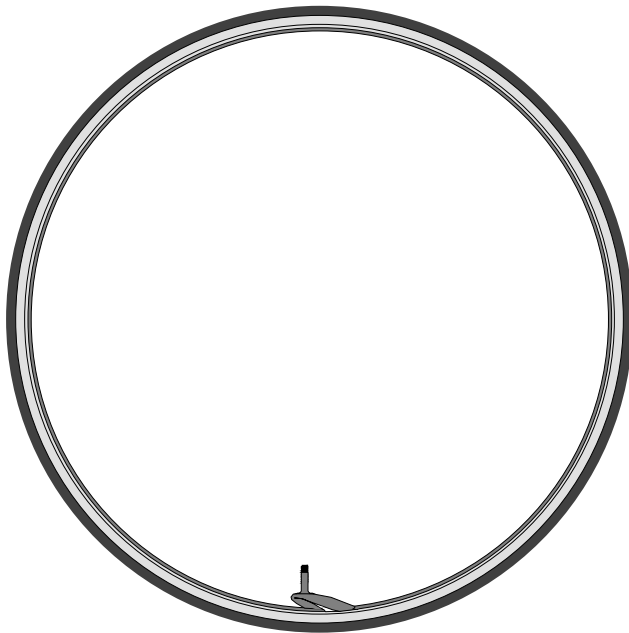
Inflated (but not expanded) tube



19.17 The fact that the inflated tube is narrower than the inside width of the rim suggests it will be too small for the tire.

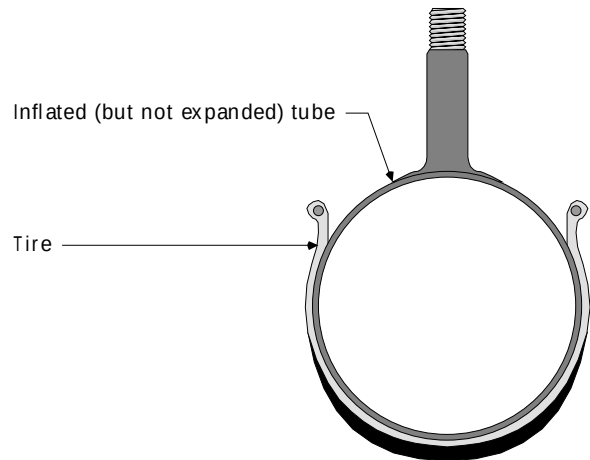
If several fingers can fit between the tube and rim, it is normal. The tube should be installed in a tire, not the rim, to be checked for being too large.

25. Place tube inside of tire and check for following symptoms that tube is too large:
- [] If tube has doubled over itself to fit inside tire, diameter of tube is too large for tire.



19.18 If the tube has doubled over to fit in the tire, it is too large.

- [] If tube is fatter than tire height (viewing tire from side, tube extends beyond inner perimeter of tire all way around tire), tube is too fat for tire.



19.19 The inflated tube will not fit inside the tire. The tube is too fat.

NOTE: If inner tube has been replaced, go to **CHANGING VALVE TYPES** (below). If inner tube has been replaced with one of same valve type, go to **TIRE INSPECTION** (page 19-9). If installing a new tire, go to **TIRE FIT AND COMPATIBILITY** (page 19-10). If simply re-installing the original tube and tire, go to **INSPECTING AND INSTALLING RIM STRIPS** (page 19-12).

CHANGING VALVE TYPES

26. [] If replacing Presta valve with Schrader valve, ream or drill rim hole to >9mm.
27. [] If replacing a Schrader valve with a Presta valve, valve grommet should be installed in rim to reduce hole size and restrict entry of dirt into rim.

TIRE INSPECTION

When the tire was still on the wheel, it was inspected for external damage and wear. Now it needs further inspections that are best done while the tire is off the rim.

The first of these inspections is for age rot. Rubber deteriorates with age, and it will show up in the tread of a tire as thousands of hairline cracks that appear more obviously when squeezing the tread. The tread is a primary factor in puncture resistance. Each of these cracks is like having an open door in a fortress wall. These cracks make the tire more vulnerable to punctures, particularly from glass. The tread also protects the carcass threads from exposure to the elements. With cracks

19 – TIRES AND TUBES

in the tread, there is a greater chance of these threads deteriorating, leading to more stone bruises (carcass threads ruptured by sharp stones) and blow outs.

28. [] Squeeze sides of tire together and inspect tread for hairline cracks that open up when tire is squeezed.

29. [] If tube was punctured, place tube on tire with valve lined up with mark (from step 1) on right sidewall and with sidewall and valve marks both facing up. Find the puncture and closely inspect the tire 3" either way from the puncture for foreign objects.

30. [] Visually inspect inside of tire for foreign objects (thorns, wire, glass, etc.) and remove them.

After a *thorough* visual inspection of the inside of the tire, use your finger tips to feel for foreign objects. The visual inspection should have detected anything that could cut fingers. The feel test will find small thorns, more than anything else. Out here in eastern Colorado, we have small cactus thorns that are as thin as hairs. They cannot be seen, but they certainly can be detected by feel. If you want to be cautious, use a rag instead of your fingers. Most thorns and staples will catch on a rag, but you're sure to miss a few that fingers would find.

31. [] Stroke inside of tire softly and carefully with finger tips to find thorns or other small foreign objects that might have missed by visual inspection and remove them.

32. [] Visually inspect inside of tire for damaged threads in the carcass. Replace tire if any threads are cut.

33. [] Inspect tire beads for abrasions and delaminations, especially if tube was blown out. Replace tire if problems are found.

NOTE: If installing a new tire, go to TIRE FIT AND COMPATIBILITY (page 19-10). If simply re-installing the original tube and tire, go to INSPECTING AND INSTALLING RIM STRIPS (page 19-12).

TIRE FIT AND COMPATIBILITY

Nothing is any more confusing on the bicycle than tire and rim sizes. The basic confusion is that the sizes consist of numbers that sound as though they might be measurements of the rim and tire. It would seem to make sense that these measurements relate to the dimensions of the rim and tire where these two parts attach to each other, but with the exception of the new and rarely-used ISO designations, the numbers have nothing to do with the measurements of the tire and rim where they attach to each other.

Traditional tire sizes were measurements of the outside diameter of the tread of the tire (size) and the fatness of the tire when mounted and inflated on the rim (width). Although these numbers might have been close to reality when they were created, tires have changed their shape and proportions without changing their dimensions at the interface to the rim many times since this system of categorization was created. Rims are named by the size of the tire that fits it, and this is why a 26" MTB rim measures approximately 22.5". To further complicate matters, sometimes there is more than one name for a size. The 700C size was developed in France, and is a metric size. Canadian companies copied the size, but gave it their own name, 28"×1-1/2". To further confuse matters, this is a smaller size than the familiar 27" (British in origin).

To solve this problem, there are now ISO (International Standards Organization) sizes, which are based on measurements of the tire and rim that relate to how these two parts fit together. These measurements are metric. Traditional tire sizes have always listed size followed by width, such as 27" (size) × 1-1/4" (width) or 700C (size) × 25 (width). So that ISO sizes will not be confused with traditional sizes, they list width, then size. The ISO equivalent of a 700C×25 tire would be 20-622. The ISO equivalent of a 26"×1.75" rim would be 20-559. In both cases, the second three-digit part of the number refers to the *bead diameter*. On the tire, this number is simply the diameter at the inside perimeter. On the rim, this number is the diameter at the point on the rim where the tire bead sits, in which case it is called the *bead-seat diameter*.

The first part of the ISO number refers to the width of the tire or rim. With regards to the rim, this is simply a measurement between the rim flanges. For the tire, the measurement is not so simple. Because tire fatness changes with rim size, inflation pressure, and whether the tire is installed or not, the ISO started its tire-width number by measuring the only constant there is in regard to tire width — its width when flattened. This flattened width is a very unfamiliar number (the very narrow 700C×21 tires have flattened widths of close to 50mm). The ISO chose to divide the flattened width by an arbitrary constant of 2.5 to convert flattened width to *ISO section width* so that ISO's width number might be a more familiar number.

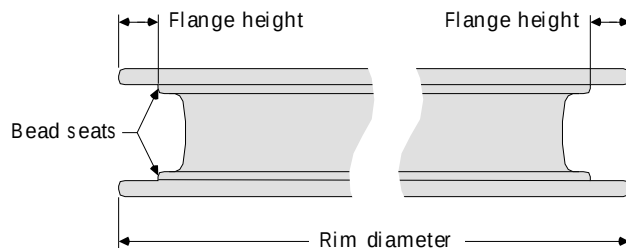
The advantage of the ISO approach to tire and rim width is that whether a tire's width is compatible with a rim's width can easily be measured and calculated. For any given rim, the tire's *section width* can be between 1.4 and 2.0 (road bikes) or 1.4 and 3.0

(MTBs) times the rim's inside width. When the tire width is outside the range created by multiplying these factors times the rim's inside width, then handling may be compromised, tires may be damaged by the brake pads, the wheel may be difficult to remove, or the rim may be more vulnerable to damage. If the ISO width information is not used, and the mechanic relies on traditional size information alone, then all the problems listed above are risked.

In the following steps, "size" refers to the overall diameter of the wheel, and "width" refers to how fat the tire and rim are.

34. Determine rim size by one or all of following choices:

- [] Look up rim size on sticker or engraved on rim. Enter here: _____
- [] Convert ISO size marked on rim to conventional size by looking in ISO size column on the TIRE AND RIM SIZES table (page 19-16) and read across to Nominal size column. Enter here: _____
- [] Determine ISO size of rim and convert to conventional size by measuring exact rim diameter and subtracting flange height twice to determine ISO size, then looking in ISO size column on the TIRE AND RIM SIZES table (page 19-16) and read across to Nominal size column. Enter here: _____
- [] Measure outside diameter of rim and look up size by finding measurement on the TIRE AND RIM SIZES table (page 19-16) in the Approximate rim O.D. column and reading across to Nominal size column. Enter here: _____



19.20 Measure the rim's diameter and subtract the flange height twice to calculate the ISO bead seat diameter.

35. Determine size of new tire by one or all of following choices:

- [] Look on sidewall of tire or molded in edge of tread for nominal size description. Enter here: _____
- [] Look on sidewall of tire or molded in edge of tread for ISO size description. Enter here: _____

[] Use TIRE AND RIM SIZES table (page 19-16) to convert ISO size to Nominal size, or Nominal size to ISO size in order to compare tire's size to rim's size, whichever nomenclature is used. Enter here: _____

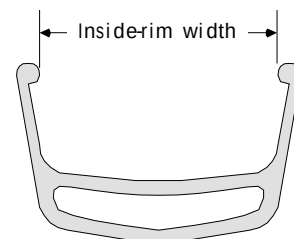
36. [] Check that tire size and rim size are compatible by comparing steps 34 and 35.

Assuming that the tire is being replaced with one of the same size category and the old rim will be re-used, if the new tire is a different width, check if the tire is compatible with the rim width. In everyone's mind, tire selection should simply be a matter of matching the named width of the rim with the named width of the tire, and that all 26" MTB tires should be compatible with all 26" MTB rims. However, for any size (such as 26" MTB) there are a variety of rim widths and a variety of tire widths. To complicate matters further, the actual width for two rims that are named the same can be quite different. The same is true of tires. If combining the narrowest of rims with the widest of tires in a given size group, or vice versa, then there may be a problem. There are a few simple measurements that can be taken and calculations to make to determine whether the tire width is acceptable to use with the rim.

If the tire is too narrow for the rim, there are several consequences. The height profile of the tire will be too low, which can lead to more rim damage and more pinch flats. Also, the shape of the tire will be deformed in a way that reduces cornering performance (particularly on road bikes). If the tire is too wide for the rim, there may be different consequences. If the bike has cantilever brakes, a common occurrence with a tire that is too wide for the rim is that the brake pads end up rubbing on the tire, resulting in its premature demise. When a tire that is too wide is installed on a road bike, the brake pads may still not clear the tire, even with the quick release all the way open. Also on road bikes, when this rim and tire combination is used, there could be a squirmy feel in the handling, depending on the tire design and the air pressure.

The following steps determine whether the new tire is within the range of widths that is acceptable on the rim.

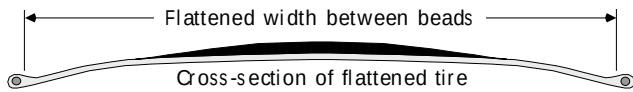
37. [] Use caliper to measure inside width of rim. Record measurement here: _____



19.21 Rim width is measured between the flanges.

19 – TIRES AND TUBES

38. [] **Measure width from bead-to-bead (edge-to-edge) of tire (flattened as best possible) and record width here:** _____



19.22 Flatten the tire and measure bead-to-bead to determine flattened width.

39. [] **Divide answer in step 38 by 2.5 to determine “section width” and record answer here:** _____
40. [] **Multiply rim inside width from step 37 by 1.4 to determine narrowest acceptable “section width” and record answer here:** _____
41. [] **Multiply rim inside width from step 37 by 2.0 (road bikes) or 3.0 (MTBs) to determine widest acceptable “section width” and record answer here:** _____
42. **Check one of following choices:**
- [] **Step 39 is included in range of steps 40 and 41, so tire width is ideal for rim.**
 - [] **Step 39 is outside of range of steps 40 and 41, so tire width is potentially unacceptable for rim. (See preceding text for description of possible problems.)**

INSTALLATION

INSTALLING A TIRE LINER (OPTIONAL)

43. [] **Roll tire liner out on inside of tire.**
44. [] **Overlap the liner over itself and tape excess down, but do not cut off excess (sharp edge left by cut may cut tube).**
45. [] **Use masking tape to hold tire liner centered under tread (optional).**

INSPECTING AND INSTALLING RIM STRIPS

The rim strip protects the tube from the rim, the spoke nipples, and the spokes. Problems with the rim strip are often the cause of “mystery” flats. There is a common type of rim called a “modular” or “double-wall” rim. The characteristic of this rim is that the tube rests on one wall of the rim, and holes are drilled in this wall for access to the spoke nipples. Sometimes these holes are filled with re-enforcing sockets called ferrules. The problem with this rim type is that the rim strip can appear to cover these holes adequately

when the tire and tube is off, but when the tire and tube are installed and under pressure the rim strip sinks down into the nipple access hole, exposing the sharp edges of the hole to the tube.

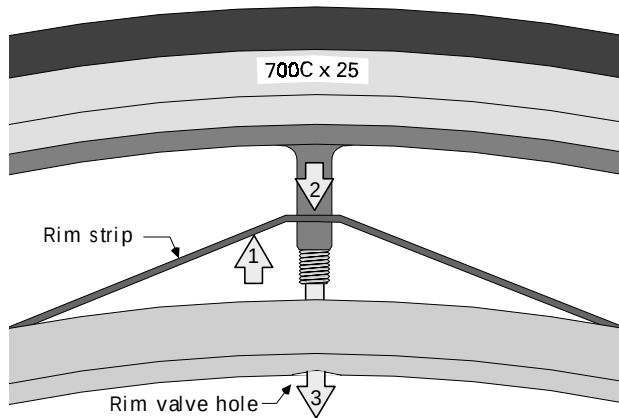
Bicycle manufacturers are often ignorant of this and supply bikes with this rim type and include inexpensive black rubber rim strips that are too elastic. Other publications often mention using strapping tape as an alternative. Strapping tape is known to crack easily and allow the tube to go into the nipple-access holes (causing flats). Adhesive cloth rim strips and polyurethane rim strips do the best job. Polyurethane rim strips are thin and smooth (makes tire installation easier), elastic enough for easy installation and removal, resistant to cracking, and stiff enough that they do not deflect down into the nipple-access hole. In either case, the challenge is getting the correct-width rim strip. Too narrow and the slightest shift of the rim strip exposes the spoke access holes. Too wide and the rim strip overlaps the rim’s bead seat, interfering with proper mounting of the tire. Polyurethane rim strips that are too wide can be cut down to size with scissors.

46. [] **Inspect that rim strip completely covers all spoke-nipple heads, or all access holes to spoke nipples. Adjust or replace as necessary.**
47. [] **Inspect that rim strip has no tears, cuts, or splits. Replace rim strip if damaged.**
48. [] **Inspect that rim strip is not twisted. Adjust as necessary.**
49. [] **Inspect that rim strip does not overlap rim bead seat (part of rim on which tire bead sits). Adjust or replace as necessary.**
50. [] **If replacing rim strip, insert valve, pencil, or #2 Phillips screwdriver through rim-strip valve hole and rim valve hole to keep holes aligned, then stretch rim strip around rest of rim. Check that rim strip is correctly positioned.**

INSTALLING THE TIRE AND TUBE

51. [] **Inflate tube so that it has shape but is not expanded.**
52. [] **Place tube inside tire with valve adjacent to pressure rating on side of tire.**
53. [] **Stand wheel on table or floor with valve hole at 12:00, with wheel’s right side facing you.**

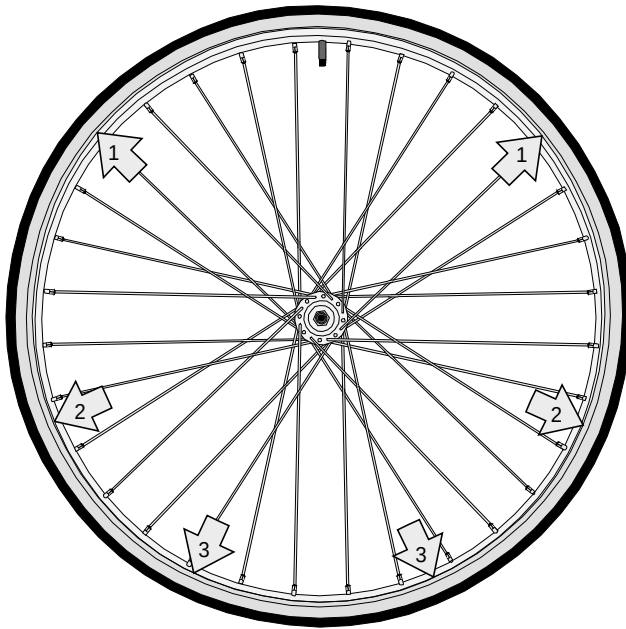
In the next step, be careful not to jam the rim strip through the rim hole with the valve. If necessary, lift the rim strip up, insert the valve through the rim strip, then put the valve (with rim strip already on it) into the valve hole in the rim (see figure 19-23).



19.23 1) Lift the rim strip out of the rim. 2) Insert the valve through the rim strip. 3) Insert the valve into the valve hole.

54. [] Place valve into valve hole (being careful not to jam the rim strip through the valve hole). Tire should have directional arrow (if any) pointing in the direction of rotation. If unsure, put tire's label on right side.

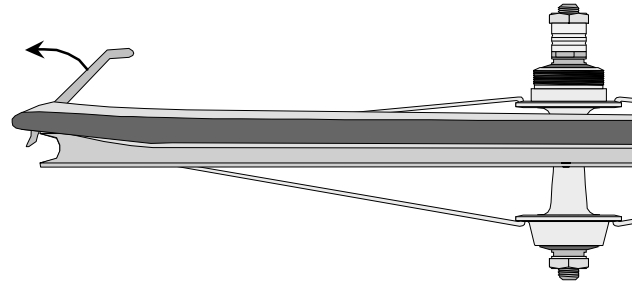
55. [] Starting at valve, work back-bead into rim with both hands simultaneously, working down toward 6:00 position.



19.24 Use your hands to work the back-bead into the rim at the valve, then at the #1 positions, then at the #2 positions, and then at the #3 positions.

56. [] When bead gets difficult to install, turn wheel over so that valve is at 6:00 and remaining uninstalled portion of back-bead is near 12:00.

57. [] Holding tire bead firmly to rim with one hand, use a tire lever from one end of the uninstalled portion to lever bead of tire over rim until bead is completely installed between rim flanges.



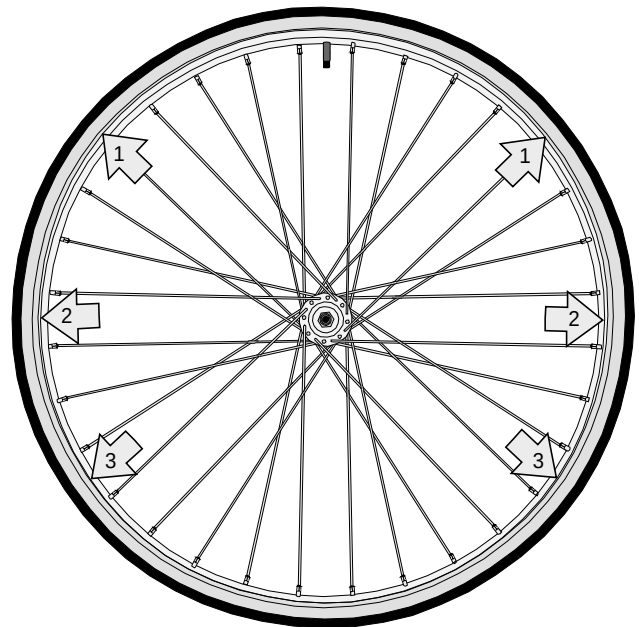
19.25 Lever the bead onto the rim, using the tire lever in the same orientation as when bead was removed.

58. [] Deflecting tire towards center of rim, inspect all around wheel for rim strip that has been pushed out of place, or section of tube caught under installed bead of tire.

59. [] With wheel horizontal, use fingers to work tube between rim flanges all around wheel. Deflate tube slightly if necessary to get it between rim flanges.

60. [] Stand wheel up, face wheel's right and rotate so valve is at 12:00.

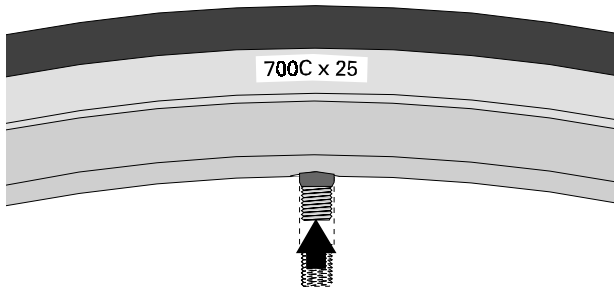
61. [] Starting at valve, use fingers to work second bead over rim flange both ways away from valve until half or more of bead is in place.



19.26 Use your hands to work the bead into the rim at the valve, then at the #1 positions, then at the #2 positions, and then at the #3 positions.

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- 62. []** Seat valve by pushing it as far as it will go into tire to prevent valve base from becoming lodged under tire beads.



19.27 *When the second bead is mostly in the rim, stop to press the valve into the tire.*

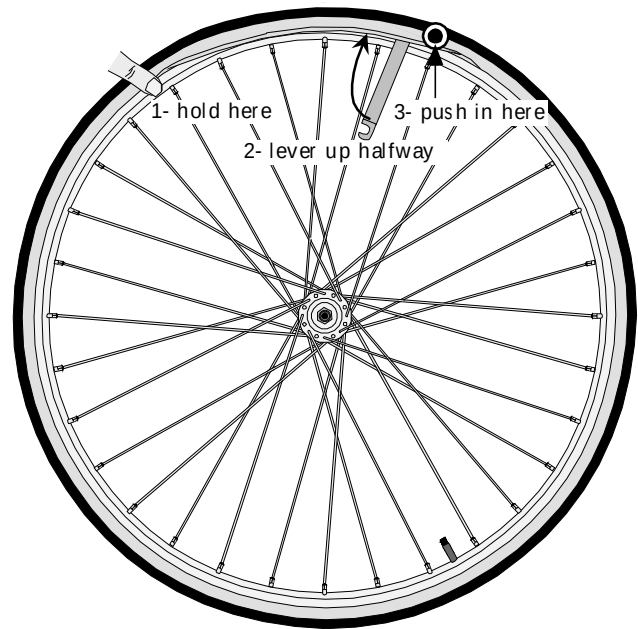
- 63. []** Turn wheel over so that valve is at 6:00 position, and continue to work bead into rim with fingers until it becomes too difficult.

A common problem when installing tires is to pinch the tube with the tire lever when installing the second bead. For this reason, a lot of “authorities” say never to use a tire lever to install a tire, insisting that a “real” mechanic can always install a tire with fingers alone. There is no reason not to try using just fingers, but when this method doesn’t work, it is important to know how to use a tire tool without pinching a tube.

There are two tricks to not pinching inner tubes. When using a tire lever to remove a tire, the tool faces out, so the hook on the handle end can be attached to a spoke. To many people, it seems that the tool should be turned around when installing the tire because the curve or hook on the business end of the tool catches nicely on the edge of the rim. Well, this same hook catches nicely on the tube. So use the tire lever for tire installation in the same orientation used for removal. The other trick has to do with how far the tire is levered with the tire lever. Start with the tip of the tool under the bead and the handle pointing in towards the hub. Lever up only 90°, so that the tool ends up perpendicular to the rim face, and use fingers to push the tire over the top of the rim if necessary. When the lever is moved a full 180° so that the tire lever points up above the tire, the tip of the tire lever can catch on the tube and pinch it. To do this correctly, place a thumb on top of the tire lever while it is against the tire in that 90° position, and push in on the tire while pulling out on the lever. If you just pull out on the lever, the tire will probably come out with it. An alternate technique is to not remove the tire lever at all, but let it drop down after levering up,

slide it a few inches over, lever up again, let it drop again, then slide over again and repeat the process. (See figure 19.28.)

- 64. []** Holding tire bead firmly to rim at one end of uninstalled portion, use tire lever (approximately 2" from other end of uninstalled portion) to lever tire bead over rim flange. (Tire lever should be oriented same as it is for tire removal, with spoke hook facing towards spokes.)



19.28 *Holding the tire bead firmly at the end where it enters the rim, use a tire lever at the other end to lever the tire halfway to push it over the rim with fingers.*

- 65. []** Remove tire lever and re-insert 2" closer to the hand holding tire bead firmly to rim, levering in tire again. Moving 2" at a time, repeat until all of tire bead is levered over rim flange.
- 66. []** Deflate tube fully as possible.
- 67. []** Squeezing sides of tire together, inspect all around wheel for rim strip out of place and tube caught under bead of tire. Correct any problems detected.
- 68. []** Check that valve is straight, and strike tire obliquely with hand to force it around rim if necessary to straighten valve.
- 69. []** Install valve stem retaining nut, if any.

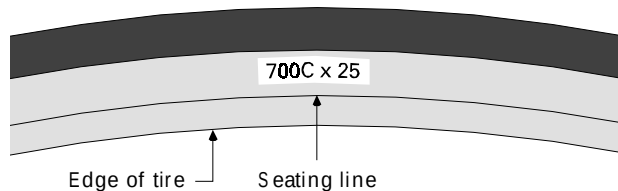
INFLATION AND SEATING OF TIRE

Different techniques and fittings are needed to inflate Schrader and Presta valves. To inflate a Schrader valve, simply remove the valve cap (if any), and place a standard air chuck or pump with a Schrader head on the valve. To inflate a Presta valve, first loosen the

valve nut on the top end of the valve. Presta valves require a fitting with a smaller aperture than Schrader valves. The air line or the pump needs to be equipped with a Presta head or air chuck. There are inexpensive adapters that fit on Presta valves so that a Schrader chuck or pump head may be used.

70. [] Inflate tire to approximately half final pressure.

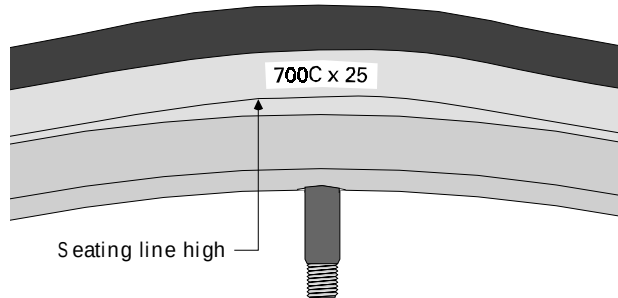
71. [] Find molded rubber line (seating line) in tire sidewall just above top of rim flange. Do not confuse color change from sidewall to bead area with molded rubber seating line.



19.29 The seating line is the line about 1/4"–3/8" above the edge of the tire.

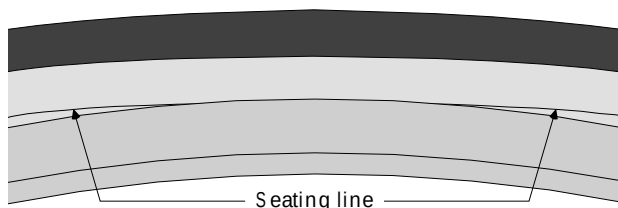
72. Spin wheel and inspect seating line on both sides of tire and check one or both of following choices:

[] Seating line periodically rises noticeably above edge of rim in places.



19.30 Here the seating line rises too high above the edge of the rim for a few inches.

[] Seating line periodically dips below edge of rim in places.



19.31 Here the seating line sinks too low below the edge of the rim for a few inches.

[] Seating line maintains a relatively uniform position just above edge of rim.

If seating line periodically rises noticeably above edge of rim in places:

73. [] Deflate tire and inspect in places where seating line rises for rim strip or inner tube caught between tire bead and rim. Correct any problems found.

74. [] Re-inflate tire to half pressure and fully inspect both seating lines again.

75. [] If seating line is too high where there is nothing caught under tire bead, deflate and try holding that section of tire firmly down into rim while re-inflating.

If seating line periodically dips below edge of rim:

76. [] Deflate and use a soapy solution or liquid soap to lubricate section of bead where seating line is dipping low, then re-inflate.

77. [] If seating line remains low after lubricating with soap, full inflation may be required to get bead to pop up.

If seating line maintains a relatively uniform position just above edge of rim:

78. [] Inflate tire to full pressure and immediately inspect for sections where seating line is too high. (Deflate immediately if seating line is high and repeat steps 73–75.)

79. [] Inspect both seating lines for section where seating line is below rim edge. If bead is already soaped in these areas, over-inflate 10psi and check again. Continue over-inflating 10psi at a time until tire is 50% over maximum, if necessary. Return tire to desired pressure.

80. [] Tighten valve nut (if Presta valve) and install valve cap (if any).

WHEEL INSTALLATION

81. [] See WHEEL REMOVAL, REPLACEMENT, AND REINSTALLATION procedure: FITTING WHEELS, ORIGINAL AND REPLACEMENT (page 18-8) steps 1–10 and INSTALLING THE WHEEL (page 18-15) steps 1–8 (front wheels) or steps 9–20 (rear wheels).

TIRE AND RIM SIZES

The following table is a selection of popular tire and rim sizes found on adult and juvenile road bikes and off-road bikes. The common practice is that rims are named by the tire that they fit.

The **Nominal size** column includes the most popular name for a size. The reason that these numbers are called nominal sizes is that they are not actual measurements. The diameter (27", 700, 26") is the approximate diameter of the tire at the tread. Tire profiles have changed dramatically since the sizes were created and it is rare that a tire actually measures the same as its name size. Rims are named by the tire they fit, rather than by the dimension where they fit the rim. Check a 26"×1.75" rim; it measures approximately 22.5" in diameter. The second part of the nominal size is the tire's inflated width. This number is based on the width of the tire when mounted on the rim, and it changes with the rim width and the tire pressure. Furthermore, tires have historically shrunk without the widths being renamed. A typical 1-1/4" tire is usually closer to 1-1/8".

The **Alternate names** column covers both vernacular names, and names used by another country for the same size tire. An example of a vernacular name would be to say "MTB tire" instead of 26"×1.75".

The **Bead-seat diameter/tire-bead diameter** column is the dimension that is most important in regard to tire fit. Bead diameter is the diameter of the tire at its inner perimeter. Bead-seat diameter is the diameter of the rim at the point the tire bead sits. The procedures in this chapter describes how to measure and calculate rim-bead-seat diameter. Tire-bead diameter can only be determined by looking up the tire's nominal size on this table and reading across to the **Bead-seat diameter/tire-bead diameter** column, unless the tire has an ISO marking.

The **ISO size** column is an alternate sizing system based on actual dimensions of tires and rims where they attach to each other. ISO stands for International Standards Organization. The two digit number before the dash is the tire's *section width*. Section width is described fully in the portion of this chapter about tire fit and compatibility (page 19-10). For each size in the table, the smallest and largest known section widths are shown. The three-digit number after the dash is the tire's bead diameter and the rim's bead-seat diameter. The table does not provide ISO rim-width information, which can be obtained easily by measuring the width between the inside faces of the two rim flanges. This number is expressed in millimeters.

The **Approximate rim O.D.** column is useful for identifying unmarked rims. It is expressed as a range for two reasons: one is that two rims of the same size have to have the same bead seat diameter, but their outside diameters (O.D.) can vary because their flange heights can be different without affecting fit; the other reason is that when measuring a rim with a hub already built in, the tape measure will have to deflect somewhat around the hub. Even if the measurement is slightly outside one of the ranges, it should be safe to assume the size of the rim. No two common sizes come closer than 3mm.

The **Typical use** column describes types of bikes where the size is most likely to be encountered, but other types occur. The suggestions are not a complete or limiting list of the types of bikes that use a particular size.

There are literally dozens of sizes that exist but are not listed. Most of the other sizes are a once-in-a-lifetime encounter for a shop mechanic and will probably never be encountered (other than a few juvenile sizes smaller than 24"). For a comprehensive listing of tire and rim sizes, see *Sutherland's Handbook for Bicycle Mechanics*.

TIRE AND RIM SIZES (table 19-1)

Nominal size, rim or tire (common name)	Alternate names (country/rare)	Bead-seat diameter/ tire-bead diameter	ISO size (tire section width/rim tire diameter)	Approximate rim O.D.	Typical use
27"×1-1/4" other widths are 1, 1-1/8, 1-3/8	British/K2	630mm	20-630 through 30-630	640-644mm	Recreational-level road bikes, touring road bikes
700C ² widths are all sizes 18mm through 47mm	French/28×1-5/8 Canada/28×1-1/2	622mm	20-622 through 47-622	632-636mm	Performance road bikes, "cross" bikes, "hybrid" bikes

(Continued next page)

TIRE AND RIM SIZES (table 19-1 continued)

Nominal size, rim or tire (common name)	Alternate names (country/rare)	Bead-seat diameter/ tire-bead diameter	ISO size (tire section width/rim or tire diameter)	Approximate rim O.D.	Typical use
26"×1-3/8" (tire to fit S-5 or S-6)	British/26×1-1/4 to fit EA1 rim	597mm	32-597 through 37-597	607-611mm	Older Schwinn 3-speeds, 5- & 10- speed "heavy" bikes
26"×1-3/8" (to fit EA3 or E3 rims) other widths are 1 and 1-1/4	French/650A	590mm	28-590 through 40-590	600-604mm	American made dept. store "12-speeds," narrow widths on some performance road bikes with small frames
26"×1-1/2" (to fit S4 rim)	French/650B	584mm	32-584 through 47-584	597-601mm	Schwinn MTB/cross bike size, rare French touring bikes
650C	USA/26"	571mm	20-571 through 47-571	583-587mm	Triathlon bikes with compact, high-performance wheels
26"×1-3/4"³	Schwinn S-7	571mm		583-587mm	Beach cruisers, old balloon-tire Schwinn
26"×1.75"⁴ other widths are all sizes 1"–2.5"	26" MTB	559mm	20-559 through 54-559	571-575mm	MTBs, ATBs, "Cross" bikes
24"×1-1/4" other width is 1-1/8	Schwinn/ 24×1-3/8 (to fit S5 or S6 rim)	547mm	20-547 through 37-547	557-561mm	Narrow sizes on "proportional" performance road bikes, 24×1-3/8 on juvenile Schwinn derailleur bikes
24"×1-3/8" (to fit E5 or F3 rim)		540mm	32-540 through 37-540	550-554mm	Juvenile, department-store 12-speeds by USA manufacturers
24"×1.75" other widths are 1"–2.125"	BMX cruiser class	507mm	44-507 through 54-507	521-525mm	Juvenile MTBs, BMX cruiser class
20"×1.75" other widths are 1.5"–2.125"	BMX	406mm	44-406 through 54-406	420-424mm	BMX bikes, all qualities, other juvenile 20" wheel bikes

¹ ISO rim width is a measurement of the width between the rim flanges. A 20-622 tire might fit a 14-622 rim.

² The "C" is sometimes omitted, which is wrong since 700, 700A, 700B, and 700C are completely different sizes. The "C" sometimes appears after the width (example: 700×25C) which is also wrong as the "C" qualifies the size, not the width.

³ Do not confuse this with 26×1.75 MTB size. They do not interchange.

⁴ Do not confuse this with beach-cruiser and balloon-tire classic size, 26"×1-3/4". They do not interchange.

TIRE AND TUBE TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Bead-seat line is too high at the valve.</i>	
Tube around base of valve is caught under rim bead.	Deflate tire and push valve into tire and then pull out again.
Rim strip is too wide for rim.	Inspect rim strip and replace it if against bottom edge of rim-bead lip.
SYMPTOM: <i>Bead-seat line is too high at points other than the valve.</i>	
Tube is caught under bead of tire.	Deflate, inspect, and reposition tube.
Rim strip is too wide or out of position so that it is against lip of rim bead seat.	Reposition or replace rim strip as necessary.
Tire fits rim loosely. High-seated areas are probably caused by low-seated areas elsewhere on the rim.	With tire at a pressure of approximately 10–15 psi, manipulate the tire by pulling out at low points while pushing in at high points. Add pressure once bead is more evenly seated.
SYMPTOM: <i>Bead-seat line will not pop out above the rim bead at one or more points.</i>	
Bead is too high at other points due to rim strip or tube caught under tire bead.	Check and fix high-seating problems.
Tire fits the rim loosely and high-seated areas elsewhere are probably keeping the tire bead in at this point.	With tire at a pressure of approximately 10–15 psi, manipulate the tire by pulling out at low points while pushing in at high points. Add pressure once bead is more evenly seated.
Tire is a tight fit.	– Deflate tire, lubricate tire bead with liquid soap or lanolin hand cream and re-inflate. – If bead is lubricated and there are no high-seating areas, inflate past recommended pressure until bead pops out.
SYMPTOM: <i>Tire seats correctly initially, then blows off of rim.</i>	
Tire was over-inflated.	Inspect for bead damage, then re-install.
Tire bead is damaged.	Inspect for damage and replace.
SYMPTOM: <i>Tire is extremely difficult to install.</i>	
Tire is wrong size.	Check tire fit.
Tube is over-inflated.	Remove air from tube.
Tube is too fat for tire.	Check tube fit.
Rim strip is too wide, interfering with bead seat area of rim.	Inspect and replace rim strip if it is jamming against bead lip on either side of rim.
Rim strip is too bulky for tight fitting rim/tire combination.	Avoid using thick black rubber and cloth rim strips.
Tire and rim are an unusually tight combination.	Lube complete tire beads with liquid soap or lanolin hand cream.
SYMPTOM: <i>Tire fabric has numerous ruptures all the way around both sides below the tread, but not just above the rim. There are no rub marks.</i>	
Tire has been ridden while punctured or virtually flat. Tire sidewalls have been rubbing on riding surface.	Replace tire and avoid riding with extremely low air pressure or no air pressure.

(Continued next page)

TIRE AND TUBE TROUBLESHOOTING (Continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Tire is extremely difficult to remove.</i>	
Tube needs additional deflation.	Squeezing tire, deflate tube further.
Tire has adhered to rim sidewall.	Run tire lever between tire and rim all the way around both sides to break free adhesion. Smear as much liquid soap or lanolin hand cream as possible between tire bead and rim.
Tire and rim are an unusually tight combination.	Lube complete tire beads with liquid soap or lanolin hand cream.
SYMPTOM: <i>Valve was in straight initially, but is now at an angle.</i>	
Hard braking has rotated tire around rim, probably because bike has been ridden with inadequate air pressure.	Deflate tire, rotate it in a direction that straightens the valve, and maintain correct pressure when riding.
SYMPTOM: <i>Rim strip is broken at valve hole.</i>	
Incorrect procedure was used when installing tube valve into rim strip and rim hole.	– Replace rim strip. – Avoid reoccurrence by lifting rim strip up at valve hole and installing valve through rim strip first and then drop rim strip and valve together into rim.
SYMPTOM: <i>Tire is flattening repeatedly from simple punctures on the outside perimeter of the tube.</i>	
Tire tread has worn thin.	Inspect tire tread and replace tire if worn.
Tire is full of cracks from aging.	Inspect for cracks and replace tire if needed.
Flat-causing object still stuck in tire.	Inspect more thoroughly for cause of flat.
SYMPTOM: <i>Tire has flattened from blowing off the rim.</i>	
Tire was over-inflated.	Inspect for bead damage and adhere to manufacturer's recommendations.
If tire was properly inflated, the tire probably was not mounted correctly.	Inspect for bead damage, and inspect tires for mounting problems before inflating fully.
Tire bead is damaged.	Remove and inspect tire, and replace tire if bead is damaged.
SYMPTOM: <i>Tire has flattened shortly after installation due to parallel slits in the sidewall of the inner tube.</i>	
Improper tool use during tire installation has damaged the tube.	Replace the tube, use only tire levers for tire installation, and avoid using the tire levers to lever the tire up any further than necessary to push the tire over the top of the rim with fingers.
SYMPTOM: <i>Tire has flattened in mid-ride due to parallel slits in the sidewall of the inner tube.</i>	
Tire has bottomed out, and tube was pinched between rim bead and riding surface.	– Avoiding riding with under-inflated tires. – Un-weight when hitting obstacles that cannot be avoided. – Use wider tires.
SYMPTOM: <i>Tire has a slow leak but inspection reveals no holes.</i>	
Valve is leaking because valve core is loose or bad.	Use bubble test to check for leaking valve with tire installed and fully inflated. Secure valve and replace if leaking continues.

(Continued next page)

TIRE AND TUBE TROUBLESHOOTING (Continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Holes found on “rim side” of tube.</i>	
Rim strip is out of position, exposing nipple heads or nipple access holes.	Inspect and reposition rim strip.
Elastic rubber rim strip appears to be covering nipple access holes when inspected, but is deflecting to expose holes when tire is fully inflated.	Use polyurethane rim strips on rims with nipple-access holes.
Spokes are too long and are protruding out of nipple heads and poking through the rim strip.	Remove rim strip and use edge of a file to file down excess spoke length.
Particularly at rim seam, rim has raw unfinished material that is puncturing or abrading the tube.	Inspect rim and file off any sharp protrusions.
SYMPTOM: <i>Tube has leak at edge of the oval mounting base of the valve.</i>	
Tube cross section is too narrow for tire and is being stretched too far to fill tire.	Replace with fatter tube.
SYMPTOM: <i>Tube has failed at the seam where two ends of tube were joined during manufacture to create a circle.</i>	
Tube is wrong size for rim (must be stretched to reach around rim) and is pulling on seam too much.	Replace with proper-size tube.
Tube cross section is too narrow for tire and is being stretched too far to fill tire.	Replace with fatter tube.
SYMPTOM: <i>Tire bead is damaged, evidenced by torn fabric wrapped around bead wire or scuffed rubber coating at bead wire, over a distance of approximately 1/2".</i>	
Improper tools or technique when levering tire off of rim.	Use plastic tire levers and find ways to solve problem if tire is difficult to remove or install.
SYMPTOM: <i>Wire bead in tire is broken, or rubber lip molded on at wire bead is scuffed off for several inches.</i>	
Over-inflation caused tire to blow off rim, which damages the beads.	Replace tire and avoid over-inflation.
SYMPTOM: <i>Tire sidewall has wear marks and frayed fabric most of the way around, just above the rim.</i>	
Brake pads are rubbing on tire because pads are out of position.	Replace tire and adjust brake-pad height.
Brake pads cannot be adjusted to correct height without rubbing on tire.	Replace tire with narrower size. Tire is too fat for rim width, and either rim or tire should be changed.
SYMPTOM: <i>Tire sidewall has rub marks and frayed fabric over a short distance just above the rim.</i>	
Rim is out of round, causing the brake pads to rub against tire intermittently.	Replace tire and correct out-of-round error. Replace rim/wheel if necessary.
SYMPTOM: <i>Tire tread or sidewall rubber is full of countless little cracks.</i>	
Rubber has hardened due to aging.	Replace tire and avoid unnecessary exposure to sunlight and/or water.
SYMPTOM: <i>Tire fabric is ruptured in tread area. Tread may or may not be damaged.</i>	
Fabric has rotted due to age.	Replace tire and inspect more frequently for cracks in the rubber.
Tire has been damaged by sharp stone.	Replace tire.

20 – TAPER-FIT CRANK ARMS

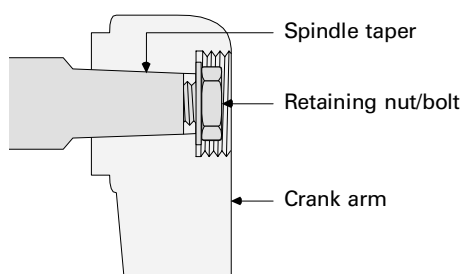
ABOUT THIS CHAPTER

This chapter is about removing and installing taper-fit crank arms (commonly called cotterless crank arms), as well as installing replacement crank arms. The **COTTERED CRANK ARMS** chapter covers cottered crank arms (page 21-1). The **ONE-PIECE CRANK ARMS** chapter covers one-piece crank arms (page 22-1). There is also a **CHAINRINGS** chapter (page 23-1), which should be referred to if the chainrings will be removed, replaced, or secured. The chapter **PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION** (page 24-1) includes information about pedal removal and installation — a job that is often done as part of crank-arm removal and installation.

A variation of this design is the splined-fit crank arm types being made by Shimano. These are discussed in the final section of this chapter **SHIMANO SPLINE-FIT CRANK ARMS** (page 20-16).

GENERAL INFORMATION

TERMINOLOGY



20.1 Cross-section of a taper-fit crank arm attached to a spindle.

Taper-fit crank: A crank design that has a tapered square hole in the crank arm that is pressed onto a tapered, square bottom-bracket spindle.

Cotterless crank: The term “cotterless cranks” is becoming obsolete and probably ought to be replaced. Decades ago, almost all quality bicycles had crank arms that slipped onto a round shaft and were retained by a pin (cotter pin) which went through a hole in the crank arm and a slot in the shaft. When a new style of crank (with no cotter pins) was invented, it was named by how it was different from the existing design, hence

the name “cotterless crank.” This design uses a square, tapered shaft with four flats. The crank arm has a similar tapered hole. A bolt or nut presses the arm onto the tapered shaft and the friction of the tapered shaft jamming into the tapered hole holds it all together. This taper-fit design is predominant now, and is the design that this chapter focuses on. From here on, the word “cotterless” is dispensed with, and the dominant design of today will be called a “crank arm” without repeatedly modifying it with any adjective.

Crank arm: The lever arm that attaches to the bottom-bracket spindle at one end and the pedal at the other end. The right crank arm has chainring(s) (gears) attached to it, usually by means of chainring-mounting arms.

Chainrings: The gears attached to the right crank arm that drive the chain when pedaling.

Chainring-mounting arms: The arms (usually five) that go from the end of the crank arm out to the chainrings. The chainrings are attached to the end of the chainring-mounting arms, which are also called *spider arms*.

Crank-arm extractor: The tool used for removal of the crank arm from the bottom-bracket spindle.

Extractor body: The portion of the crank-arm extractor that threads directly into the crank arm.

Extractor shaft: The portion of the crank-arm extractor that threads into the extractor body and pushes against the end of the bottom-bracket spindle.

Extractor threads: These are the threads in the crank arm that the crank-arm extractor threads into.

PREREQUISITES

Pedal removal and installation

Before removing a crank arm, the pedal should be removed. Pedals are much easier to remove with the crank arm still attached to the bike. If removing the crank arm(s) for simple maintenance (cleaning) or bottom-bracket service, pedal removal is optional. Although it may not appear so, pedal removal is generally not required for chainring removal; although, this is something that may be done to the crank arm once it is off. See the **PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION** chapter for pedal removal (page 24-3) and installation (page 24-4).

Chainring removal and installation

If replacing a right crank arm, chainring removal will be required. For anything else, chainring removal is strictly optional. It is easier to do a thorough job of cleaning the cranks arms and chainrings with the chainrings removed. See the **CHAINRINGS** chapter for chainring removal (page 23-8) and installation (page 23-10).

Front-derailleur adjustment and replacement

If replacing a right crank arm with a non-identical one, the new one may position the chainrings slightly further in or out, requiring additional adjustment of the derailleurs limit screws and cable tension. If replacing the right crank-arm/chainring assembly with an identical arm, but a larger or smaller chainring, then the front-derailleur height must be changed. When changing the height of the front derailleur, the derailleur's rotational adjustment may also change, which in turn may affect limit screws and cable tension. See the **FRONT DERAILLEURS** chapter for front-derailleur adjustment (page 33-10).

Front-derailleur replacement is only required in two cases: if installing a new crankset or right crank arm with chainrings that have less than an 8-tooth difference between the largest ring and the next smaller one; or when the front derailleur was designed for a triple chainring with a 10-tooth or more difference. See the **FRONT DERAILLEURS** chapter to tell how front-derailleur capacity has been exceeded (page 33-4). If installing a “micro-drive,” Shimano “compact drive,” or other crankset with reduced-size chainrings, there could be other problems with front-derailleur capacity.

Chainline error

If replacing a right crank arm with one that is *not* identical, the chainrings may end up further in or out. While this might be acceptable in terms of chainring-to-frame clearance and/or front-derailleur range of motion, it might change the chainline alignment. This alignment affects front-derailleur performance, drive-train noise, and drive-train wear. Only by knowing how well the chainrings aligned originally, and combining that information with how much further in or out the chainrings will end up relative to the frame, can you determine whether the new crank arm is acceptable for use with the existing bottom-bracket spindle.

Rear-derailleur replacement

In the case of installing a new crankset or a new right arm with different-size chainrings than the original ones, it is possible to exceed the capacity of the rear derailleur to eliminate the chain slack when the chain is in the smallest chainring and smallest rear cog. It is the difference in number of teeth between the smallest and largest chainring that is important, not the absolute size of either chainring. See the **REAR DERAILLEURS** chapter (page 32-6) to determine if the capacity matches the new chainring set.

INDICATIONS

Maintenance cycles

If properly installed, crank arms should not need any routine maintenance. Other books and periodicals recommend routine tightening of crank-arm mounting nuts/bolts. This would only be necessary if they were under-tightened initially. Routine tightening of the nuts/bolts without using a torque wrench to make sure that they are not being over-tightened invites damage to the arm from over-tightening.

New bikes

If assembling a new bike, removing and re-installing the crank arms is recommended. This is the only way to know that the mounting surfaces are properly prepared and the torque is correct. It is an unfortunately common problem with new bikes that the crank arms work loose and are destroyed. Although this would be covered by warranty, it would be nicer to avoid it altogether.

Bottom-bracket service

To adjust, overhaul, or replace the bottom bracket, crank-arm removal is required. There may be no apparent problems with the crank arms, but this is an excellent opportunity to check for potential problems.

Symptoms indicating loose crank arms

One of the most persistent problems with crank arms is that they work loose. This can strand the rider, and it can easily destroy the arm that works loose — an expensive concern. Creaking noises from the crank area are a warning sign that the arms may be loosening, but loose pedal parts and loose chainring bolts can cause similar noises, so check all these areas at the

same time. When the arm makes a knocking sound or feels loose while pedaling, the situation is critical. If it is not too late, it may be possible to save the arm by not pedaling on it until it can be secured. Pedaling lightly, for even one block, may destroy the arm.

With proper installation, most riders do not need to periodically tighten the crank arms. Other books and magazine articles often state “re-tighten crank arms every 100 miles,” or something similar. The crank arm would be the most under-designed part on the bicycle if this was the case, and bike shops would be selling as many replacement crank arms as they do inner tubes. In fact, it is possible to damage crank arms from routine tightening without a torque wrench, which is why it is not recommended. With a torque wrench, crank arms can be regularly checked without risk. If they are remaining tight (as they should), then the torque wrench will show this without adding any tightness. If they have worked loose, the torque wrench will tighten them back to the original torque. If they work loose more than once, consider a higher torque. This “torque checking” (as opposed to periodic re-tightening) is an excellent form of preventive maintenance.

Symptoms indicating damaged crank arms

When the normal installation techniques (plus using the *maximum* recommended torque) fail to keep the arm secure, it means the tapered square hole in the arm is deformed (enlarged or distorted). The crank arm should be replaced.

Symptoms indicating bent crank arms

Crank arms bend sometimes when the bike is crashed, and they can bend from abusive jumping. The symptom of a bent crank arm is an oscillating sensation felt in the ankle while pedaling. This oscillation may feel like a twisting back and forth on the ball of the foot, or like the outer edge of the foot is rocking up and down, or it may feel like both at once. The identical symptoms are caused by bent pedal shafts, which can easily be damaged by the same forces that damage crank arms. Depending on the relative strength of the crank arm or pedal shaft, either may be more likely to bend. The first step is to remove the pedal and look at the end of the shaft as it rotates. If the end does not oscillate, then it is the

crank arm that is bent. If it does oscillate, new pedals are needed. If the symptom is still felt when riding with new pedals then, the arm is also bent.

Symptoms indicating damaged pedal-mounting threads

Pedal-mounting threads can be damaged from improper pedal installation. The only symptom is difficulty threading in the pedal. Sometimes it is repairable, which is described in the chapter **PEDAL REMOVAL, REPLACEMENT AND INSTALLATION** (page 24-6), but sometimes it is necessary to replace the crank arm.

Symptoms indicating damaged crank-arm-removal threads

The crank-arm-removal tool threads into the crank arm where the bolt/nut dustcap comes out. Damage to these threads will be indicated by difficulty threading in the crank extractor, or by the extractor pulling out of the crank-arm threads when attempting a crank-arm removal. These threads can be damaged from failure to protect them with the bolt/nut dustcap, improper removal tool use, or failure during removal due to over-tight arm installation. In some cases, this thread damage may be repairable, but in most cases it is not. When the threads are damaged beyond repair, the arm should be replaced. There is a section at the end of this chapter on repair of these threads, and how to remove the arm when the threads are unrepairable.

Symptoms indicating cracked crank arms

Crank arms can crack in a number of places. Sometimes a crack will develop between the pedal mounting hole and the end of the arm. Sometimes a crack will develop at the crotch of the chainring-mounting arms (spider arms) and the crank arm. Sometimes a crack will develop between a corner of the tapered square hole and the mounting end of the arm. These cracks may make themselves known through creaking noises, but that is not likely. Most likely, the cracks will be discovered through inspection. Whenever servicing the crank arms (especially when cleaning), inspect in all these areas for cracks. If the arm cracks and is not replaced, it can result in a catastrophic failure, which can lead to serious injury.

TOOL CHOICES

The design or brand of crank arm and spindle will determine the tools needed.

Table 20-1 (below) covers all tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is in **bold**, it means that several tools are required for different configurations of parts.

Although some distributors sell special pullers for removing crank arms with stripped threads, none of these tools are listed here because the best techniques for doing the job do not require any special tools.

TIME AND DIFFICULTY RATING

Crank-arm removal and re-installation is a 1–2 minute-per-arm job of little difficulty. Fitting a new replacement crank arm, which can include chainring and pedal removal and installation, as well as front-derailleur adjustment, is a 10–45 minute job of little difficulty (unless derailleur adjustment is included, in which case difficulty may be high).

TAPER-FIT CRANK-ARM REMOVAL TOOLS (table 20-1)

Tool	Fits and considerations
EXTRACTORS	
Campagnolo 770	22 × 1mm RH-thread extractor, works with bolt-type spindles only
Campagnolo 1170005	22 × 1mm LH-thread extractor for C-Record track cranks and Campagnolo road cranks that have an Allen-wrench removal system that is absent
Park CCP-2 (replaces CCP1 that had poor tip design)	22 × 1mm & 23 × 1mm extractor with built in handle for removing common crank arms and T.A. brand crank arms from <i>both</i> nut-type or bolt-type spindles (poor leverage due to handle length and thinness)
Park CWP-5	22 × 1mm RH-thread extractor, works with nut-type and bolt-type spindles
Shimano TL-FC10	22 × 1mm RH-thread extractor, works with bolt-type spindles only
Sugino Mighty 202	22 × 1mm RH-thread extractor, works with bolt-type spindles only
Sugino Maxi 203	22 × 1mm RH-thread extractor, works with nut-type spindles only
VAR 11	22 × 1mm RH-thread extractor, works with bolt-type spindles only
VAR 12	23 × 1mm (fits T.A.), removes from bolt-type spindles only
VAR 22/2	Fits older Stronglight cranks with 16mm bolt and unique 23.35 × 1mm thread
VAR 392/2	22 × 1mm RH-thread extractor, works with bolt-type spindles only
VAR 393	22 × 1mm & 23 × 1mm extractor for removing common crank arms and T.A. brand crank arms from <i>only</i> bolt-type spindles (poor mechanical advantage)
VAR 932	Use on crank arms with stripped threads, expensive, very limited effectiveness
OTHER CRANK-ARM TOOLS	
Bicycle Research TC-8	Thread chaser, repairs mangled 22 × 1mm crank-arm threads
Shimano TL-FC20	Fits 2 pin-hole dust cap on older Shimano crank arms
VAR 22/3	23 × 1mm tap for repairing stripped 22 × 1mm arms
Stein CES	Converts stripped 22 × 1mm threads to 24 × 1.5mm. Comes with shop extractor (24 × 1.5mm) and one-key-release system to be left installed in crank. Expensive.

COMPLICATIONS

Dustcap will not unthread

Cross-threading or corrosion can turn the relatively simple task of removing a crank-arm dustcap into an ordeal. The tool-fitting in the dustcap usually strips out. The best solution is to drill two holes in the face of the dustcap and use an adjustable pin spanner to get it out. Some plastic threaded dustcaps with this problem will just rip apart instead of unthreading. In this case, there is no choice except to use some sort of pick or pry tool to dig out the remaining pieces bit-by-bit.

Extractor will not thread into arm

Never force the extractor in! The first thing to check when the extractor will not thread in is whether the bolt/nut has actually been removed. Next, try more carefully to keep the axis of the extractor aligned with the axis of the spindle rather than perpendicular to the face of the crank arm. If this does not solve the problem, then the threads are probably mangled. There is a section at the end of the chapter about repairing mangled threads.

Threads are stripped out in arm

If the threads are stripped out before crank-arm removal is attempted, then it is simply a matter of removing and replacing the arm (procedure at end of this chapter). If they strip while attempting removal, it is important to determine why. If correct removal technique has been used, then the failure has occurred because the arm was too tight. This is not unusual. The responsibility lies with the last person to install the arm. If there is not 100% certainty that the removal technique was correct, then the shop owes the customer a replacement arm.

Chainrings wobble excessively with crank in all four mounting positions

Lack of precision with the spindle flats and with the square hole in the arm can effect the amount of chainring wobble that occurs in each of the four possible positions that the arm can be mounted on a spindle. If the wobble is unacceptable in the best of these four positions, then the problem is with the chainring-mounting arms or the chainrings themselves, and not with the crank-arm/spindle fit. Both of these problems are addressed in the **CHAINRINGS** chapter (page 23-3 and 23-12).

Replacement arm does not fit spindle

It is not unusual for one brand of crank arm to not fit another brand's spindle. Sometimes there are even compatibility problems between different models or

years of the same brand. Many older European brand crank arms cannot be used with most spindles manufactured in Asia. New Shimano crank arms cannot be used with anything but new Shimano spindles. The removal and installation procedures in this chapter include inspections to determine whether an arm and spindle are compatible. Unfortunately, it is not practical to create a table of compatibility for the huge and ever-changing selections of spindles and crank arms.

Replacement arm changes chainring clearance

A non-identical replacement of the right-side crank arm may fit the spindle, but not necessarily put the chainrings in the same position relative to the frame. If the chainrings end up closer to the frame, it could be a problem. The following procedures have steps for checking the original clearance and the clearance after installing a new right arm.

Replacement arm changes chainline

Because a replacement right-side arm can change the chainring positions, it can change the alignment of the chainrings to the rear cogs (chainline). The following procedures have steps for checking chainline before and after, but the separate **CHAINLINE** chapter should be referred to for help in how to measure chainline (page 27-5) and how to identify whether an error is significant (page 27-3).

New chainring size/position changes front-derailleur adjustment

If installing a replacement right-side crank arm, the chainrings may move in or out. This would necessitate changing both limit screws and the cable setting on the front derailleur. If the replacement crank arm has a large chainring of a different size, then derailleur height and rotation would need to be reset (which leads to limit screw and cable adjustment as well).

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into two parts. The first part is the procedure for crank-arm removal and installation. There are double check-boxes next to all the steps that would be done twice, once for each crank arm. It includes all the necessary steps for crank-arm replacement; however, it refers to other chapters for pedal and chainring removal and installation. The second part is about how to remove a crank arm with damaged extractor threads.

NORMAL CRANK-ARM REMOVAL AND INSTALLATION

IF REPLACING ARM(S) OR TO FACILITATE CLEANING

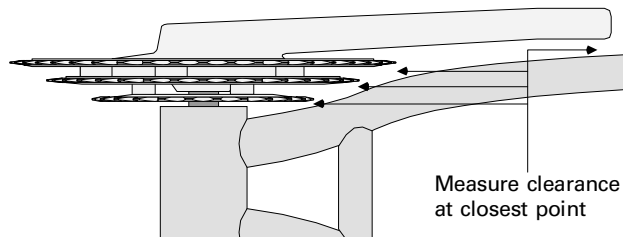
1. [] [] [] Optionally, remove pedal(s). See **PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION** worksheet.

PREPARATION AND PRE-REMOVAL INSPECTIONS

In the next step, measure the clearance between the right-crank assembly and the chain stay. The chain stay is the frame tube that runs from the bottom bracket to the rear dropout. If the bike has raised chain stays (they connect to the seat tube above the front derailleur), measure to the side of the seat tube instead. The measurement is useful, even if just reinstalling the same crank arm, for two reasons.

First, due to frame flex and chainring flex, there must be at least 2mm clearance between any part of the right-crank assembly and the chain stay. Otherwise, frame damage may occur while the bike is being ridden. Measuring before removal reveals a problem, or borderline problem, before going to the trouble of re-installing the arm. If clearance is poor before removal, it will be necessary to check and replace a worn-out arm, or put in a longer bottom-bracket spindle if the arm is fine. If the clearance is marginal before removal, measuring will alert you to a potential problem when the arm is re-installed.

Second, after re-installing the original arm or installing a replacement arm, measuring the change in the clearance reveals whether it will be necessary to re-adjust the front derailleur.



20.2 Use a stack of feeler gauges to measure the clearance between the chain stay and the part of the crank assembly that comes closest to rubbing the chain stay.

2. [] Measure clearance between chain stay and part of right crank that comes closest to chain stay (usually inner chainring or bolt heads holding on inner chainring, but occasionally another chainring). Record measurement here: _____. If bike has raised chain stays, measure to side of seat tube.

In the next step, measure the chainline error. Chainline is the alignment of the front gears to the rear gears, and is covered extensively in the **CHAINLINE** chapter (page 27-6). It affects drive-train noise and shift performance. Measure it before making any changes, and then again after re-installing the original right arm or a new right arm so it will be known whether chainline ended up worse, in which case it would be necessary to check for symptoms in order to determine whether the error was significant.

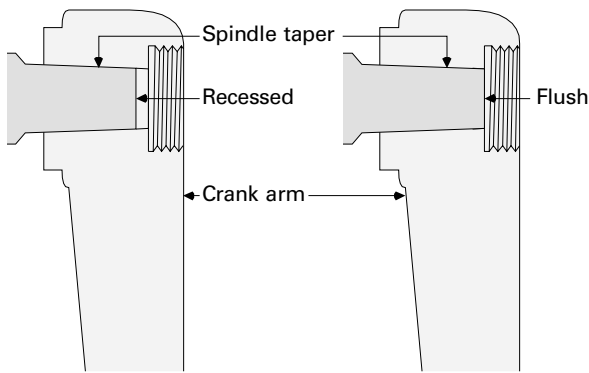
3. [] Measure chainline error:
Chainrings **out (+)** or **in (-)** (circle one)?
Amount: _____ mm
4. [] [] [] Remove dust cap(s) (if any). (Except crank arms with built-in removers. Evidence will be an Allen bolt visible through a hole in a heavy duty steel dust cap.)

If the bolt being removed in step #5 is an Allen bolt, then there is a possibility that the crank arm has a built-in removal system. In this case, the arm will come off as the bolt is loosened, and the arm and bolt will stay together as a unit. There are not special concerns or precautions necessary.

NOTE: Skip ahead to step 11 if the arm and bolt come off as a unit.

5. [] [] [] Remove nuts or bolts/washers.

In the next step, check for evidence that the crank arm is worn out or was originally a poor fit to the spindle. After removing the nut or bolt/washer, a square hole in the crank arm should become visible (this is where the spindle is inserted). If the end of the square portion of the spindle is recessed inside the square hole of the crank arm by any amount, then the fit is most likely acceptable. If the square end of the spindle fills up the entire depth of the square hole in the crank arm, then the fit is unacceptable. In this latter case, the nut or bolt that secures the crank arm will be stopped by the end of the spindle before it has pushed the crank arm far enough on to secure it. The resulting symptoms would be creaking sounds and repetitive loosening of the arm.



20.3 The left picture shows the position of the spindle when fit is good and the right one shows when fit is bad, because the square portion of the spindle fills the full depth of the square hole in the crank arm.

6. After removing bolts/washers, inspect if spindle fills square hole (should not). Circle one choice for each arm removed:

☐ Right arm OK? ☐ not OK? (circle one).

If not OK, arm should be replaced.

☐ Left arm OK? ☐ not OK? (circle one).

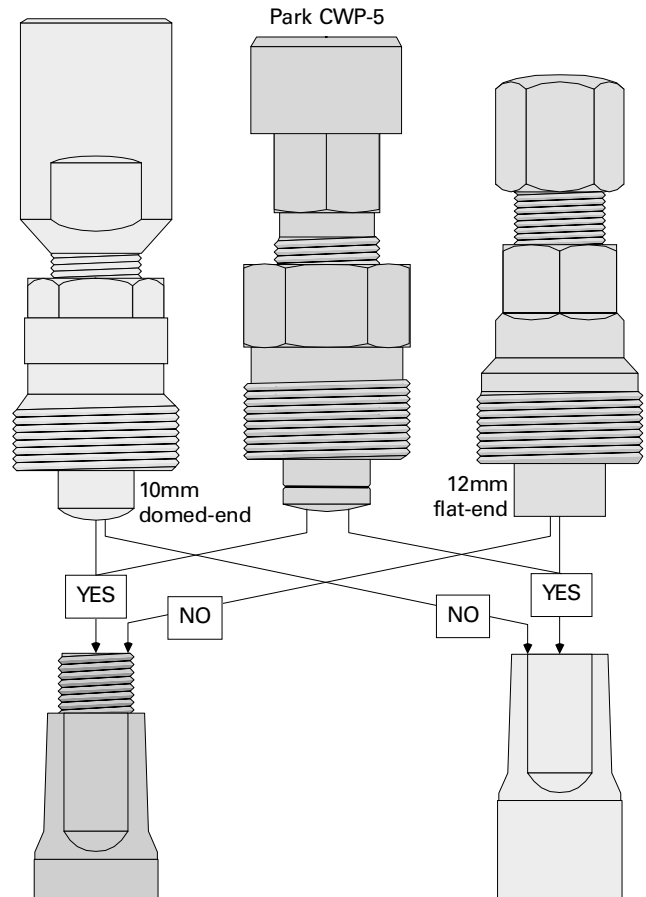
If not OK, arm should be replaced.

CRANK-ARM REMOVAL AND INSPECTION

In the following steps, a crank-arm extractor is installed and a crank arm removed. This is a very critical procedure. If done improperly, the crank arm or the spindle can be destroyed. Use the tool list (page 20-4) to select an appropriate extractor. It is critical that the extractor is compatible with the thread of the crank arm and with the shape of the end of the spindle. If using one of the recommended tools, simply follow the guidelines indicated in the table.

If using an existing extractor and it is not one of the models listed in the table, consider these factors. Thread compatibility is not an issue unless the crank arms are one of the following brands/models: T.A. (all models), Stronglight (models retained by a 16mm bolt only), Viscount (all models), Lambert (all models), or Campagnolo (all models since 1990). Viscount and Lambert removers are no longer available. For removers that are a compatible-thread type for the other brands, see the preceding tool list (page 20-4). All other cranks have the common 22×1mm thread. The other important factor is whether the spindle is a nut-type or bolt-type. Many different brands of extractors are compatible with each of these spindle types. If the tip of the extractor shaft is approximately 12mm diam-

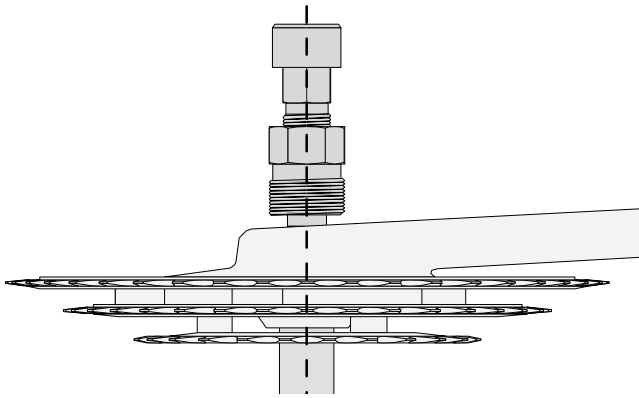
eter, it is designed for use with spindles that accept a bolt to retain the crank arm. If the tip of the extractor shaft is approximately 10mm diameter, it is designed for use with spindles that accept a nut to retain the crank arm. *Use of the wrong extractor type may destroy the crank arm or the spindle!* The Park CCP-2 and CWP-5 are the *only* commonly available tools that are compatible with both spindle types.



20.4 This picture shows the two types of spindle ends with the corresponding correct remover to use. Note that the extractor used with a spindle that has a threaded stud on the end has a domed and relatively narrow tip. Note that the extractor used with a spindle that has no threaded stud on the end is flat on the end and has a relatively fat tip.

When threading the extractor into the crank arm, it should go in easily using just fingers. If the extractor does not thread in easily, it may be cross-threading, or the threads may be damaged. To avoid cross-threading, align the shaft of the extractor in line with the spindle axis rather than perpendicular to the face of the crank arm. If the threads are damaged, move ahead to the section of this chapter titled **REMOVING CRANK ARMS WITH DAMAGED EXTRACTOR THREADS** (page 20-13).

20 – TAPER-FIT CRANK ARMS

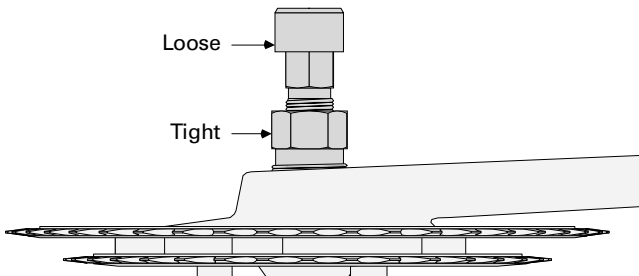


20.5 The drawing shows that a properly installed extractor must be in line with the spindle axis, but not necessarily perpendicular to the face of the crank arm.

In step #7, the extractor is secured in the arm with a wrench. There is no particular torque, and a lot of force is not required. The purpose is simply to ensure that the extractor is fully installed instead of just hanging up on a rough thread. If it is installed fully and it begins to rotate further during arm removal, stop the procedure before unrecoverable damage occurs.

7. [] [] Thread extractor into crank arm with fingers and snug with wrench.

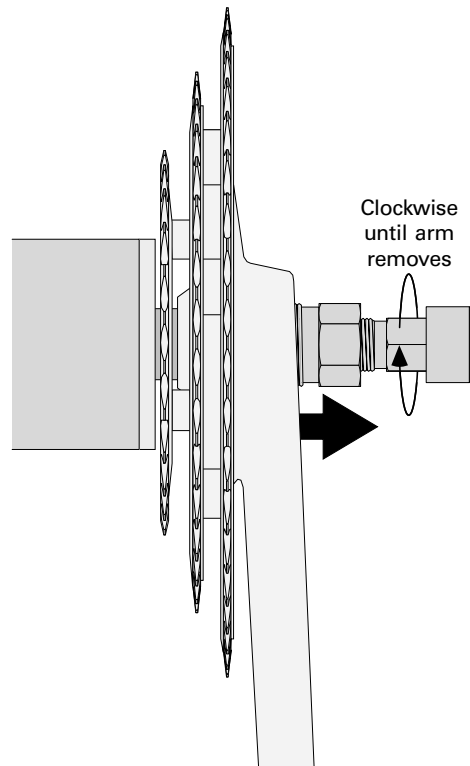
A common mistake is to fail to install the extractor all the way in because the extractor shaft bottoms against the spindle before the extractor is fully threaded into the crank arm. Step #8 is a safety check so that this does not happen. If everything is set up right when the extractor body is secured with a wrench, it should still be possible to turn the extractor shaft either way with fingers. If the extractor shaft cannot be turned with fingers, the shaft is engaging the spindle before the extractor body is fully engaged in the crank-arm threads. When there is poor thread engagement, crank-arm-thread failure is likely to occur.



20.6 When the extractor is properly installed and when ready to remove the arm, the extractor body should be tight and the shaft should be loose and easily turned with fingers.

- 8. Check with fingers whether extractor shaft turns and check one of following choices:**
 [] [] Shaft is tight, loosen it further and re-snug extractor into crank.
 [] [] Shaft is loose, ready for arm removal.

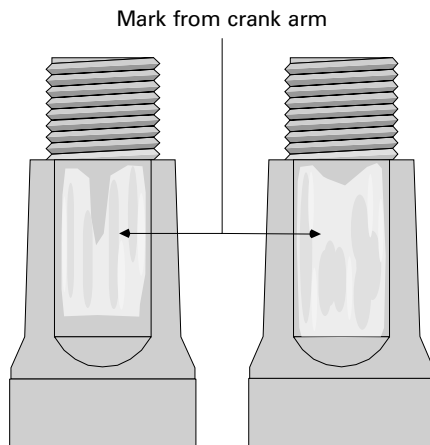
In step #9, tighten the extractor shaft to remove the crank arm. At this point in the procedure, there is still a possibility of removal failure and damage to the crank arm. If the correct warning signs are looked for during arm removal, it may be possible to detect a failure before the damage gets critical, solve the cause of the problem, and then successfully remove the arm. While tightening the extractor shaft, simultaneously watch for either of the following warning signs. *First, if the extractor body starts to rotate, the crank-arm extractor-threads may be stripping.* *Second, if the extractor appears to begin pulling out of the arm (or start cocking to one side in the arm), the crank-arm extractor-threads may be pulling out.* In both cases, immediately stop tightening the extractor shaft and remove the extractor from the arm. Inspect for a nut, bolt, or washer that was not removed. Inspect thread compatibility of the extractor to the crank arm, and inspect for compatibility of the extractor type with the spindle type. If no problems are found, then the only problem might be that the arm is seized to the spindle. Flood the hole with penetrating oil and attempt removal again.



20.7 Turn the extractor shaft clockwise with a wrench to remove the crank arm.

- 9. [] [] Tighten extractor shaft to remove crank arm(s).**
10. [] [] With arm still on spindle but loose, break loose extractor from crank arm.

After removing the crank arm, inspect for another indication of poor fit between the spindle and the crank arm. Crank arms invariably leave marks on spindle flats. As long as these marks do not extend all the way to the inner end of the flats, the crank-arm fit is acceptable. If the marks cover the full length of the spindle flats, the arm is worn out or has always had a bad fit to the spindle. If the crank arm presses all the way onto the spindle, then the arm is bottoming against the fat part of the spindle at the end of the flats, instead of the taper firmly wedging inside the square hole of the arm. This will result in creaking and ultimately in repetitive loosening of the crank arm.



20.8 The marks on the left spindle indicate good fit because they do not cover the full length of the spindle flat. The marks on the right spindle indicate poor fit because they cover the full length of the spindle flat.

11. Inspect marks on spindle flats and circle one choice for each arm removed:
☐ Right arm OK? not OK? (circle one).
If not OK, arm should be replaced.
☐ Left arm OK? not OK? (circle one).
If not OK, arm should be replaced.

IF REPLACING RIGHT ARM OR TO FACILITATE CLEANING

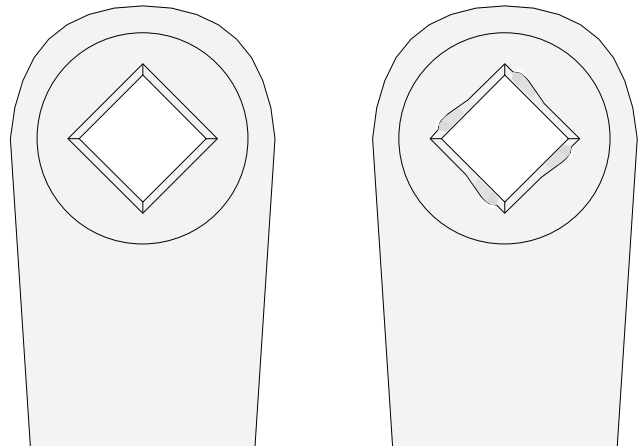
12. ☐ Remove chainrings (optional). See **CHAINRING REMOVAL, INSTALLATION, AND ALIGNMENT** procedure if removing or replacing chainrings.

CRANK-ARM CLEANING AND DAMAGE INSPECTION

13. ☐ Clean crank arms and chainrings (if any).

In step #14, inspect inside the square hole in the crank arm for damage. A normal hole will have four flat sides, and maybe a burr on each flat where the

end of the spindle flat stopped. When an arm is ridden while it is loose, the spindle rotates slightly inside the hole of the arm. This will show up as extra corners on the edge of the hole. (See the following illustration for clarification.) Once this happens, the arm has a tendency to loosen up rapidly after proper installation. The best solution is to replace the arm. A temporary repair using Loctite RC680 (bearing supply houses) on the mating surfaces of the spindle and arm may be attempted, if the damage is not severe. Be aware that each time the damaged arm is removed and re-installed a fresh application of RC680 is required.



20.9 Compare the hole in the left crank arm (good) to the hole in the right crank arm (damaged).

14. Inspect inside square hole in each crank arm for deformed flats and circle one choice for each arm removed:
☐ Right arm OK? not OK? (circle one).
If not OK, arm should be replaced.
☐ Left arm OK? not OK? (circle one).
If not OK, arm should be replaced.
15. Inspect arm for cracks originating at square hole in each crank arm and circle one choice for each arm removed:
☐ Right arm OK? not OK? (circle one).
If not OK, arm should be replaced.
☐ Left arm OK? not OK? (circle one).
If not OK, arm should be replaced.
16. Inspect for cracks originating at pedal-mounting hole in each crank arm and circle one choice for each arm removed:
☐ Right arm OK? not OK? (circle one).
If not OK, arm should be replaced.
☐ Left arm OK? not OK? (circle one).
If not OK, arm should be replaced.
17. ☐ Inspect right arm (if removed) for cracks at crotch of spider arms to crank arm.
☐ OK? not OK? (circle one).
If not OK, arm should be replaced.

CRANK-ARM INSTALLATION

18. [] Install chainrings, if removed. See **CHAINRING REMOVAL, INSTALLATION, AND ALIGNMENT** procedure (page 23-10).

NOTE: If re-installing a single arm that was removed, skip to step 33.

In steps #19 through #31, install a right arm in all four possible positions in order to determine the position that results in the least chainring wobble. There is imprecision in both the fabrication of the spindle flats and in the fabrication of the square hole in the crank arm. In some combinations, the imprecision of each will add together to cause the chainrings to wobble unacceptably. In other combinations, the imprecision of each will cancel the other out, allowing the chainrings to run relatively true. This is why it is best to try mounting the crank arm in all four positions.

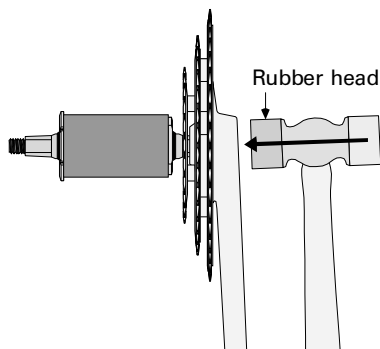
The above-mentioned technique requires that the arm be somewhat secured on the spindle. Of course, this could be done by securing the arm with the nut/bolt, checking the chainring wobble, removing the nut/bolt, and then using the extractor to remove the arm so that another position could be checked. This method is good, but time consuming. The method described in the following steps uses a soft hammer to strike the arm on and off, which will save considerable time and effort. If done properly, it is effective and will not damage any equipment. If unwilling to strike the crank arm with a soft hammer, then use normal mounting and removal procedures wherever the step suggests using a hammer.

Installing a pair of crank arms

19. [] Use a marker to mark one corner between two flats on right end of spindle.

20. [] Turn spindle so that mark is at 12:00.

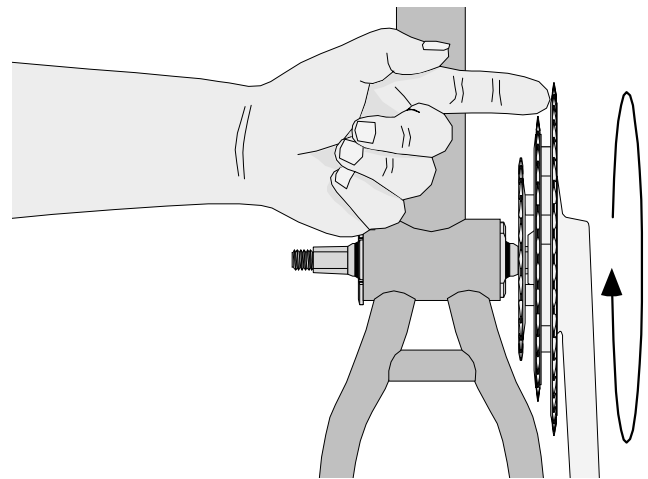
21. [] Place right crank arm on spindle so that arm points to 6:00 and tap firmly on with rubber/plastic mallet.



20.10 Strike the crank arm with a rubber/plastic mallet to temporarily secure the arm to the spindle. Pull on the arm to check that it does not jiggle or come off.

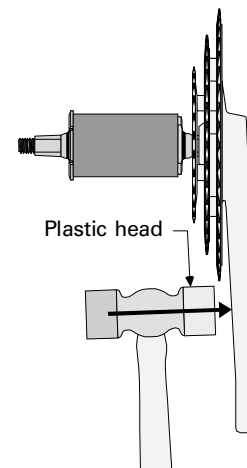
In step #22 and some later steps, spin the crank and check chainring wobble. If the front derailleur is still mounted and the cable hooked up, the best way to check chainring wobble is to position the nose of the derailleur's outer plate directly over the outer chainring. Sight down through the outer plate of the derailleur while spinning the crank and observe to what degree the chainring moves inside and outside of the nose of the derailleur's outer plate.

If the front derailleur is not set up, use another method to check wobble. Brace a hand against a frame tube and position the tip of a finger lightly against the inside face of the teeth of the outer chainring. As the rings spin, see and feel the teeth move towards and away from the finger.



20.11 Use the tip of a finger against the inner face of the outer chainring teeth. As the chainrings spin, check the degree of wobble.

22. [] Check that crank arm is not loose on spindle and spin crank to check degree of chainring wobble.



20.12 Tap on the back of the crank arm with the rubber/plastic mallet to remove the crank arm in order to check chainring wobble in another of the four possible mounting positions of the right crank arm.

23. [] Tap on back of crank arm with rubber/plastic mallet to remove arm.
24. [] Rotate spindle so that mark is at 3:00, and place right crank arm on spindle so that arm points to 6:00. Tap firmly on with rubber/plastic mallet.
25. Check that crank arm is not loose on spindle, and spin crank to check degree of chainring wobble. Check one of following choices:
 - [] *Better* than with spindle mark at 12:00.
 - [] *Not better* than with spindle mark at 12:00.
26. [] Tap on back of crank arm with rubber/plastic mallet to remove arm.
27. [] Rotate spindle so that mark is at 6:00, and place right crank arm on spindle so that arm points to 6:00. Tap firmly on with rubber/plastic mallet.
28. Check that crank arm is not loose on spindle, and spin crank to check degree of chainring wobble. Check one of following choices:
 - [] *Better* than with spindle mark at 12:00 or 3:00.
 - [] *Not better* than with spindle mark at 12:00 or 3:00.
29. [] Tap on back of crank arm with rubber/plastic mallet to remove arm.
30. [] Rotate spindle so that mark is at 9:00, and place right crank arm on spindle so that arm points to 6:00. Tap firmly on with rubber/plastic mallet.
31. Check that crank arm is not loose on spindle, and spin crank to check degree of chainring wobble. Check one of following choices:
 - [] *Better* than with spindle mark at 12:00, 3:00, or 6:00.
 - [] *Not better* than with spindle mark at 12:00, 3:00, or 6:00.
32. [] Tap on back of crank arm with rubber/plastic mallet to remove arm.

In step #33, prepare the arm for installation by cleaning the mating surfaces of the spindle and arm with acetone or alcohol. The purpose of this is to remove any traces of lubricant. Since these two pieces are held together by friction, grease or oil may enable the arm to go on further (not necessarily a good idea). Further is not more secure if arrived at by using lubrication. Crank manufacturers are unanimous in recommending against lubrication of the spindle when mounting the arm. Arguments to the contrary have been voiced, *but never lubricate the spindle flats!* If there is a concern about preventing corrosion or about contaminants getting in the gaps between the spindle flats and the hole flats in the arm, then treat the mating surfaces with Loctite 222 or 242 (bearing-supply or automotive-supply stores). The Loctite will seal the

surfaces from moisture or dirt, reduce creaking problems, will not cause the arms to be less secure, and will allow arm removal with normal effort.

33. [] [] Clean flats on spindle end(s) and in crank-arm square hole(s) with acetone or alcohol.

34. [] [] Grease bolt/nut threads (inside nuts) and under bolt head(s) or nut flange(s).

NOTE: Go to step 38 if one crank arm was removed and only one needs to be installed.

Installing right arm

35. [] Place right arm on spindle in same “better than” position as it was in highest numbered of steps 22, 25, 28, and 31.
36. Install nut, or bolt and washer (if any), and torque bolt/nut to one of following choices:
 - [] Manufacturer’s maximum recommended torque (if literature for crank is available, and spindle and arm are brand-matched parts).
 - [] Torque nut/bolt to 390in-lbs (32.5ft-lbs, or 65lbs@6" or 50lbs@8"), then check for ≥2mm clearance of chainrings to frame.
37. [] Grease dust-cap threads (if any) and install. Torque to 48in-lbs (16lbs@3") if dustcap is threaded.

Installing second arm

38. [] Place arm on spindle so that it points 180° away from already-installed arm.
39. Install nut, or bolt and washer (if any), and torque bolt/nut to one of following choices:
 - [] Manufacturer’s maximum recommended torque (if literature for crank is available, and spindle and arm are brand-matched parts).
 - [] Torque nut/bolt to 390in-lbs (32.5ft-lbs, or 65lbs@6" or 50lbs@8").
40. [] Grease dust-cap threads (if any) and install. Torque to 48in-lbs (16lbs@3") if dustcap is threaded.

CHECKING FIT OF REPLACEMENT CRANK ARM

NOTE: Skip to step 53 if arms installed are original arms removed, not replacements.

Checking chainring fit if replacement arm is a right arm

If using old chainrings with a new crank arm, check the **CHAINRINGS** chapter (page 23-5) to determine whether the new arm is compatible with the chainrings. Chainring compatibility is not just a matter of whether the mounting holes in the chainrings and the crank arm match up. With some chainrings, spacing between the two is critical and not universal.

20 – TAPER-FIT CRANK ARMS

In the next step, measure the right chainring clearance. With the new arm installed, check the chainring position. Any change in clearance could represent a potential problem with shifting, chainline alignment, and frame clearance. Step #41 establishes whether the chainrings have changed position in a way that will cause a problem with frame clearances, and whether they have changed position enough to require adjustment of the front derailleur. Step #42 and #43 establish whether any chainline error has worsened or improved.

Some bikes have raised chain stays (chain stays that are above the chainrings and do not overlap the chainrings). In this case, clearance between the chainrings and the chain stays is no longer an issue. However, changes in chainring position still affect front-derailleur adjustment and chainline. With these bikes clearance to the chainstays cannot be measured, so the distance between the seat tube and the chainrings should be measured.

41. Measure chainring-to-chainstay clearance and check one of following choices (measure clearance to seat tube if bike has raised chain stays):

- ☐ Clearance is $\geq 2\text{mm}$ (ignore for bikes with raised chain stays), and clearance is $> .2\text{mm}$ different than number in step 2.

Front-derailleur limit screws and cable will need adjustment.

- ☐ Clearance is $< 2\text{mm}$, *replacement arm is unacceptable to use with existing spindle.* (Skip this step for bikes with raised chain stays.)

- ☐ Clearance is different by $\leq .2\text{mm}$ from number in step 2, *front-derailleur adjustment is not needed.* Arm is a good fit.

In the next two steps, measure the chainline after installing a new right crank arm to determine whether it has been changed enough to create or solve a problem. Don't limit your focus to whether there is a measurable error, but include whether the error has changed enough *to introduce or eliminate chainline error symptoms*. See **CHAINLINE** chapter for information about how to measure chainline error (page 27-6) and symptoms of chainline error (page 27-3).

42. Measure chainline error, record here:
Chainrings *out (+)* or *in (-)* (circle one)?
Amount: _____

43. Compare step 42 to number and direction in step 3, then choose one of following choices:

- ☐ Error is equal to step 3. Arm is acceptable if no chainline-error symptoms were experienced with original arm.

- ☐ Error is in the same direction but less than step 3. Arm is acceptable unless previous chainline error was unacceptable and change is not enough to eliminate symptoms. Bike should be evaluated for chainline-error symptoms.

- ☐ Error is in new direction. Bike should be evaluated for chainline-error symptoms.

- ☐ Error is in same direction but greater. Bike should be evaluated for chainline-error symptoms.

Checking fit to spindle of either or both arms

NOTE: Perform steps 44–52 complete for one arm before doing 44–52 for a second arm.

When installing mismatched brands of arm and spindle, or installing a used arm on a different spindle, it is important to check whether the arm and spindle are a compatible fit. The only practical way to check this is to remove the arms again and inspect the conditions found during and after removal. If everything is fine, then just reinstall the arms. To avoid having to re-find the best of four positions for the right arm, do not remove both arms at once.

44. ☐ ☐ ☐ Remove dust cap(s) (if any).

45. ☐ ☐ ☐ Remove nuts or bolts/washers.

46. Inspect crank-arm fit (does spindle fill square hole?) after removing bolts/washers and circle one choice for each arm removed:

- ☐ Right arm OK? not OK? (circle one).
If not OK, arm should be replaced.

- ☐ Left arm OK? not OK? (circle one).
If not OK, arm should be replaced.

47. ☐ ☐ ☐ Thread extractor into crank-arm fit with fingers and snug with wrench.

48. Check with fingers whether extractor shaft turns and check one of following choices:

- ☐ ☐ ☐ Shaft is tight, loosen it further and re-snug extractor into crank.

- ☐ ☐ ☐ Shaft is loose, ready for arm removal.

49. ☐ ☐ ☐ Tighten extractor shaft to remove crank arm(s).

50. ☐ ☐ ☐ With arm still on spindle (but loose), break loose extractor from crank arm.

51. Inspect marks on spindle flats and circle one choice for each arm removed:

- ☐ Right arm OK? not OK? (circle one).
If not OK, arm should be replaced.

- ☐ Left arm OK? not OK? (circle one).
If not OK, arm should be replaced.

52. ☐ ☐ ☐ Repeat steps 38 through 40 for each arm removed.

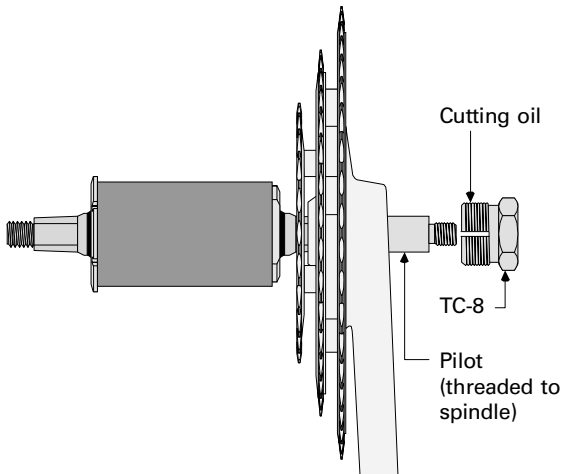
INSTALL PEDALS

53. ☐ ☐ ☐ Install pedal(s) if removed. See **PEDAL REMOVAL AND INSTALLATION** procedure.

REMOVING CRANK ARMS WITH DAMAGED EXTRACTOR THREADS

MANGLED THREADS

With luck, the only problem being experienced is getting the extractor to start threading into the crank arm without jamming. If this is the case, there is a simple repair. The tool needed is a Bicycle Research TC-8 crank-arm-thread chaser. This simple tool has a pilot shaft that attaches to the spindle once the nut/bolt is removed. A thread chaser slips over the pilot and then threads into the crank arm, re-aligning the mangled threads. Removal of the crank arm is then done normally after removing the TC-8.



20.13 After attaching the pilot shaft to the spindle, thread the chaser part of the TC-8 into the crank arm to re-align the threads.

1. [] **Attach pilot shaft to spindle.**
2. [] **Lubricate threads of thread chaser with aluminum cutting oil or other very light oil.**
3. [] **Slip chaser onto pilot shaft and thread chaser into crank arm. Resistance may be encountered and force may be necessary to thread chaser in fully.**
4. [] **Remove thread chaser and pilot and attempt normal removal of crank arm. If threads fail, proceed to STRIPPED THREADS.**

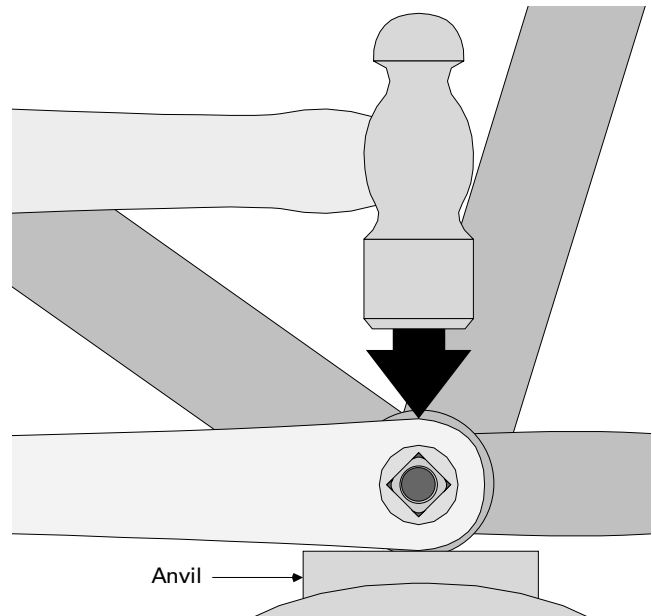
STRIPPED THREADS

Stripped threads are clearly identified when the extractor pulls out of the arm, instead of the arm pulling off of the spindle when attempting arm removal. In this case, count on needing a new arm. The prob-

lem is how to get the arm off in order to replace it. The following steps actually include two methods for arm removal. If at the end of step #3 the arm has loosened adequately, then no more is needed. If not, continue to the end of the steps.

Many modern right arms are shaped in such a way that there is no flat surface to strike with the hammer. (See figure 20.14.) Since the arm should be considered a loss already, the solution to this is not as drastic as it sounds. Remove the chainrings and use a hacksaw to cut off the chainring-mounting arm that is just past the chainring-mounting arm that is immediately adjacent to the crank arm. This should create the spot needed to strike with the hammer.

1. [] **Reinstall any arm or pedals that have been removed, and put bike in rideable condition.**
2. [] **Install nut/bolt onto spindle on side with stripped extractor threads in arm, then loosen nut/bolt 2–3 full turns.**
3. [] **In an untrafficked parking lot or up a steep hill, ride bike hard. (Use brakes to create resistance in flat parking lots.) Crank arm should loosen noticeably. If not, proceed to next step.**
4. [] **Back in shop, remove nut/bolt fully.**



20.14 With the nut/bolt removed and the arm supported on an anvil or similar surface, strike hard and repeatedly with a ball peen hammer to get the arm to pop off.

5. [] **With crank arm horizontal, support crank arm under the end that spindle is inserted in on anvil or some other firm support.**
6. [] **Strike top side of arm with a ball peen hammer as hard as possible with control. Strike repeatedly until crank arm pops off of spindle. (Arm is not re-useable.)**

CRANK-ARM TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>When riding, one ankle feels as though the end of the pedal is rocking up and down, and/or it feels as though the surface of the pedal is rotating back and forth.</i>	
Pedal shaft is bent from a crash.	Remove pedal and inspect end of pedal shaft for oscillation when rotating. Replace if bad. If symptom persists when pedal shaft is good, crank arm is bent and should be replaced.
If pedal shaft is not bent, crank arm is bent.	Replace crank arm.
SYMPTOM: <i>A popping sound or sensation is experienced once per crank revolution, often on the down stroke of the right pedal.</i>	
Loose crank arm.	Check and secure crank arm.
Loose pedal-cage piece(s).	Check and secure pedal-cage piece(s).
Loose pedal mounting.	Check and secure pedal mounting.
Loose chainring bolt(s).	Check and secure chainring-mounting bolt(s).
Loose B.B. cup, lockring, or retaining ring.	Check and secure B.B. cups, lockrings, or retaining rings.
Bent chainring tooth.	Inspect and bend back.
SYMPTOM: <i>A ticking or scraping sound is heard once per crank revolution.</i>	
Loose crank arm causing chainring wobble, causing chain to scrape derailleur cage.	Check and secure crank arm.
Crank arm is hitting front-derailleur cage.	Re-adjust front-derailleur limit screws and/or rotational alignment.
SYMPTOM: <i>Chainrings, chainring-mounting bolts, or some other part of the crank-arm assembly is rubbing the chain stay continuously or intermittently when the crank is being spun when not under load.</i>	
Crank arms worn out or bad fit to spindle.	Perform removal process, including fit inspections.
Bottom bracket spindle is too short.	Replace spindle or cartridge bottom bracket with one that will position crank arm further out.
SYMPTOM: <i>Wear marks are found on the chain stay where they might have been left by the chainrings, chainring-mounting bolts, or some other part of the crank-arm assembly, but no rubbing is evident upon visual inspection.</i>	
Clearance that is adequate without load is not adequate when crank assembly and/or chain stays flex under load.	Check for and replace worn out or misfit crank arm. Replace spindle or cartridge bottom bracket with one that will position crank arm further out.
SYMPTOM: <i>Extractor mounting threads fail when crank-arm removal is attempted.</i>	
Extractor was not fully threaded into crank arm.	Attempt repair with Bicycle Research TC-8 thread chaser. If threads fail completely when attempting removal again, use procedure for removing crank arms with damaged extractor-mounting threads. Replace crank arm.
Crank-arm removal was attempted without removal of the retaining nut or bolt, or without removal of the washer that was under the bolt head.	Attempt repair with Bicycle Research TC-8 thread chaser. If threads fail completely when attempting removal again, use procedure for removing crank arms with damaged extractor-mounting threads. Replace crank arm.
Crank arm was mounted excessively tight.	Use procedure for removing crank arms with damaged extractor-mounting threads. Replace crank arm.

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>A creaking sound is coming from the crank, particularly under hard pedaling load.</i>	
Crank arm is loosening.	Check and secure crank arm.
Mating surfaces of crank arm and spindle are contaminated.	Remove and clean mating surfaces. Optional: add Loctite #242 or #222 to mating surfaces to fill gaps.
Crank arm is a poor fit to spindle due to incompatibility or wear.	Remove and inspect crank arm and spindle for evidence of poor fit. Replace if there is evidence that fit is bad.
Loose pedal-cage piece(s).	Check and secure pedal-cage piece(s).
Loose pedal mounting.	Check and secure pedal mounting.
Loose chainring bolt(s).	Check and secure chainring-mounting bolt(s).
Cracks in crank arm or chainring-mounting arms.	Remove, clean, and inspect crank arm and chainring-mounting arms.
Loose B.B. cup, lockring, or retaining ring.	Check and secure B.B. cups, lockrings, or retaining rings.
SYMPTOM: <i>A crank arm is repeatedly loosening up.</i>	
Inadequate torque.	Use torque wrench if not already. Use maximum recommended torque, if not already.
Crank arm is worn out and fits poorly, or is not compatible with spindle and fits poorly.	Remove and inspect crank arm and spindle for evidence of poor fit.
Crank-arm and spindle-mating surfaces are contaminated with lubricant.	Clean mating surfaces and remount dry or with Loctite #242 or #222.

SHIMANO SPLINE-FIT CRANK ARMS

TERMINOLOGY

Splines: An alternating arrangement of axially-aligned lands (ridges) and flutes (grooves) around a cylinder.

Splined spindle: A bottom-bracket spindle that is splined on the ends, as opposed to the traditional squared taper.

Splined hole: A cylindrical hole that is splined.

One-Key Release: A design of crank-arm retaining bolt that serves as a remover when the bolt is loosened.

TYPES

There are two types of spline patterns used. The original pattern, found on Shimano XTR, Dura-Ace, Ultegra, and 105 crank arms and corresponding bottom brackets are the “short-spline” type. The critical spline dimensions of this type are that the eight lands (ridges) are 2.2mm thick and 5mm long. The second pattern, introduced on 2000 Deore XT and LX models and corresponding bottom brackets, are the “long-spline” type. This type has eight lands that are each 2.8mm thick and 9mm long and is not interchangeable with the 2.2 × 5mm pattern. After seeing both, it is effortless to visually distinguish the types from each other by the relative length of the splines.

CRANK-ARM REMOVAL

Some of the models feature Shimano One-Key Release. This feature can easily be identified by looking at the cap that surrounds the Allen bolt that secures the crank. If the cap has two pin holes 180° apart, then the mechanism is a One-Key Release. In this case, to remove the crank arm, first make sure that the cap is secure with a pin spanner, then loosen the Allen bolt, which automatically removes the arm. If the cap tends to unthread while loosening the bolt, remove the cap, check that the plastic washer is between the cap and bolt head, grease the back side of the cap, then reinstall the cap and try again. If the One-Key Release fails or is missing parts, remove the bolt and use the technique described next for cranks with no One-Key Release.

Certain models of spline-fit crank arms do not have a One-Key Release, and cannot be removed by a conventional remover without the use on an additional

tool. That additional tool is a Shimano TL-FC15, which is a plug that goes in the spindle after the removal of the crank-arm mounting bolt. Only with this plug in place is it possible to use a regular crank-arm remover, because otherwise the shaft of the extractor would insert inside the oversize hole in the spindle and therefore not press against the end of the spindle.

CRANK-ARM INSTALLATION

If replacing parts or assembling parts that have never previously been installed, make sure the spline pattern of the spindle and the crank arms are compatible. Since the splined hole of the crank arm is partially filled by the mounting bolt, it is difficult to take any measurements of the spline pattern. Check whether the spindle splines are 5mm or 9mm long. As of the 2000 model year, if the spindle splines are 9mm long, then the only compatible arms are marked XT and LX. According to Shimano, the longer spline pattern is required by the softer metals used in the less expensive models, so in subsequent years expect this spline pattern on more basic models only.

The following arm-installation procedure includes removal of the One-Key Release, which insures that the splines will engage properly. Leaving the One-Key Release in the arm while installing the arm risks improper engagement of the splines. Furthermore, the proper setup of the One-Key Release is critical to its function when removing the arm, and it is likely it is not installed correctly. If not removing the One-Key Release because there is no question that it is properly installed, take every caution to insure that the splines are engaging properly when securing the arm.

If the arm being installed does not utilize the One-Key Release, simply perform steps 1–6.

1. [] **Grease spindle splines and cylindrical taper.**
2. [] **If installed, remove One-Key Release.**
3. [] **Place arm on spindle, checking that splines are engaged.**
4. [] **Grease metal washer and install in arm.**
5. [] **Grease bolt threads and thread into spindle.**
6. [] **Torque bolt to 435in-lbs.**
7. [] **Install plastic washer over bolt head.**
8. [] **Grease inside of One-Key Release cap.**
9. [] **Put one drop of Loctite 242 on One-Key Release cap threads.**
10. [] **Install and secure cap.**

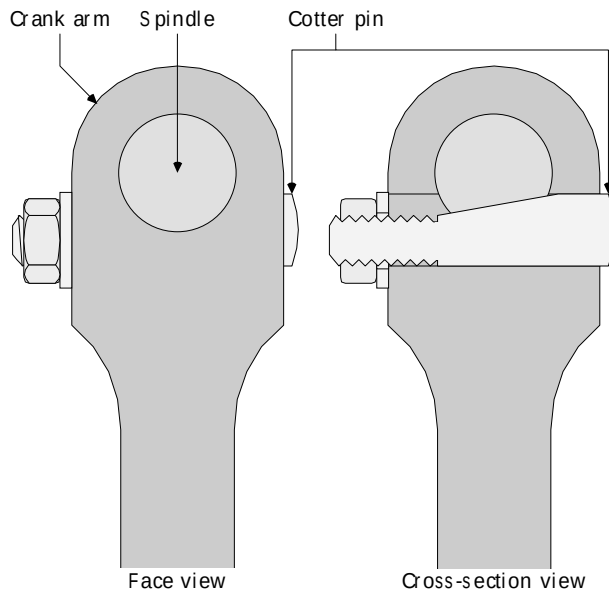
21 – COTTERED CRANK ARMS

ABOUT THIS CHAPTER

This chapter is about removing and installing cottered crank arms. There are different chapters for taper-fit crank arms (**20 – TAPER-FIT CRANK ARMS**) and for one-piece crank arms (**22 – ONE-PIECE CRANKS**). There is also a separate chapter (**23 – CHAINRINGS**), which should be referred to if the chainrings will be removed, replaced, or secured. There is also a separate chapter (**24 – PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION**), which includes information about pedal removal and installation, a job that is often done as part of crank-arm removal and installation.

GENERAL INFORMATION

TERMINOLOGY



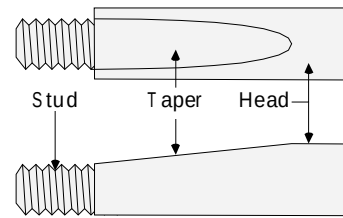
21.1 Face view and cross-section view of the end of a cottered crank arm at the end joined to the bottom-bracket spindle.

Cottered crank: The term “cottered cranks” applies to a crank-arm type that once was seen on almost all European imports, but is now limited primarily to the sort of inexpensive Asian imports found in

department stores. The crank arms slip onto a round shaft and are retained by a pin (cotter pin) that goes through a hole in the arm and a slot in the shaft.

Crank arm: The lever arm that attaches to the bottom-bracket spindle at one end and the pedal at the other end. The right crank arm has chainrings (gears) attached to it, usually by means of chainring-mounting arms.

Cotter pin: A round shaft with a sloped and tapered flat along its length and a threaded stud at one end.



21.2 A cotter pin.

Cotter-pin taper (or “taper”): The shaft of the cotter pin has a section cut off along the length of the pin that is cut at an angle to the axis of the shaft. This results in a flat surface that is sloped and tapers to a point at one end. This is the taper.

Cotter-pin stud (or “stud”): A threaded stud at one end of cotter pin onto which a retaining nut threads.

Cotter-pin head (or “head”): The end of the cotter-pin shaft without threads.

Cotter-pin hole (or “pin hole”): The cotter pin inserts in a small round hole in the crank arm into which the cotter pin is inserted. This hole is perpendicular to the hole in the crank arm for the bottom-bracket spindle.

Cotter-pin stud (or “stud”): The threaded stud at one end of the cotter pin onto which a retaining nut threads.

Spindle hole: The large round hole in the crank arm that the bottom-bracket spindle inserts in.

Chainrings: The gears attached to the right crank arm that drive the chain when pedaling.

Chainring-mounting arms: The arms (usually three, occasionally five) that go from one end of the crank arm out to the chainrings. The chainrings are attached to the end of the chainring-mounting arms. Chainring-mounting arms are also called *spider arms*.

21 – COTTERED CRANK ARMS

PREREQUISITES

See the **PREREQUISITES** section of the preceding chapter, **TAPER-FIT CRANK ARMS** (page 20-1). All prerequisites are the same for both types of crank designs.

INDICATIONS

Maintenance cycles

If properly installed, crank arms should not need any routine maintenance.

Bottom-bracket service

Crank arms must be removed to adjust, overhaul, or replace the bottom bracket. There may be no apparent problems with the crank arms, but this is an excellent opportunity to check for potential problems.

Symptoms indicating loose crank arms

One of the most persistent problems with crank arms is that they work loose. This can strand the rider — and it can easily destroy the arm that works loose, an expensive concern. Knocking or popping noises from the crank area are a warning sign that the arms may be loosening. But loose pedal parts and loose chainrings can cause similar noises, so check all these areas at the same time. When the arm makes a knocking sound or feels loose while pedaling, the situation is critical.

With proper installation, most riders do not need to periodically tighten the crank arms.

Symptoms indicating damaged crank arms

When proper installation technique fails to keep the arm secure, it means the cotter-pin hole in the arm is deformed (enlarged or distorted). The crank arm should be replaced.

Symptoms indicating bent crank arms

Crank arms bend sometimes when the bike is crashed, and they can bend from abusive jumping. The symptom of a bent crank arm is an oscillating sensation felt in the ankle while pedaling. This oscillation may feel like a twisting back and forth on the ball of the foot; it may feel like the outer edge of the foot is rocking up and down; or it may feel like both at once. The identical symptoms are caused by bent pedal shafts, which can easily be damaged by the same forces that damage crank arms. The first step is to remove the pedal and look at the end of the pedal shaft as it rotates. If the end does not oscillate, then it is the crank arm that is bent. If it does oscillate, new pedals are needed. If the symptom is still felt when riding with new pedals, then the arm is also bent.

Symptoms indicating damaged pedal-mounting threads

Pedal-mounting threads can be damaged from improper pedal installation. The only symptom is difficulty threading in the pedal. Sometimes it is repairable, which is described in the chapter **PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION** (page 24-6), but sometimes it is necessary to replace the crank arm.

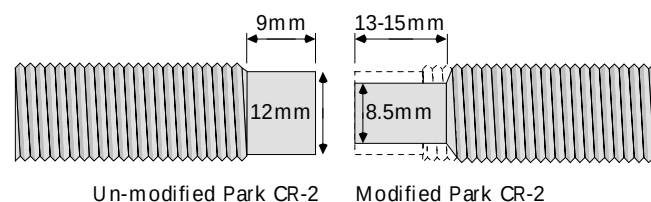
TOOL CHOICES

For many mechanics, the tool of choice to remove cotter pins is a hammer. This is a sure way to damage cotter pins, achieve inadequate security, and dramatically increase the time it takes to complete the job. Special cotter-pin presses are made by VAR and Park, but the Park CR-2 is clearly superior to use and less than one-third the price of the VAR. Some of this price savings is lost because it is a good idea to have two Park CR-2 tools.

One of the tools should be left in its original form and be used exclusively for pin installation. The second CR-2 should be permanently modified to make it more suitable for cotter-pin removal (and unsuitable for installation).

Modifying a Park CR-2 for pin removal

The tip of the pressing shaft of the tool is a smooth shaft approximately 9mm long with an 11mm O.D. It needs to be modified on a grinder or with a file to be approximately 13–15mm long and less than 8.5mm O.D. This modification does not have to be very precise. It can be done on a grinding wheel in 1–2 minutes.



21.3 *Modifying the end of a Park CR-2*

This modification allows the tip of the tool to go inside the pin hole in the arm, which is particularly useful when the pin jams or when the stud bends and must be broken off (common).

TIME AND DIFFICULTY RATING

Crank-arm removal and re-installation is a 1–2 minute-per-arm job of little difficulty. Fitting a new replacement crank arm, which can include chainring and pedal removal and installation as well as front

derailleur adjustment, is a 10–45 minute job of little difficulty (unless derailleur adjustment is included, in which case difficulty may be high).

COMPLICATIONS

Exact replacement cotter pins not available

It is very unusual to be able to find exact replacement cotter pins. Included in this chapter are guidelines for determining suitability of a nonidentical replacement and how to accommodate for a pin that is not suitable (page 21-5).

Replacement arm does not fit spindle

Depending on the country of origin, there is some variation in spindle and spindle-hole diameters. English and Japanese are interchangeable. French and Italian are interchangeable.

Replacement arm changes chainring clearance

There is usually a 1–2mm range of position of the arm on the spindle. First, try sliding the arm in or out to improve the situation.

A nonidentical right-side replacement arm may be suitable fit to a spindle, but not necessarily put the chainrings in the same position relative to the frame. This could be a problem if the chainrings end up closer to the frame. The following procedures have steps for checking the original clearance and the clearance after installing a new right arm.

Replacement arm changes chainline

There is usually a 1–2mm range of position of the arm on the spindle. First, try sliding the arm in or out to improve the situation.

Because a replacement right-side arm can change the chainring positions, it can change the alignment of the chainrings to the rear cogs (chainline). The following procedures have steps for checking chainline before and after, but the separate **CHAINLINE** chapter should be referred to for help in how to measure chainline (page 27-5) and how to identify whether an error is significant (page 27-3).

New chainring-size/position changes front-derailleur adjustment

There is usually a 1–2mm range of position of the arm on the spindle. First, try sliding the arm in or out to improve the situation.

If installing a replacement right-side crank arm, the chainrings may move in or out. This would necessitate changing both limit screws and the cable setting on the front derailleur. If the replacement crank arm has a large chainring of a different size, then derailleur height and rotation would need to be reset (which leads to limit screw and cable adjustment, as well).

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is the procedure for crank-arm removal and installation. There are double check-boxes next to all the steps that would be done twice, once for each crank arm. It includes all the necessary steps for crank-arm replacement except that it refers to other chapters for pedal and chainring removal and installation.

CRANK-ARM REMOVAL AND INSTALLATION

IF REPLACING ARM(S) OR TO FACILITATE CLEANING

1. [] [] Remove pedal(s) (optional). See *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-3).

PREPARATION AND PRE-REMOVAL INSPECTIONS

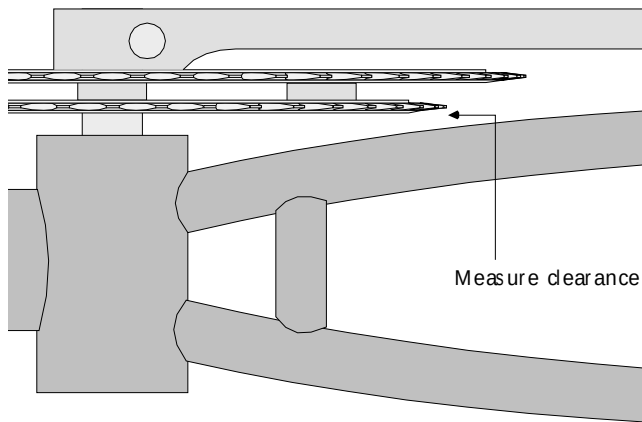
In the next step, measure the clearance between the right-crank assembly and the chain stay. The chain stay is the frame tube that runs from the bottom bracket to the rear dropout. If the bike has raised chain stays (they connect to the seat tube above the front derailleur), measure to the side of the seat tube instead. The measurement is useful even if just re-installing the same crank arm, for two reasons.

Due to frame flex and chainring flex, there must be at least 2mm clearance between any part of the right-crank assembly and the chain stay. Otherwise, rubbing that can damage the frame may occur while the bike is being ridden. Measuring before removal can reveal a problem, or borderline problem, before going to the trouble of re-installation the arm. If clearance is poor before removal, it will be necessary to

21 – COTTERED CRANK ARMS

check and replace the arm if it is found to be worn out, or put in a longer bottom-bracket spindle if the arm is fine. If the clearance is marginal before removal, measuring it is a warning to check carefully when the arm is re-installed.

After re-installing the original arm or installing a replacement arm, measuring the change in the clearance reveals whether it will be necessary to readjust the front derailleur.



21.4 Use a stack of feeler gauges to measure the clearance between the chain stay and the part of the crank assembly that comes closest to rubbing the chain stay.

- 2. [] Measure clearance between chain stay and part of right crank that comes closest to chain stay (usually inner chainring or bolt heads holding on inner chainring, but occasionally another chainring). Record measurement here: _____ mm. If bike has raised chain stays, measure to side of seat tube.**

In the next step, measure the chainline error (detailed procedure on page 27-5). Chainline is covered in its own chapter. Chainline is the alignment of the front gears to the rear gears. It affects drive-train noise and shift performance. Measure chainline now and then again after re-installing the original right arm or a new right arm. This measurement allows you to know whether chainline has improved, stayed the same, or gotten worse, in which case it would be necessary to check for symptoms in order to determine whether the error was significant. (See page 27-3.)

- 3. [] Measure chainline error: Chainrings out (+) or in (-) (circle one)? Amount: _____**

In the next step, the position of the right crank-arm face relative to the right end of the spindle is measured, using the depth gauge of a caliper. There is usually a range of position in which the arm can be installed. Taking this measurement and reestablishing it during re-installation avoids messing up the front-derailleur adjustment.

- 4. [] Measure position of face of right crank arm relative to right end of spindle.**

Spindle protrusion/recess: _____ mm.

CRANK-ARM REMOVAL

From this point on, steps that need to be repeated for both arms (if servicing both arms) have two check-boxes. One is to use for the first arm, and one for the second arm. If only servicing one arm, use one check-box only and do not repeat the step for the second arm.

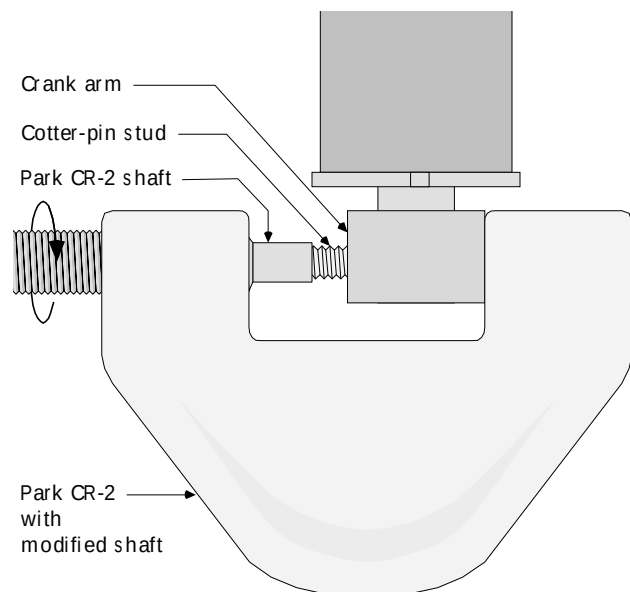
- 5. [] [] Remove nut and washer from cotter pin.**

Cotter pins can be difficult to remove; when they are, the stud will almost always bend. Prevent this as much as possible by using penetrating oil, as indicated in the next step.

- 6. [] [] Flood both ends of pin with penetrating oil.**

In the next step, cotter-pin removal is attempted. It is not unusual for the stud to bend before removal is accomplished. If this occurs, don't waste time straightening the stud and trying removal again. Bend the stud back and forth until it snaps off and continue the removal process without the stud. The modified CR-2 is required for this purpose.

If you have only the non-modified Park CR-2, the best approach is to break off the stud (bend it back and forth), then insert a 8–10mm length piece cut from the head-end of a used cotter pin between the CR-2 shaft and the remainder of the stud. This insert needs to be smaller or equal to the diameter of the cotter pin being removed. The insert will have a tendency to cock to the side and jam. The modified CR-2 is a much better solution to this common problem.

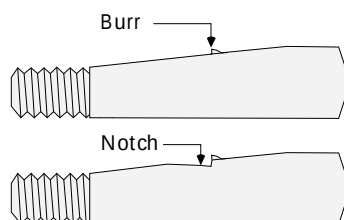


21.5 Correct set up of Park CR-2 for cotter-pin removal.

7. [] [] Install modified CR-2 so end of shaft is against stud and turn handle clockwise to drive cotter pin fully out.
8. [] [] Pull arm off end of spindle.

INSPECTION

9. Inspect pin holes in arms for enlargement and for being ovalized:
 - [] Right arm OK? not OK? (circle one).
If not OK, arm should be replaced.
 - [] Left arm OK? not OK? (circle one).
If not OK, arm should be replaced.



21.6 Top cotter pin has burr, but can be reused. Bottom one is notched and must be replaced.

10. Inspect pin tapers on pins for notches or deformation (burrs may be filed off):
 - [] Right pin OK? not OK? (circle one).
If not OK, pin should be replaced.
 - [] Left pin OK? not OK? (circle one).
If not OK, pin should be replaced.
11. Thread nuts back onto studs to check for damaged studs:
 - [] Right pin OK? not OK? (circle one).
If not OK, pin should be repaired or replaced.
 - [] Left pin OK? not OK? (circle one).
If not OK, pin should be repaired or replaced.

IF REPLACING RIGHT ARM, OR TO FACILITATE CLEANING

12. [] Remove chainrings (optional). See **CHAINRING REMOVAL, REPLACEMENT, AND INSTALLATION** procedure (page 23-9) if removing or replacing chainrings.

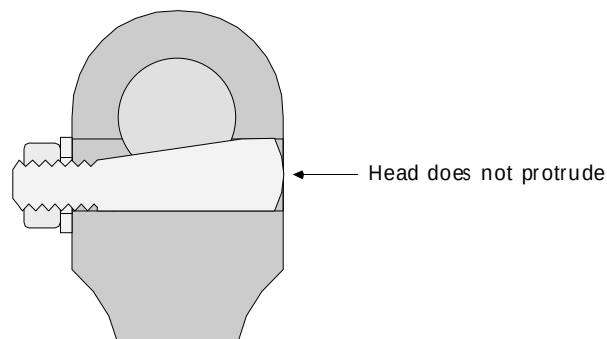
CRANK-ARM CLEANING

13. [] Clean crank arms and chainrings (if any).

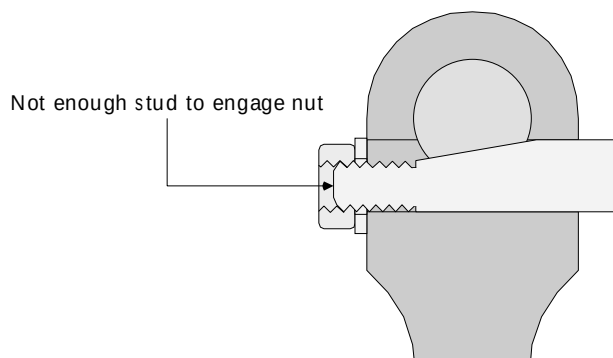
DETERMINE REPLACEMENT- COTTER-PIN SUITABILITY

Exact replacement cotter pins are almost impossible to find. Use the following guidelines to determine suitability of a replacement cotter pin.

1. Pin diameter must match. (Common sizes are 9.0mm and 9.5mm, but 8.0mm and 8.5mm sizes also exist.)
2. Pressed-in pin must have head protruding from arm. If not, different pin must be used. See example 1 (figure 27.7).
3. Pressed-in pin must have enough stud protruding to engage washer and nut. Pin can be filed to improve this condition. See example 2 (figure 27.8).
4. Pressed-in pin should not have full stud exposed. Washers with I.D. larger than pin can be used over pin shaft to improve this condition. See example 3 (figure 27.9, page 21-6).
5. Pin-taper angles must match or arms will not be 180° apart. Both pins should be replaced to avoid this problem. See example 4 (figure 27.10, page 21-6).

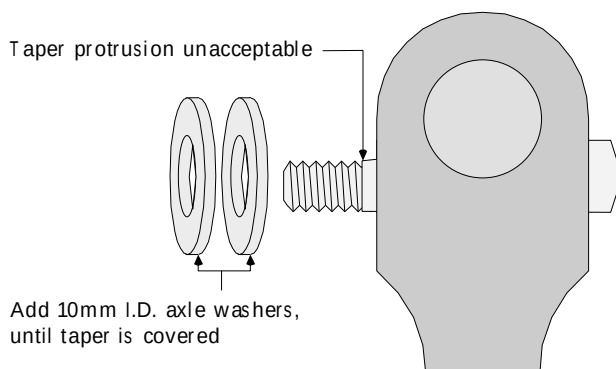


21.7 Example 1: The cotter pin in this picture does not have enough head protruding to allow further pressing after break-in.

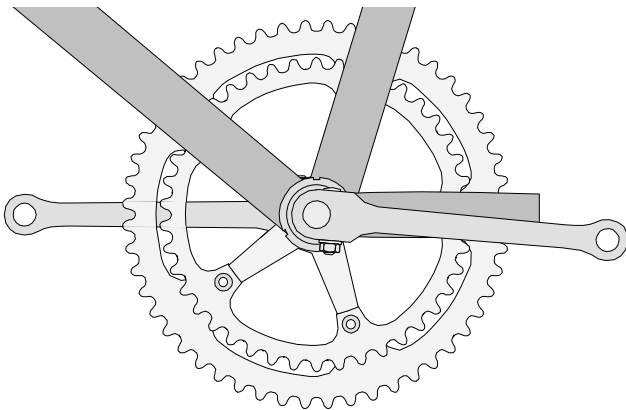


21.8 Example 2: The cotter pin in this picture does not have enough stud protruding. The taper can be filed deeper to improve this condition.

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21.9 Example 3: The cotter pin in this picture has too much of the stud end protruding. Add washers to improve this condition.



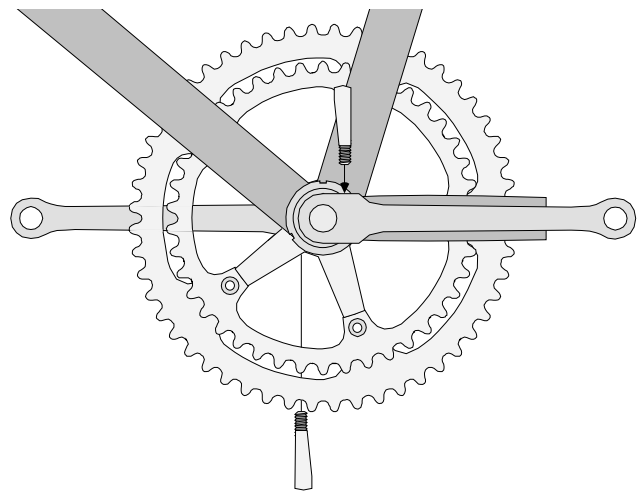
21.10 Example 4: The arms are not 180° apart because the cotter pins do not have the same taper angle. Both pins should be replaced with identical replacements to solve this problem.

Filing cotter pins to improve fit

A flat file can be used to file the taper deeper so that a pin will insert further. Do not try to change the angle of the taper, just its depth. A VAR 371 is a tool designed to hold the cotter pin for filing. Although not required, it makes an awkward job effortless.

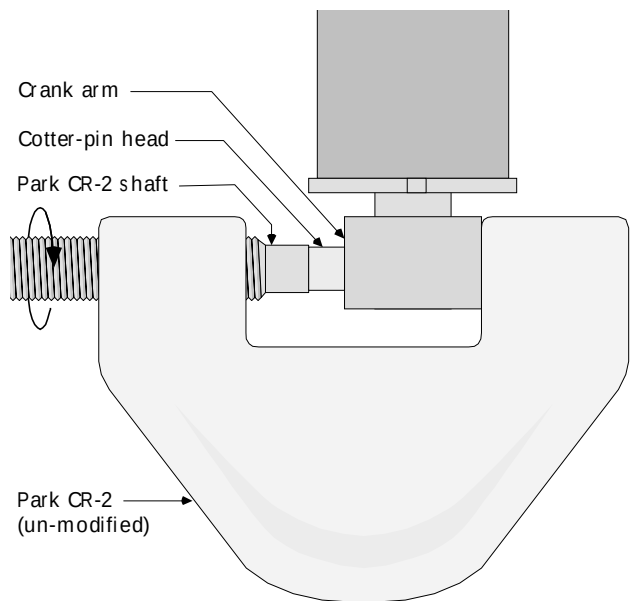
CRANK-ARM INSTALLATION

14. [] Install chainrings if removed. See **CHAINRING REMOVAL, REPLACEMENT, AND INSTALLATION** procedure (page 23-10).
15. [] Clean cotter pin, pin hole, and spindle flat with acetone or alcohol.
16. [] Slide crank arm onto spindle.



21.11 When the cotter pin in the left arm is “head-up,” the pin in the right arm should be “head-down.”

17. [] Slide cotter pin into pin hole. (When installing second arm, be sure pin heads point opposite directions when viewed simultaneously.)
18. [] Position right arm (if re-installing original) to restore measurement from step 4.



21.12 Setup for using the CR-2 to press in the cotter pin.

19. [] Use CR-2 to press in pin fully. With handle extended fully to one end, minimum of 55 pounds of force is required at 4".
20. [] Grease stud threads.
21. [] Thread on retention nut and secure to 60in-lbs (20lbs@3").

CHECKING FIT OF REPLACEMENT CRANK ARM

NOTE: Skip to step 25 if arms installed are same ones removed, not replacements.

Checking chainring fit if replacement arm is a right arm

If using old chainrings with a new crank arm, check the **CHAINRINGS** chapter (page 23-5) to determine whether the new arm is compatible with the chainrings before installing the chainrings. Chainring compatibility is not just a matter of whether the mounting holes in the chainrings and the crank arm match up. With some chainrings, spacing between them is critical and not universal.

In the next step, measure the right chainring clearance with the new arm installed to check if the chainring position has changed. Be concerned with discovering whether a clearance problem to the chain stays has been created or solved, and whether the chainrings have moved enough to require readjusting the front derailleur.

22. Measure chainring-to-chainstay clearance and check one of following choices:

- ☐ Clearance is ≥ 2 mm, but is more than .2mm different than number in step 2. *Front-derailleur limit screws and cable will need adjustment.* (Measure to seat tube if raised-chain-stay bike, ignore minimum clearance.)
- ☐ Clearance is < 2 mm, *replacement arm is unacceptable to use with existing spindle.* (Skip this step for raised-chain-stay bikes.)
- ☐ Clearance is different by $\pm .2$ mm from number in step 2, *front-derailleur adjustment is not needed. Arm is a good fit.*

In the next two steps, measure the chainline after installing a new right crank arm to determine whether it has been changed enough to create or solve a problem. Consider not only whether there is a measurable error, but whether the error has changed enough *to introduce or eliminate chainline-error symptoms*. See the **CHAINLINE** chapter for information about how to measure chainline error (page 27-5) and symptoms of chainline error (page 27-3).

23. Measure chainline error, record here:

Chainrings *out (+)* or *in (-)* (circle one)?
Amount: _____

24. Compare step 23 to number and direction in step 3, and choose one of following choices:

- ☐ Error is equal to step 3, arm is acceptable if no chainline-error symptoms were experienced with original arm.

- ☐ Error is in same direction but less than step 3, arm is acceptable unless previous chainline error was unacceptable and change is not enough to eliminate symptoms. Bike should be evaluated for chainline-error symptoms.
- ☐ Error is in new direction. Bike should be evaluated for chainline-error symptoms.
- ☐ Error is in same direction but greater. Inspect bike for chainline-error symptoms.

INSTALL PEDALS

- 25.** ☐ Install pedal(s) if removed. See *PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION* procedure (page 24-4).

COTTERED-CRANK-ARM TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
NOTE: Symptoms not unique to cotter-pin crank arms are found in the troubleshooting chart in the previous chapter TAPER-FIT CRANK ARMS (page 20-14).	
SYMPTOM: <i>Cotter pin becomes loose quickly after installation.</i>	
Was not installed with enough force.	Use minimum of 55 lbs. force at 4" on Park CR-2.
Lubrication present on pin, pin hole, or spindle flat.	Clean all mating surfaces with acetone or alcohol.
Under-sized pin has been used.	Cotter-pin diameter must match pin-hole diameter closely.
Pin hole in arm was enlarged by being ridden with loose pin too long.	Replace arm.
Pin is poor fit (too much stud protruding), and retaining-nut washer stopped against shaft of pin instead of arm surface.	Replace pin, or use washers with an I.D. larger than pin shaft between arm and retaining-nut washer.
Head swells when hammer is used for installation.	Replace pin and use press tool for installation.
SYMPTOM: <i>Stud folds over during pin-removal attempt.</i>	
Failure to use penetrating oil before removal.	Break stud off and perform removal without stud.
Use of hammer for pin removal.	Break stud off and perform removal without stud, using modified Park CR-2.
SYMPTOM: <i>Cotter pin is extremely difficult to remove, in some cases even though arm is loose on spindle.</i>	
Bike has been ridden while pin was loose, bending pin in arc around spindle.	No tricks available. Use modified Park CR-2, penetrating oil, and cheater bar on tool handle.
SYMPTOM: <i>Taper has deep notch in its surface.</i>	
Bike has been ridden while pin was loose, pin has been bearing against edge of spindle flat.	Replace pin and tighten adequately.
SYMPTOM: <i>Arms are not 180° apart.</i>	
Matching pins are not installed with heads facing opposite directions, when viewed simultaneously.	Reverse direction of one pin.
Non-matching pin has been installed.	Remaining original pin should be replaced with replacement pin that matches other side.
SYMPTOM: <i>Retaining-nut threads or stud threads stripped out.</i>	
Retaining nut over-tightened.	Replace nut, tighten nut to 60in-lbs (20lbs@3").
Retaining nut was used to install cotter pin.	Replace nut. Retaining nut cannot be used for installing pin.
SYMPTOM: <i>Cotter-pin head is flush with arm surface and cannot be pressed in further to secure arm.</i>	
Pin worn out or wrong-size pin.	Install better-fitting cotter pin.
SYMPTOM: <i>Washer and retaining nut do not bear against crank arm when tightened fully.</i>	
Poor fitting pin has been used.	Replace pin, or use washers with I.D. larger than pin shaft between arm and retaining-nut washer.
SYMPTOM: <i>Not enough stud protrudes to engage washer and retaining nut.</i>	
Poor-fitting cotter pin.	Remove pin and file taper deeper, or use different pin.

22 – ONE-PIECE CRANKS

ABOUT THIS CHAPTER

This chapter is about a type of crankset called a one-piece crank. The name comes from the fact that the crank arms and the bottom-bracket spindle are all integrated into one piece. Consequently, crank-arm removal and bottom-bracket-bearing service are all one operation.

These cranksets are found on many types of bikes with one common characteristic: low cost. Most department store models, including derailleur and non-derailleur types, have this crank style. Almost all BMX bikes of any quality do, also. Older Schwinn of all types and virtually all single-speed coaster brake bikes have this crank style.

One of the few virtues of this crank style is that it uses a universal bottom-bracket shell. No matter what the brand, bike type, or vintage, a new complete crankset can always be installed.

GENERAL INFORMATION

TERMINOLOGY

One-piece crank(set): A crankset that has one continuous piece of metal that forms both the left and right crank arms and the bottom-bracket spindle.

Pressed cups: Bearing cups that press into the bottom-bracket shell.

Crank arm: The arm to which the pedal attaches.

Arm set: The piece that includes both crank arms and the bottom-bracket spindle.

Bottom bracket: The bearing assembly about which the crank arms rotate, installed in the bottom-bracket shell.

Bottom-bracket shell: The cylindrical shell at the bottom of the frame into which the crankset bearings are installed.

Fixed cone: A bearing cone that is fixed in position. The fixed cone is threaded onto the left end of the spindle-portion of the crank-arm set.

Adjustable cone: A bearing cone that has an adjustable position. The adjustable cone is threaded onto the left end of the spindle-portion of the crank-arm set.

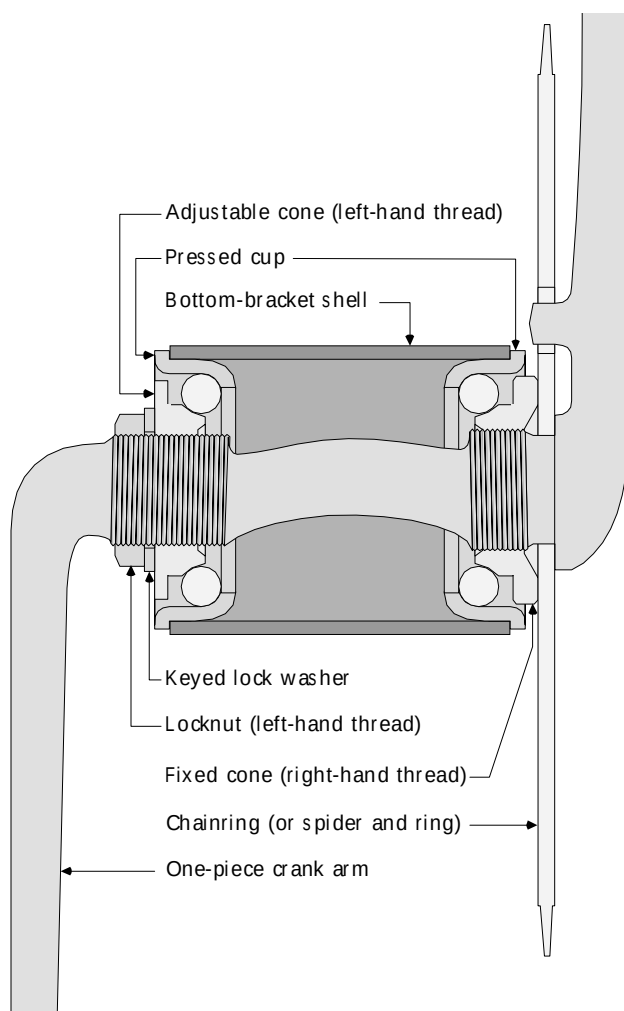
Locknut: A nut that is threaded against the adjustable cone to secure its position.

Lock washer: A keyed washer that goes between the locknut and the adjustable cone so that one can be turned without affecting the position of the other.

Bearing retainer: A circular clip filled with ball bearings. Also called simply a “retainer.”

Spider: A structure that mounts to the crank arm behind the fixed cone to which the chainring attaches. It originally consisted of five arms, hence the name “spider.” These days, the spider is often a disc.

Chainring: A disc or ring with teeth at the outer perimeter that mounts to the spider or directly to the crank arm behind the fixed cone.



22.1 Parts on a one-piece crankset.

PREREQUISITES

The only prerequisites for servicing one-piece cranks are the ability to remove and install pedals and the rear wheel.

INDICATIONS

Maintenance cycles

Due to the soft metal that is used in all brands and models of these cranks and the exposed nature of the bearings, adjustment and overhaul of these bearings is required much more frequently than with adjustable-cup bottom brackets. Its likely that anytime a bike with this type of equipment comes into the shop, the bearings will be in need of some sort of service. It is unlikely that the typical owner of a bike with this equipment is going to be willing to have a shop service the bearings as often as the bearings need it. Consequently, the shop is often forced to leave problematic one-piece-crank bearings alone, or is left with no choice but to make less-than-satisfactory adjustments to worn-out and dirty equipment.

Symptoms indicating bearings need adjustment

If play is felt at the ends of the crank arms, adjustment is needed. Since the bearings lack precision and the arms cannot be removed from the spindle, over-tight adjustments are harder to detect. With the chain removed from the chainring, a good shove should spin the crankset around several revolutions. If it stops quickly, the bearings should be adjusted.

Symptoms indicating bearings need overhaul

When play has been eliminated, if the crank does not spin for several revolutions after a good shove with the chain off the rings, then the bearings are due for overhaul.

Symptoms indicating need of arm-set replacement or repair

Crank arms bend frequently on these cranks.

If they are bent from abusive jumping, either of the two following symptoms might be immediately apparent: 1) crank arms that are no longer 180° apart, 2) chainrings that appear to oscillate as they rotate. If the crank-arm set is bent in the spindle portion, upon further inspection it is likely to be found that the bearing adjustment becomes too tight at the point free-play is eliminated, or that the faces of the cones will appear to oscillate as the crank turns (certain proof of a bent spindle-portion). If further inspection shows that the cones and cups are not worn out, then the tight-adjustment problem is caused by the spindle portion of the crank-arm set being bent. In all cases the crank-arm set must be replaced.

When the bike falls over, a crank arm may bend in on one side. Oscillating will be felt in the ankle on that side when the bike is ridden. It could also be a bent pedal shaft. A bent crank arm can sometimes be repaired. It is repaired on the bike using the Park HSC-1.

Stripped pedal-mounting threads cannot be repaired by using a thread-bushing (as is the case with other cranks, see page 24-6) due to the thin amount of material around the hole. The arm set must be replaced.

Symptoms indicating need of chainring replacement

Single chainrings rarely need to be replaced because, if bent, they can be bent back with great success. They do not need to be very straight to work, since there is no shifting or front derailleur.

Multiple chainrings usually need to be replaced when they wobble. Precision repair is difficult, but true chainrings are critical to derailleur performance.

ONE-PIECE-CRANKSET TOOLS (table 22-1)

Tool	Fits and considerations
LOCKNUT, ADJUSTABLE-CONE, and FIXED-CONE WRENCHES	
Diamond C79	Old-fashioned monkey wrench fits odd-size fixed cones not fit by fixed-cone spanners and all sizes of locknuts (special order from Ace hardware stores)
Park HCW-1	26mm open end for locknut, some adjustable cones, and 43mm for fixed cone
Park SPA-4	Fits slots in face of some adjustable cones
Hozan C205	Hook spanner fits some fixed cones
CUP PRESS	
Bicycle Research CP1	Fits bottom-bracket pressed cups and BMX headset cups
Park HHP-1	Expensive, fits bottom-bracket pressed cups and BMX headset cups

TOOL CHOICES

The design or brand of bottom bracket will determine the tools needed. Table 22-1 (page 22-2) covers tools for one-piece bottom brackets only. This list covers all the tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is in **bold**, it means that several tools are required for different configurations of parts.

TIME AND DIFFICULTY

Adjustment of a one-piece-crank bearing is a 2–5 minute job of little difficulty.

Overhaul of the bearings, replacement of the arm set, or replacement of the spider/chainring is a 30–35 minute job of little difficulty.

COMPLICATIONS

Left-hand threads

The locknut and adjustable cone on the left side of the bike are left-hand threaded. This is the opposite of the thread direction on the left side of a adjustable-cup bottom bracket. A mechanic's first few encounters with a one-piece crank are confused by this need to turn all the left-side parts the opposite direction of normal.

Stripped key on lockwasher

Many bottom brackets do not allow simultaneous use of a tool on the locknut and adjustable cone. The design relies on the lock washer to keep the adjustable cone from rotating when the locknut is being broken loose or secured. When the washer fails during locknut removal, the cone and locknut rotate together and never break loose from each other. Persistent high force is required to turn the locknut until it is all the way off the threads.

If the lock washer fails while securing the locknut, the adjustable cone will turn and tighten up the bearings until the crank will not rotate. If this is detected early, the locknut is usually not very tight against the cone, and can easily be threaded off so that the lock washer can be replaced.

Non-compatible retainers

There are two sizes of retainers used in this type of crank. They are called #64 and #66, and are not easily distinguished by sight. They fit inside cups that are slightly different in size inside, but are not marked differently in any way. The #66 retainer snaps into a cup made for a #64 retainer.

The problem that results from using a #66 retainer in the wrong cup will be experienced *only while disassembling*. Since there is no good way to grasp a retainer and pull it out of a cup, it is essential that the retainer be a loose fit in the cup, so that it can fall out on its own once the cone is out of the way. The #66 retainer in a wrong-size cup is too tight a fit to fall out. In this case, the retainer must be mangled and pried out before the arm set can be removed.

Two thread types

The arm set and cones are either threaded 24tpi or 28tpi. There are no simple guidelines about when a specific pitch might be encountered. The simplest approach is to always replace complete bearing sets, and to select one that matches the pitch of the arm set.

Difficult pressed-up installation

There is officially only one dimension for the fit of the pressed cups to the bottom-bracket shell, but sometimes it will seem as though the cups must be the wrong size because they are so difficult to install. This is usually in chromed frames and is due to thick layers of chrome. The best solution is to grease the cups (not normally done), use a press tool made specifically for these cups (see table 22-1, page 22-2), and just use whatever force is necessary.

Loose pressed cups

Extremely loose cups cause mysterious knocking sounds while riding the bike. Marginally loose cups will creak. There are not different sizes available to improve fit to the shell. Use Loctite RC680 to improve fit.

Primitive adjustment

The adjustment of these bearings is primitive because the precision of the parts is poor and because the control over the adjustable cone while securing the locknut is sometimes limited. Do not apply conventional standards to what a “good” adjustment is. Of course, there should be no free play in the finished adjustment. If the crank spins a few times once play has been eliminated, consider the adjustment good.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into two sections, **OVERHAUL AND REPLACEMENT** and **ONE-PIECE-CRANKSET TROUBLESHOOTING**.

If you are just adjusting the bearings, go to the section of **OVERHAUL AND REPLACEMENT** titled **BEARING ADJUSTMENT** (page 22-6).

OVERHAUL AND REPLACEMENT

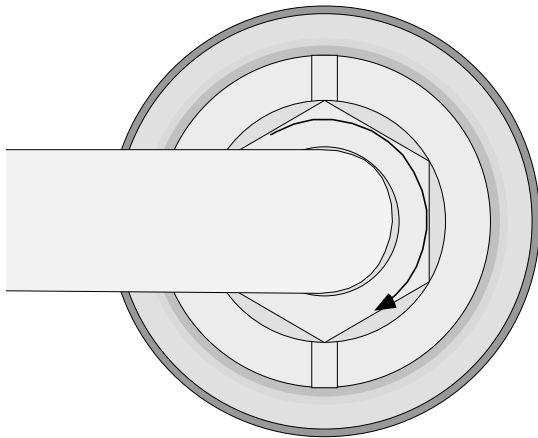
PREPARATIONS

1. [] Remove left pedal.
2. [] Only if replacing arm set, remove right pedal.
3. [] Move rear wheel to create chain slack, and drop chain off of chainring.
4. [] Inspect for arms not 180° apart.
5. Spin crank and look for (check all that apply):
 - [] bent chainring
 - [] oscillating chainrings/spider
 - [] oscillating cone faces

DISASSEMBLY

Arm-set removal

6. [] Turn locknut clockwise to break loose and thread fully off.



22.2 Turn locknut clockwise to remove.

7. [] Remove lock washer.
8. [] Turn adjustable cone clockwise to unthread fully.
9. [] Pull retainer out of left cup.
10. [] Shift crankset to right and drop retainer out of right cup and onto spindle.
11. [] Snake crankset out right side of bottom-bracket shell.

Inspection

As in all other bottom brackets, cones and cups wear by pitting. In addition, the cups may have cracks at the inner edge, indicating over-tight bearing adjustment (all the way around), or jumping abuse (bottom half only).

The lock washer has a key on the inner perimeter. This key is critical to adjusting the bearings, so the lock washer should be replaced if the key is deformed in any way.

12. [] Inspect cones, cups, and lock washer to determine wear and failure.

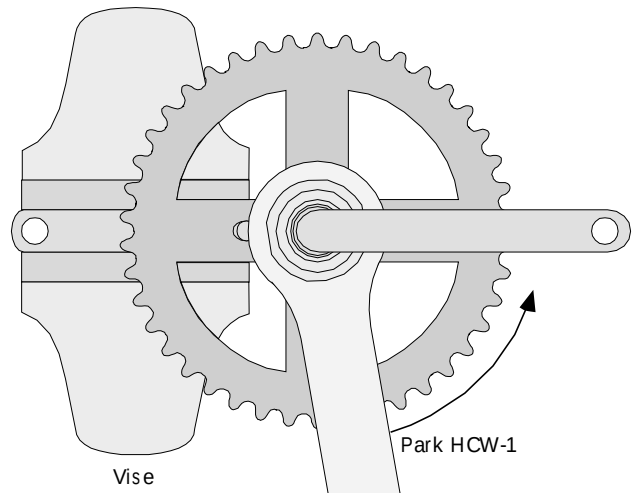
Bearing-set removal

NOTE: Skip step 13 if cups and cones were fine in inspection (step 12).

13. [] Use punch to drive both pressed cups out of shell.

NOTE: Skip step 14 if cups and cones were fine in inspection (step 12), and chainring/spider will not be replaced.

14. [] Secure right arm in soft jaws in vise with spindle portion of arm set facing up, and turn fixed cone counterclockwise to remove.



22.3 Removing the fixed cone.

Chainring/spider removal

NOTE: Skip step 15 if chainring/spider will not be replaced.

15. [] Noting direction it faces, lift chainring/spider off arm set.

CLEANING

16. [] **Clean all parts thoroughly, including inside of shell (except retainers, which should always be replaced).**

PARTS REPLACEMENT

Retainer replacement

Bearing retainers are usually marked “64” or “66.” If not marked, #64 retainers have nine balls and #66 retainers have 10 or more. If unsure which size is needed for existing cup, try pressing a #66 retainer into the cup. If it snaps in, the cup fits a #64. If it goes in effortlessly, the cup fits a #66 retainer.

17. [] **Determine if existing retainers are #64 or #66 and find matching replacement.**

Bottom-bracket replacement

It is not recommended to replace individual cups and cones due to limited parts availability and compatibility issues, as well as economy issues. Since the fit to the bottom-bracket shell is universal, the only critical thing to selecting a suitable replacement bearing set is the arm-set thread pitch, which could be 24tpi or 28tpi. Measure the pitch with a thread-pitch gauge.

18. [] **Determine if existing arm set thread pitch is 24tpi or 28tpi and find matching bottom bracket.**

Arm-set replacement

Arm sets vary in thread pitch and in arm length. Measure the pitch with a thread-pitch gauge. Arm length is measured from the center of the spindle axis to the center of the pedal-mounting hole. Arms come in 1/2" increments, so precision of measurement is not critical.

19. [] **Determine if existing arm-set thread pitch is 24tpi or 28tpi and find matching arm set of same or preferred arm length.**

Chainring/spider replacement

Chainrings and spiders can have different mounting-bolt patterns. Although almost all spiders and chainrings have five-bolt patterns, the hole-to-hole dimension of the chainring and mounting arms may vary (see page 23-6). If the number of bolt holes in the chainring and spider match, and hole-to-hole dimensions match, then two parts have the same bolt pattern.

All multiple chainring sets have a uniform tooth thickness, which fits only a 1/2" × 3/32" derailleur chain. Single chainrings could have a tooth thickness of approximately 2.2mm or approximately 2.7mm. The thinner teeth fit all chains, but the 2.7mm teeth fit 1/2" × 1/8" chains only.

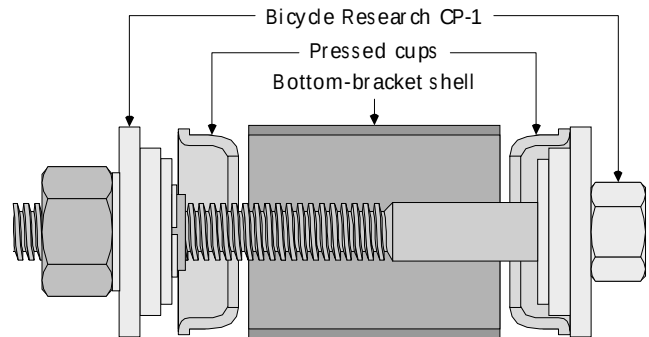
If the number of teeth change when installing a new chainring, the chain length will need to be changed.

20. [] **Determine chainring-bolt pattern and find matching chainring or spider (select one-piece chainring/spider) of suitable tooth number and tooth thickness.**

ASSEMBLY

The pressed cups are kept in by friction. The mating surfaces should be cleaned with alcohol or acetone. If the cups are an extremely tight fit, or loose, there are exceptions. Extremely difficult to install cups should be greased. Loose cups should be installed with Loctite RC680.

21. [] **Clean cups and shell with alcohol/acetone and use press to install cups fully in bottom-bracket shell.**



22.4 Setup for using the Bicycle Research CP1 to install the cups.

22. [] **Secure right arm in soft jaws of vise with spindle portion of arm set pointing up.**

Install chainring/spider

23. [] **Place chainring/spider over left end of arm set and rotate to engage arm-set peg into chainring/spider hole.**

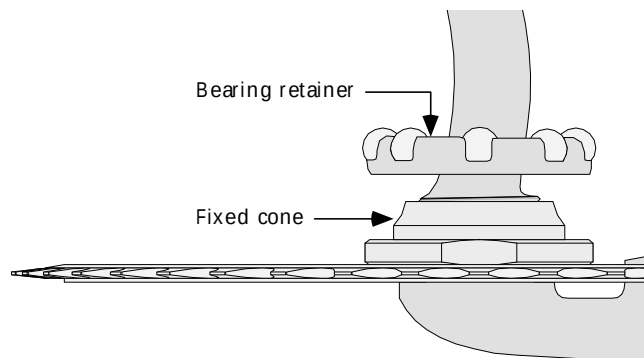
24. [] **Grease fixed cone threads.**

25. [] **Thread fixed cone on clockwise and secure to 300–350in-lbs (30–35lbs@8").**

22 – ONE-PIECE CRANKS

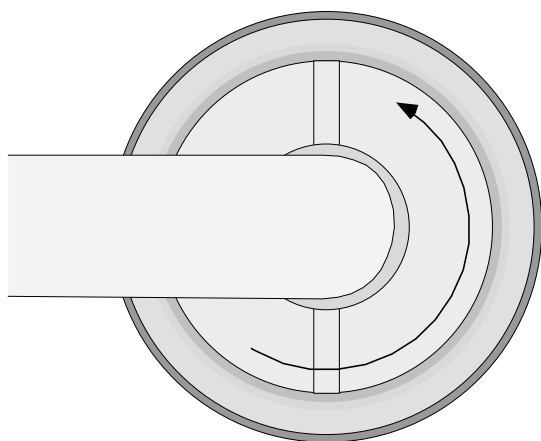
Arm-set installation

- 26. [] Put heavy coat of grease on fixed cone.
- 27. [] Place retainer (exposed-bearings-side up) on fixed cone and cover heavily with grease.



22.5 Place retainer on fixed cone.

- 28. [] Put heavy coat of grease on adjustable cone.
- 29. [] Place retainer (exposed-bearings-side up) on adjustable cone and cover heavily with grease.
- 30. [] Grease left-side threads on arm set.
- 31. [] Snake left end of arm set into right side of bottom-bracket shell until right-side retainer is inside of right cup.
- 32. [] Thread adjustable-cone/retainer assembly counterclockwise onto left threads of arm set.



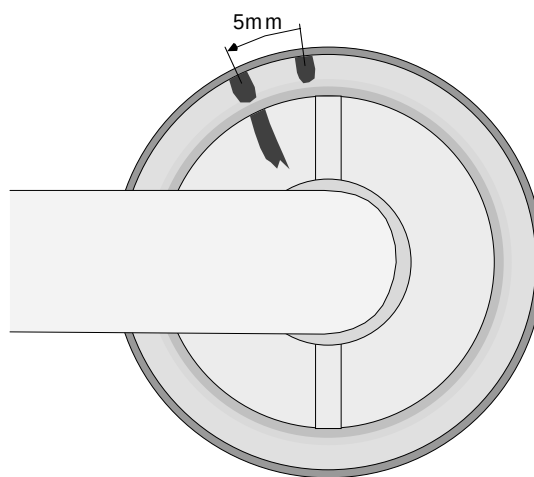
22.6 Thread adjustable cone on counterclockwise.

- 33. [] Slide lock washer onto left end of arm set.
- 34. [] Thread locknut counterclockwise onto left-side threads.

BEARING ADJUSTMENT

NOTE: If bearings were not just overhauled or installed, turn locknut clockwise to break loose and loosen adjustable cone before doing step 35.

- 35. [] Thread adjustable cone counterclockwise towards bearings until contact is just felt, then back off clockwise 90°.
- 36. [] Holding adjustable cone stationary if possible, secure locknut counterclockwise to approximately 300in-lbs (30lbs@10").
- 37. Jerk on ends of crank arms to feel for free play:
 - [] If none felt, redo step 35 even looser.
 - [] If play felt, proceed to next step.
- 38. [] Use marker to put matching marks at edge of cone and lip of cup.
- 39. [] Break loose locknut.
- 40. [] Rotate cone counterclockwise to put cone mark 5mm past cup mark and put new matching mark on cup lip.



22.7 Cone moved to 5mm counterclockwise of original cup mark, and new mark added to cup.

When securing the locknut, the cone mark may shift counterclockwise from the new cup mark. If this happens once, it should happen the same every time. If this is the case, deliberately set the cone mark short of the new cup mark so that when the locknut is secured, the cone mark will shift to line up with the cup mark.

- 41. [] Holding adjustable cone stationary if possible, secure locknut counterclockwise to approximately 300in-lbs (30lbs@10").
- 42. Jerk on ends of crank arms to feel for free play:
 - [] If no play felt, adjustment is complete.
 - [] If play felt, repeat steps 39–42.

COMPLETION

- 43. [] Install pedal(s), if removed.
- 44. [] Mount chain on chainring.
- 45. [] Tension chain and secure rear wheel.

23 – CHAINRINGS

ABOUT THIS CHAPTER

This chapter is about removing and re-installing chainrings from the right crank arm. There are separate chapters about crank arms (**20 – TAPER-FIT CRANK ARMS**, and **21 – COTTERED CRANK ARMS**) which should be referred to if the crank arms will be removed, replaced, or secured.

Chainrings might be removed for cleaning or replacement. It is possible to clean chainrings adequately without removing them from the crank arm and without removing the crank arm from the bike. Replacement of worn and damaged chainrings is possible on most cranks, but some cranks may have permanent chainrings, or the chainrings may be in an unusual configuration for which no replacements are available. There are several critical issues of compatibility between crank arms and chainrings, so before beginning to replace chainrings with non-identical parts, become familiar with the section of this chapter on chainring/crank-arm compatibility (page 23-5).

GENERAL INFORMATION

TERMINOLOGY

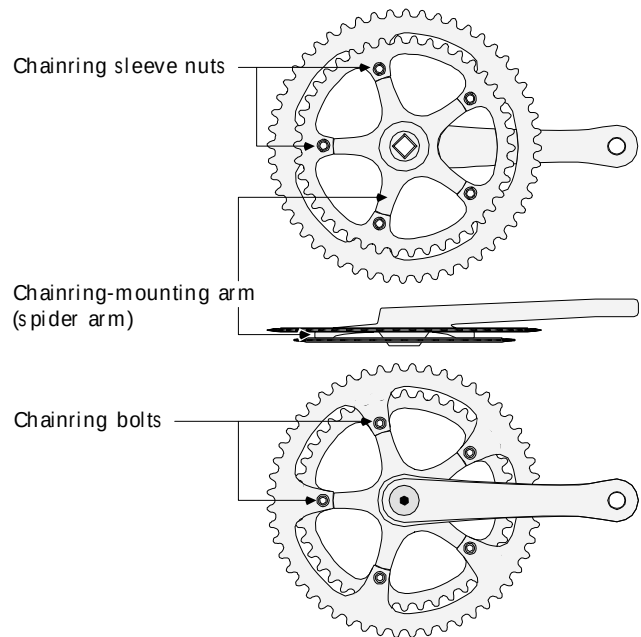
Chainring: A toothed ring that is part of the crankset. Other words used are “chainwheel” and “sprocket.”

Chainring bolt: There are several chainring bolts that attach the chainring to the crank arm. These bolts may thread directly into the crank arm or directly into another chainring, but most likely thread into a sleeve nut. Usually the bolt has a broad flange for a head and is fit by an Allen wrench. It may at times just be called an “Allen bolt.”

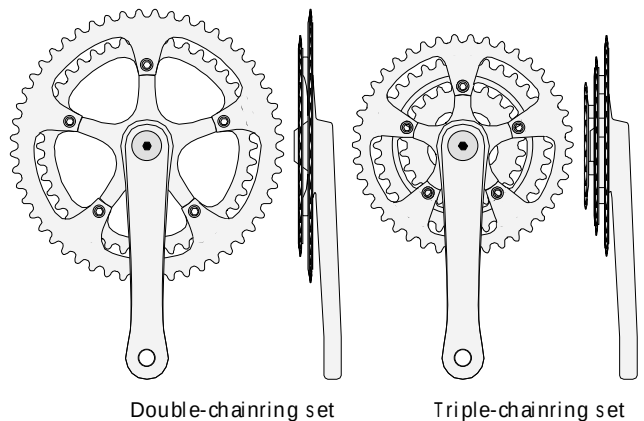
Sleeve nut: The thin-walled cylinder that the chainring bolt threads into.

Chainring-bolt set: A set comprised of the chainring bolt, the sleeve nut, and any spacers that fit between the bolt, nut, and chainrings.

Chainring-mounting arms: The arms (usually five), that go from the end of the crank arm out to the chainrings. The chainrings are attached to the end of the chainring-mounting arms. Chainring-mounting arms are also called “spider arms.”



23.1 Parts of the chainring set.



23.2 Chainring sets.

Double-chainring set: A set of two chainrings on a crank arm. Usually found on road bikes, particularly for racing bikes.

Triple-chainring set: A set of three chainrings attached to a crank arm. Usually found on off-road bikes and on road-touring bikes.

Bolt-circle diameter: A measurement used to describe the fit of a chainring to a crank arm. It is the diameter of the imaginary circle that goes through the centers of all the holes in the chainrings where the chainring bolts are inserted (see figure 23.5, page 23-6).

Hole-to-hole dimension: A measurement used to identify the bolt-circle diameter of the chainring. The hole-to-hole dimension is measured from the edge of one chainring-bolt hole to the opposite edge of the adjacent chainring-bolt hole (see figure 23.5, page 23-6). The hole-to-hole-dimension is located in a table (page 23-6) to be converted into the bolt-circle diameter.

Bolt pattern: The chainring-bolt pattern is the combination of the number of bolts that hold on the chainring and the bolt-circle diameter, such as “The bolt pattern is 5-hole, 130mm.”

BioPace: A quasi-elliptical chainring designed by Shimano. Essentially, the shape is that of a generously rounded parallelogram, not a true ellipse. Other brands of non-round chainrings are simple ovals (ellipses).

SG/SGX/HyperDrive: Loosely interchangeable terms used by Shimano to describe a chainring design that features specially-shaped teeth and other features that allow a chain to simultaneously engage two chainrings while in the process of being shifted. With regular chainrings, the chain must disengage one chainring fully before it can engage another.

Chain stay: A frame tube that goes from the bottom bracket to the rear dropout, and comes close to the chainrings and crank arms. It is mentioned here because clearance between the chainrings and the chain stay is often a concern.

PREREQUISITES

Crank-arm removal and installation

Before removing chainrings, the right crank arm may need removal, particularly if the chainrings are a triple-ring set. See the **TAPER-FIT CRANK ARMS** chapter (page 20-6), or the **COTTERED CRANK ARMS** chapter (page 21-4) for crank-arm removal.

Chainsizing

If replacing the chainrings with ones of different size, then it may be necessary to re-size or replace the chain. See the **CHAINS** chapter (page 26-11).

Front-derailleur adjustment and replacement

If replacing chainrings with ones of a different size (particularly the outer ring), it will be necessary to adjust the front derailleur. See the **FRONT-DERAILLEURS** chapter (page 33-10).

Front-derailleur replacement is only required in two cases. First, if installing new chainrings, crankset, or right crank arm with chainrings that have less than an eight-tooth difference between the largest ring and

the next smaller one, but the original front derailleur was designed to use triple-chainring sets with differences of 10 teeth or more, a new front derailleur may be needed. See the **FRONT-DERAILLEURS** chapter (page 33-4) to tell how front-derailleur capacity has been exceeded. Second, if installing a “micro-drive” or other crankset with reduced-size chainrings, there could be other problems with front-derailleur capacity.

Rear-derailleur replacement

When installing new chainrings of a different size, or a new crankset or a new right arm with different size chainrings than the original ones, it is possible to exceed the capacity of the rear derailleur to wrap up the slack chain when in the smallest-size-chainring and smallest-rear-cog combination. It is the difference in number of teeth between the smallest and largest ring that is important, not the absolute size of either chainring. See the **REAR DERAILLEURS** chapter (page 32-6) to determine if the capacity matches the new chainring set.

INDICATIONS

Maintenance cycles

Chainrings need periodic cleaning (whenever the chain is being cleaned), and the mounting bolts should be periodically checked for tightness.

Chainrings wear out, affecting front-derailleur shifting and the tendency for the chain to remain attached to the inner ring and jam against the chain stay. These problems should be dealt with on a symptomatic basis, rather than as part of routine maintenance.

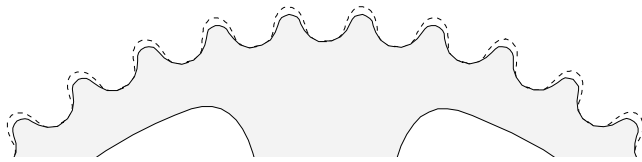
Chainrings can be damaged by striking objects in the trail (off-road riding) and by catastrophic shifting errors (derailing and jamming the chain). The chainrings should be inspected for damage after any such occurrences.

Symptoms indicating shift-worn chainrings

Shifting from a smaller ring to a larger ring slowly wears out the teeth on the larger chainring. When the teeth become significantly worn, they lose their shifting performance. This can also be caused by derailleur problems and chain wear. Check chain wear and check all derailleur adjustments. If the shifting cannot be restored to previous good performance levels, when the chain is not worn out and the derailleur adjustment is good, then the teeth are worn out and the chainring should be replaced.

With an experienced eye, visual inspection can determine whether this wear is getting significant. Worn teeth (from shifting) get shorter and thinner. If all teeth

had a uniform shape when new, this would be simple, but they do not. Visual determination of wear is best done by comparing the used chainring to a fresh one of the same brand. In some cases, it is possible to compare teeth on one part of the ring to teeth on another part of the ring. This can work because most riders have a tendency to shift in the same part of the pedaling stroke every time, causing some teeth to wear out before others. The limitation to this is that not all chainrings start out with uniform teeth all the way around the ring. Specifically, Shimano BioPace and SG/SGX/HyperDrive chainrings do not have uniform teeth.

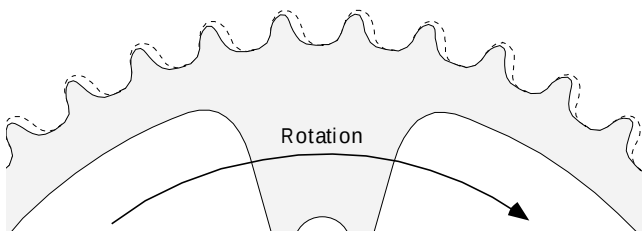


23.3 These chainring teeth are worn from shifting. The dashed line represents the original tooth profile.

Symptoms indicating load-worn chainrings

Chainrings can wear from the load of driving the chain. The symptom is sometimes called “chain suck.” The worn teeth develop a hook that causes the chain to remain attached to the chainring at the six o’clock position, where the chain is supposed to be released to go back to the rear derailleur. When the chain is carried up far enough, it jams into the chain stay. This damages the stay and chainrings, and could lock up the crankset. This symptom can be caused by a dirty chain or chainrings, as well. Before concluding the chainrings are worn out, clean the chain and chainrings.

The visual indicator that this condition exists is a pronounced hook to the leading edge of each chainring tooth. Although it is easy to think of the force applied to the chain by the chainring to be a pulling force, what actually happens is that the leading edge of each tooth pushes against the backside of each chain roller. This is why the wear is on the leading edge of each tooth. Most chainring teeth have symmetrical leading and trailing edges, so detecting this wear visually is often just a matter of comparing the two edges.



23.4 This chainring is worn from load. The dashed line shows the original tooth profile.

Symptoms indicating bent chainring(s)

Bent chainrings wobble side-to-side when spun, but not all wobbling chainrings are bent. They can also wobble because the mounting arms are mis-aligned (see page 23-12) or because the crank arm needs to be mounted in a different position (steps #22 through #32 in the **CRANK-ARM INSTALLATION** procedure, page 20-10).

If the chainring is bent, it will wobble side-to-side independently of the other ring(s). If the mounting arms need alignment, or the arm needs to be mounted in a different position, all the rings will wobble in unison.

Although minor chainring bends are repairable, it is generally best to replace the damaged ring. When metal bends, its molecular structure elongates (the space between the molecules increases). Bending it back does not eliminate this elongation. What this means with a thin piece of metal like a chainring, is that the best that can be done when trying to repair a bend is to change a single large wobble into a series of smaller, less obvious wobbles. There are tools available that are for the purpose of bending chainrings, but they are little more than clamps with levers attached that grip the chainring. What really gets the job done is the finesse of the person using the tool. For the shop mechanic, there is no substitute for practice.

Symptoms indicating bent chainring teeth

Chainring teeth can be bent from impact, usually with a stone, curb, or log. The symptom that might be experienced will be a click or snap sound or feeling coming from the crank once per-revolution when the chain is on the affected chainring (usually the outer one). To find the bent tooth, close one eye, line the other eye up with the chainring so that only the teeth and neither face of the chainring can be seen, spin the crank slowly, and look for a tooth that jumps out of line from the others. Shimano SG/SGX/HyperDrive chainrings come from the factory with teeth that deliberately stagger back and forth to facilitate shifting.

If a bent tooth is found, simply grasp it with an adjustable wrench or pliers and bend it back into line with the other teeth.

Symptoms indicating misaligned chainring-mounting arms

When the mounting arms of the chainrings are misaligned, all the chainrings will wobble side-to-side in unison. This could also be because the crank arm is not mounted in the best of the four possible positions (steps #22 through #32 in the **CRANK-ARM INSTALLATION** procedure, page 20-10). The only way to isolate the source of the problem is to test-mount the crank in all

four positions to see if it reduces or eliminates the wobble. Once this has been done and the wobble remains unacceptable, then it should be clear that the problem is with the chainring-mounting arms.

Wobbles of less than .5mm are insignificant. Wobbles larger than this but less than 1mm are tolerable under most conditions, but not with certain narrow-cage front derailleurs. Wobbles larger than these limits will always cause problems with the front derailleur.

There are steps for aligning chainring-mounting arms at the end of the **CHAINRING REMOVAL, INSTALLATION, AND ALIGNMENT** procedure (see page 23-8).

Symptoms indicating loose chainring bolts

When chainring bolts are slightly loose, there may be a creaking or snapping sound that comes from the crankset once per crank-revolution. With a triple crankset that has two rings held on by one bolt set and the third ring held on by another bolt set, the noise will follow the bolt set involved. In other words, if the noise occurs when using either of the rings held on by the first bolt set but not when using the third ring held on by its own bolt set, then the noise is likely to be the bolts.

In all cases, diagnosis by analysis is unnecessarily complicated. The simplest thing is just to check all the bolts for security whenever this symptom occurs.

Left unattended, a loose bolt can be catastrophic. Without the support of all the bolts, a chainring might collapse under pedaling load. At least, the chainring will be destroyed. It is quite likely the collapsed ring will interfere with the rotation of the crank and the

rider will end up pushing the bike home. It is even possible the collapsed ring could jam into and damage the chain stay or front derailleur.

Similar symptoms can be caused by crank-arm-mounting problems, pedal-mounting problems, loose pedal parts, pedal/cleat-interface problems, and bottom-bracket problems (loose cups or retaining rings). If securing the chainring bolts does not eliminate the symptom, be sure to check all these areas until the cause of the problem is found.

TOOL CHOICES

Table 23-1 (below) covers all the tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is in **bold**, it means that several tools are required for different configurations of parts.

TIME AND DIFFICULTY

Chainring removal and re-installation is a 5–10 minute job of little difficulty, as long as the replacement rings are compatible and the same size. If different-size rings require front-derailleur adjustment or replacement, the job has a moderately-high difficulty rating and could take 25–45 minutes more. If the chain must be shortened or replaced due to a change in chainring size, add 5–10 minutes. If the rear derailleur must be replaced because of capacity problems, this is also a moderately-high difficulty job and another 25–45 minutes should be added.

CHAINRING TOOLS (table 23-1)

Tool	Fits and considerations
CHAINRING-BOLT TOOLS	
Campagnolo 768	Fits 12mm sleeve nuts
Shimano TL-FC20	Fits 12mm sleeve nuts, but preferred for use on Shimano crank dustcaps
Sugino 207	Fits rare 10mm sleeve nuts
Sugino 208	Fits 12mm sleeve nuts
VAR 352	Fits 12mm sleeve nuts, simultaneously secures sleeve nut while built-in Allen is used to tighten or loosen bolt.
CHAINRING-SIZING TOOLS	
Park CDG-1	Caliper-like tool easily measures chainring bolt-circle diameter
CHAINRING-ALIGNMENT TOOLS	
Bicycle Research LC1	Narrow engagement more likely to crease chainring
VAR 940	Wide engagement prevents damage, use two at a time for control

COMPLICATIONS

Stripped Allen fittings

Over-tightened chainring bolts often have rounded Allen fittings. The only solutions are to try to turn the sleeve nut instead, and if that fails, to drill out the bolt with an 8mm bit.

Spinning sleeve nuts

The sleeve nut may have a tendency to spin as the bolt is loosened or tightened. A sleeve-nut spanner or the VAR 352 (preferred) should solve the problem.

Missing spacers

If a chainring bolt falls out, a spacer between the chainrings is often missing. If an identical spacer cannot be found, then the whole set should be replaced with the closest-thickness spacers available.

Unique spacers

Some chainrings require spacers of unique thickness or configuration. Keep track of spacers at all times!

Bolt types

There are several types of chainring bolts, and several lengths of bolts of the same type. Sometimes a triple crankset will have two sets of bolts that are the same type but different lengths. The shorter bolts are used to hold on a pair of chainrings and the longer bolts are used to hold the single chainring. This runs contrary to what logic would dictate. If the longer bolts are put where the shorter bolts should be, they will usually extend through the back of the sleeve nut and interfere with the chain on the inner chainring.

Some triple-chainring-set inner bolts are a 6mm diameter thread. Some of these have a 1mm pitch and some have a .75mm pitch. Failure to note this difference could destroy the crank arm by stripping the threads in the chainring-mounting arms.

Reversing chainrings

Chainrings need to face a specific way in most cases. There are no universal rules of thumb about how to tell which way they should face. It's best to mark them or make clear notes before removal to prevent reversing them on installation.

Rotational position

Many chainrings are meant to be used at one specific rotational position. With others, it does not matter. Always assume that rotational position matters unless it is known for certain that it does not.

Chainring-to-arm compatibility

As many as four different things influence whether a chainring will fit a crank arm. These are number of bolt holes, diameter of holes, diameter of the bolt circle, and whether the arm will create the proper spacing between the chainrings. Chainrings can meet the first three factors (but not the fourth) and still be mounted on the crank arm. If the fourth is not dealt with, the results could be mysterious shifting problems and chain noise.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter has two sections. The first is **COMPATIBILITY AND FIT** and the second is **CHAINRING REMOVAL, INSTALLATION, AND ALIGNMENT**.

COMPATIBILITY AND FIT is about the fit of the chainrings to the crank-arm-bolt pattern, the offset (or spacing) between the chainrings, chainring size and derailleur capacities, and chainring compatibility with special shifting systems.

CHAINRING REMOVAL, INSTALLATION, AND ALIGNMENT is about removing the chainrings, installing them, and aligning them if necessary. It includes sections on checking compatibility if changing the size of the rings or brand. If these checks indicate a need to adjust and/or replace the front or rear derailleur, then it refers to the appropriate chapters to perform those procedures (page numbers are provided at these points). When checking chainring alignment, there will be a reference to checking the four mounting positions for the right crank arm. If this needs to be done, the appropriate page number is provided at that point.

COMPATIBILITY AND FIT

Compatibility and fit of chainrings is a complex and often ignored subject. As shifting systems become more sophisticated, the issue becomes more important. The issues of compatibility and fit can be broken down into six general areas:

1. Bolt pattern
2. Bolt-hole size
3. Offset (spacing) between chainrings
4. Derailleur capacity
5. Non-round chainrings
6. Special shift systems

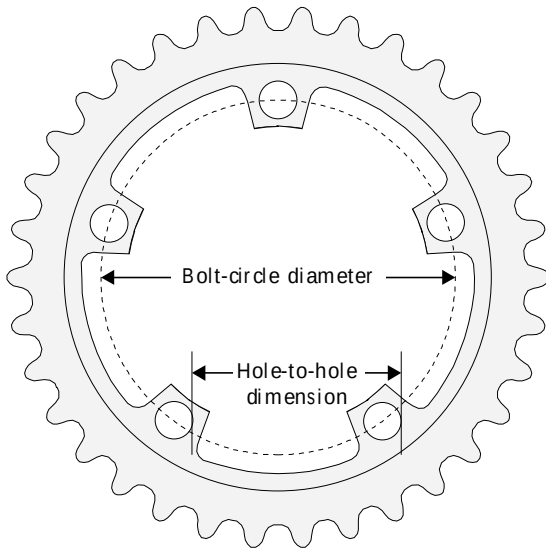
BOLT PATTERN

Chainrings and crank arms must have the same bolt pattern for the chainrings to fit. The bolt pattern is a function of how many bolts are used (almost always five), and the diameter of the circle that goes through the center of all the bolts (see figure 23.5).

Converting hole-to-hole dimension to bolt-circle diameter by using Table 23-2

Since the number of bolts is almost always odd, it is difficult to directly measure the bolt-circle diameter. Instead, the recommended method is to measure the distance from one bolt to the next and then look up the corresponding bolt-circle diameter on table 23-2 (below, right). This measurement is called the “hole-to-hole” dimension. If the measurement is not on the table, then use the formula method (top of column to right) to calculate the approximate bolt-circle diameter.

Even if using a caliper, it can be difficult to measure from the center of one hole (or bolt) to the center of the adjacent hole (or bolt) because the center is somewhere in the middle of a big hole. The same thing can be achieved by measuring from the edge of one hole (or bolt) to the opposite edge of the adjacent hole (or bolt) . If the chainring is not mounted, measure from the edge of one bolt hole to the opposite edge of the adjacent bolt hole (see figure 23.5). Whichever measurement method is used, look it up in the **Hole-To-Hole** column and then read across to the adjacent **Bolt-Circle Diameter** column on table 23-2.



23.5 Chainring dimensions.

Formula method for determining chainring bolt-circle diameter for five-hole chainrings

If the measurement of the hole-to-hole dimension was in millimeters, multiply the measurement by 1.699 and round the answer to the nearest whole millimeter (bolt-circle diameters are always in whole millimeters). For example, if the measurement was 71.6mm, calculate $71.6 \times 1.699 = 121.65$, then round 121.65 to 122mm.

Tool method for determining chainring-bolt pattern for five-hole chainrings

Park makes a tool (CDG-1) that measures bolt-circle diameter. The two tips of the tool are placed in adjacent chainring-bolt holes, or chainring holes, and the corresponding bolt-circle diameter is read off a scale.

BOLT-HOLE SIZE

Perhaps the simplest issue of fit is bolt-hole size. The mounting arms on the crank arm have holes for the bolts to go through. The chainrings do also. The holes in both must be the same diameter. It is extremely

FIVE-HOLE-CHAINRING
BOLT-CIRCLE DIAMETERS (table 23-2)

Approximate Hole-To-Hole Dimension	Bolt-Circle Diameter	Typical uses or common brands
32.9mm	56mm	SunTour Micro (inner ring)
34.1mm	58mm	Shimano SG/SGX/HyperDrive-C (inner two rings)
43.6mm	74mm	Smallest chainring of most triple cranksets
55.3mm	94mm	SunTour Microdrive (outer two) and Shimano SG/SGX/HyperDrive-C (outer ring)
55.9mm	95mm	Shimano SG/SGX/HyperDrive-C, (if stamped steel, less expensive models only)
64.7mm	110mm	Outer pair of chainrings on most triple cranksets
69.4mm	118mm	SR (Sakae) road (less expensive)
76.5mm	130mm	Double-ring cranks: Shimano, Sachs, Sugino, Mavic, SunTour
79.5mm	135mm	Current Campagnolo (1985 to present)
84.8mm	144mm	Double-ring cranks: Older Campagnolo, Mavic, SR, Sugino

rare that chainrings would share a common bolt-circle diameter and not share a common hole diameter. The only likely occurrence is on some older 10-speeds that had Sakae cranks with a 118mm bolt-circle diameter.

OFFSET BETWEEN CHAINRINGS

Offset between chainrings can be an issue for two reasons. The first reason is that not all chainrings are the same thickness, so manufacturers use a different spacer to achieve the correct positioning. The second reason is that some manufacturers have special or unique offset to suit special design considerations.

Measuring offset

The simplest approach is to use a stack of feeler gauges to measure the gap between chainrings, record it, and restore that dimension if installing non-identical chainrings. The problem develops when the new chainrings require different spacers. These are not broadly available in a full range of thickness. The most common offset between chainrings is approximately 6.4mm.

Another problem develops when the chainring is not a simple flat piece of metal. Anytime the chainring has bulges or offsets, the issue is the distance from the teeth of one chainring to the teeth of another, and there is no simple way to measure this. The best way would be to put the crankset on a flat surface, face up; measure the distance from the teeth on one ring to the surface; measure the distance from the teeth on another ring to the surface; and subtract the difference to determine the ring-to-ring offset.

Common offset problems

There are two relatively common chainring offset problems to watch out for. The first can present itself if the ring being replaced is approximately 2mm thick and flat, and has a thin washer (1.5mm) between it and the mounting arm. Do not use the 1.5mm washer if the replacement ring is a more normal 3.5mm thick. If switching from the thick ring to the thinner, then a washer will need to be added. (Some thin rings have a 1.5mm offset just out from the mounting hole, in which case they do not need the thin washer.)

The second problem is specific to Shimano SG/SGX/HyperDrive chainrings. These chainrings require special offset that is built into the Shimano crank arms. Although the bolt-circle diameter of Shimano SG/SGX/HyperDrive chainrings is the same as many non-Shimano cranks and older non-SG/SGX/HyperDrive Shimano cranks, these chainrings can only be used on Shimano SG/SGX/HyperDrive style cranks. This problem usually is encountered when

upgrading to some exotic, lightweight, high-tech crank arms. To further compound the problem, the derailleur and shift lever are designed to work specifically with the SG/SGX/HyperDrive chainrings. If the crank arms are upgraded, and non-SG/SGX/HyperDrive chainrings are put on, the front derailleur will not shift correctly. Normal offset for these chainrings is approximately 6.4mm from the outer to the middle chainring and 7.2mm from the middle to the inner chainring.

DERAILLEUR CAPACITY

Front derailleurs have both a minimum and maximum capacity. If changing the size of the chainrings, consider whether there will be a problem with capacity.

Maximum front-derailleur capacity is a rating of the largest difference between the smallest and largest chainrings that the derailleur can handle. If it is exceeded, the chain will drag on the tail end of the front-derailleur cage when the chain is in the small-front/small-rear combination. This symptom is only significant if it shows up when there is tension on the chain. If a slack chain dangles and rubs, it is not a serious problem.

Minimum front-derailleur capacity is a rating of the smallest difference between the largest and next-to-largest chainrings. It is generally only relevant on triple cranks, and then only if the gearing is a very unusual design called *half-step*. With half-step gearing, the difference between the chainrings will be as little as four to six teeth. If the derailleur is not compatible with half-step, the symptom will be that the bottom edge of the inner plate of the front-derailleur cage will rub against the middle chainring when the derailleur is in a position to put the chain on the outer chainring.

NON-ROUND CHAINRINGS

Although they are out of favor now, for a number of years in the late 1980s and early '90s, non-round chainrings such as Shimano BioPace were popular. Mechanically, there is little concern with compatibility when mixing round and non-round rings on one crank. However, biomechanical concerns do exist. The muscular coordination required to pedal each type of chainring is different, and in each case it is a learned skill. When mixing types, the rider will be physically unable to take advantage of either (according to Shimano), so it is not recommended. If the bike has non-round chainrings and the customer is considering replacing some of them with round chainrings, replacing the whole set is recommended.

SPECIAL SHIFT SYSTEMS

Front indexed-shifting systems rely on compatible components to function correctly. The shift lever, cable housing, inner wire, front derailleur, chainring type, and chainring offset must all be correct for the indexing to work to its full potential. If the bike has front indexed shifting and the rider is considering replacing the chainrings, sticking with exact replacements (except, perhaps, number of teeth) is strongly recommended. If installing a front indexed-shifting system, it should include the correct crank arm and chainrings.

Shimano SG/SGX/HyperDrive chainrings have one other factor to consider: the chainrings are designed to work as matched sets. For example, if a bike has a SG/SGX/HyperDrive crank with original chainrings of 26, 36, and 46 teeth, and the rider would like to replace the 46 with a 48 SG/SGX/HyperDrive ring, *it will not be compatible!* The reason for this is that these rings have special teeth at specific locations for releasing and picking up the chain. The release teeth and the pickup teeth have to be the correct distance apart. When Shimano makes a 48, the pickup teeth have been designed to be the correct distance from the release teeth on a 38, not on a 36. Shimano makes chainrings available individually, so that worn ones can be replaced with identical ones, not for customizing gear combinations.

CHAINRING REMOVAL, INSTALLATION, AND ALIGNMENT

PREPARATION AND PRE-REMOVAL INSPECTIONS

In step #1, inspect the chainrings for side-to-side wobble. Too much wobble interferes with making a proper front-derailleur adjustment. If the chainrings wobble independently of each other, it indicates bent chainrings. If they wobble in unison, it means that the mounting arms need alignment, or that the right arm should be tried in all four possible mounting positions to find the one that creates the least chainring wobble.

A spindle-to-crank-arm mating is basically a square shaft that fits in a square hole. This means that there are four possible ways that the crank arm can be

mounted. In some of these ways, there will be more chainring wobble, and in other ways less. If starting with little or no wobble, then it would be nice to not have to go through a trial and error process to find the best of four positions. This is not a problem if not removing the left arm, because with it already installed there is only one possible position for the right arm. If removing both arms and starting off with acceptable chainring wobble, mark the spindle (paint-pen, piece of tape, scratch mark) so that the trial-and-error process of finding the best mounting position for the right arm can be avoided.

1. ☐ **Rotate crank and check whether chainrings wobble side-to-side ³.5mm.**
Yes? No? (circle one)
2. **If yes to step 1, do they wobble in unison or separately?**
☐ **Unison: Arm should be checked for best-of-four mounting positions and/or mounting arms need alignment.**
☐ **Separately: Wobbling chainring(s) should be replaced.**
3. ☐ **If left arm will also be removed, and if outer ring or all rings are rotating with <.5mm wobble, mark spindle so that arm can be re-installed in same position.**

In step #4, check the distance between the chainrings and the frame. Later, when everything is back together, there will be an opportunity to check if this distance remained the same. This is important because it tells whether the front derailleur might need to be readjusted. A change here is only likely if the arm was on too tight or too loose, if changing the brand of chainrings, or if changing the position of some chainring spacers.

4. ☐ **Use stack of feeler gauges to measure clearance between innermost chainring and chain stay (measure with calipers to seat tube if bike has raised chain stays). Record measurement here: _____mm**
5. ☐ **Remove pedal (optional). See *PEDAL REMOVAL, REPLACEMENT AND INSTALLATION* procedure (page 24-3).**
6. ☐ **Remove crank arm. See *TAPER-FIT CRANK-ARM REMOVAL AND INSTALLATION* procedure, steps 4-10 (page 20-6).**

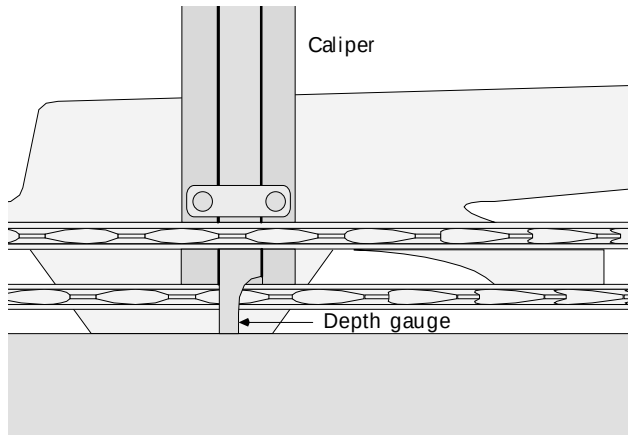
In step #7, mark the chainrings so that when they are re-installed, it will be easy to install them facing and rotated the same way. It is always mandatory that they face the same way. An “X” mark is suggested because it cannot be confused with a scratch.

In the case of non-round chainrings, outer chainrings with an over-shift peg, or chainrings that have special teeth at certain points to facilitate shifting, it is mandatory to maintain the rotational alignment.

(An over-shift peg is a protrusion built into the outer face of the outer chainring that is located behind the crank arm that prevents an over-shifted chain from dropping down between the chainring and the crank arm.) If the chainrings have none of these features, it may prolong chainring life to deliberately rotate the chainrings to a new position when re-installing them.

7. [] If re-installing any or all chainrings, put an “x” mark with scribe or indelible marker on back face of each ring, in line with crank arm.

Steps #8 through #13 are a method to measure and calculate the offset between the chainrings. By using the same procedure for re-installing the old chainrings (or identical replacements), it is possible to check that all the spacers are in correctly. By using the same procedure after installing non-identical chainrings, it is possible to check whether the offset has been altered in a way that will cause problems with shifting.



23.6 Measure first one chainring, then another, in this fashion. Subtracting the smaller number from the larger calculates the chainring offset.

8. [] Place crank assembly face up on flat surface and stabilize the crank so that chainrings are parallel to surface.
9. [] Using depth gauge of caliper, measure distance from front face of inner-ring teeth to surface and record here: _____mm
10. [] Using depth gauge of caliper, measure distance from front face of teeth of second ring to surface and record here: _____mm
11. [] Subtract measurement in step 9 from measurement in step 10 to determine offset from inner chainring to next chainring and record calculation here: _____mm

NOTE: Skip steps 12 and 13 if crankset has two chainrings.

12. [] If crank has three rings, use depth gauge of caliper to measure from front face of outer-ring teeth to surface and record here: _____mm

13. [] If crank has three rings, subtract measurement in step 10 from measurement in step 12 to determine offset from middle chainring to outer chainring and record calculation here: _____mm

REMOVING CHAINRINGS

When disassembling the chainring set, it is very important to keep track of the sequence of parts, differences between spacers, and differences between similar, but not identical, bolt sets. The following steps suggest loosening and removing bolt sets so that each chainring remains held on by only one bolt. Then, while removing the last bolt from each chainring, pay close attention to the sequence of parts and record the sequence.

NOTE: Skip steps 14–17 if crankset has a double-chainring set.

14. [] If triple-chainring set, loosen but do not remove 5 bolts retaining innermost chainring.
15. [] If triple-chainring set, remove 4 of 5 bolts retaining innermost chainring and remove 4 of 5 spacers/spacer sets (if any).

In the next step, measure the length of the bolt that comes out. On many triple-chainring sets, there are two bolt sets that are similar in every way except length. It is critical that they not get mixed up, and there have been countless times a mechanic — relying on logic or intuition, rather than measurement — has gotten it exactly backwards.

16. [] If triple-chainring set, measure and record length of one removed bolt here: _____mm
17. [] If triple-chainring set, measure and record thickness of spacer/spacer-set here: _____mm
18. [] Double and triple-chainring sets, loosen but do not remove 5 bolts of remaining bolt set that retains outer ring(s).
19. [] Remove 4 of 5 bolts retaining outer ring(s) and remove 4 of 5 spacers/spacer sets (if any).
20. [] Measure length of one of bolts just removed and record measurement here: _____mm
21. [] Measure and record thickness of spacer/spacer-set just removed here: _____mm

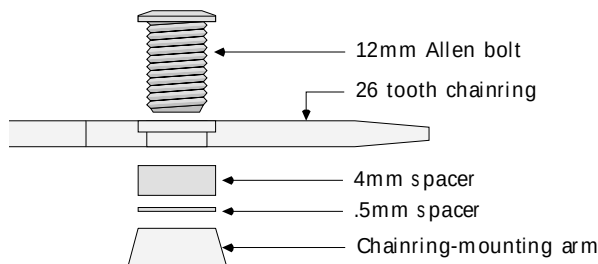
Step #22 is only for cranks with a triple-chainring set. Now that the inner chainring is retained by one bolt, it is time to remove it and carefully note the sequence of bolts, spacers, and ring in step #22. An example step #22 is included here to make what needs

23 – CHAINRINGS

to be filled in the blanks clear. The notations that you would be add to the worksheet if your crank were identical to the example are written in **script**.

Example:

22. [] 12mm Allen bolt , 26 tooth ring ,
4mm spacer , .5mm spacer .



23.7 Possible sequence for inner chainring of a triple.

22. [] If triple-chainring set, remove remaining bolt that retains inner ring and note sequence of parts as removed here:

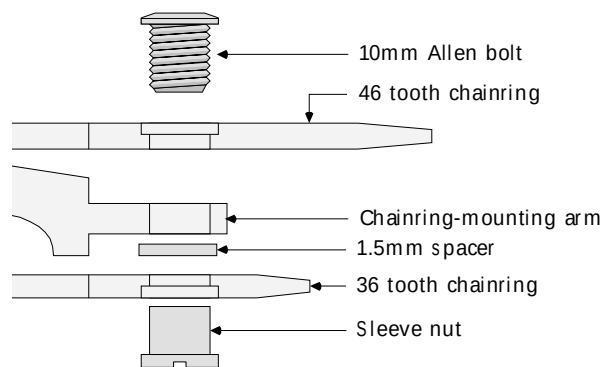
_____, _____,
_____, _____.

Step #23 notes the sequence of parts as the outer two chainrings (double or triple-chainring set) are removed. An example step #23 is written as the parts are removed from the outside to the inside. There are some parts that are outward of the chainring-mounting arms, and there are some parts that are inward of the chainring-mounting arms. In the example below, the notes that you would add to the worksheet if your crank were identical to the example are written in **script**.

Example:

23. [] Doubles and triples, remove remaining bolt that retains outer two rings and note sequence of parts as removed here:

10mm Allen bolt , 46 tooth ring ,
_____, mounting arms ,
1.5mm spacer , 36 tooth ring ,
sleeve nut , _____.



23.8 Possible sequence for outer two chainrings.

23. [] Doubles and triples, remove remaining bolt that retains outer two rings and note sequence of parts as removed here:

_____, _____,
_____, mounting arms ,
_____, _____,
_____, _____.

CLEANING AND INSPECTION

For description and pictures of the visual nature of different types of chainring wear, see under the heading **INDICATIONS** (page 23-2).

24. [] Clean all chainrings thoroughly (if being re-used), particularly faces and edges of teeth.

25. [] Inspect outer ring for visible evidence of shift wear.

26. [] Inspect middle ring, if any, for visible evidence of shift and load wear.

27. [] Inspect innermost ring for visible evidence of load wear.

28. [] Inspect all rings for non-round design or special teeth that indicate rotational alignment of chainring must be maintained when re-installing.

29. [] Inspect outer ring for presence of over-shift peg on outer face that indicates that rotational alignment of chainring must be maintained when re-installing.

30. [] (Optional), clean and inspect crank arm for cracks and damage. See **TAPER-FIT CRANK-ARM REMOVAL AND REINSTALLATION** procedure, steps 13–17 (page 20-9).

31. [] (Optional), inspect spindle flats for marks that indicate whether crank arm is worn out or bad fit to spindle. See **TAPER-FIT CRANK-ARM REMOVAL AND REINSTALLATION** procedure, step 11 (page 20-9).

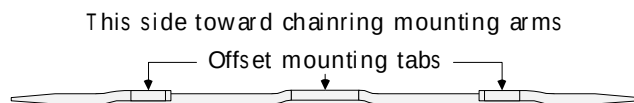
ASSEMBLY OF CHAINRINGS TO CRANK ARM

In steps #32 and #33, new marks are put on the chainrings at the same location, but on the opposite face from, the “X” marks. Use an “O” for these new marks to stand for “outer face.” These marks are needed because it is the outer face that will be seen when installing the outer chainrings of a triple or both chainrings of a double.

Obviously, if installing replacement chainrings, there will not be any “X” mark to place the “O” mark opposite of. If the chainrings have special rotational-position requirements, the manufacturer has probably marked them in some way. Sometimes there will be a triangular engraving or stamp mark that is supposed to

be in line with the crank arm. Other times there will be a small tab at the inner perimeter of the ring that serves the same function. Sometimes, both these manufacturer's marks will be found on one chainring, in which case both will always be in the same location.

Determining which way a chainring should face is another matter. If there is a triangular mark, there is no consistency as to whether it faces in or out. There may be no marks on the face of the chainring other than brand, model, and tooth number, and these can face either way. The best clue is if there are recesses in a chainring face at each bolt hole. These recesses are for the bolt flange or the sleeve-nut flange. If they are there, they should face *out* on the outer chainring, and *in* on any inner chainring(s). Some thin inner rings (doubles), and middle rings (triples) have an offset to the mounting-tab portion of the ring where the bolt hole is (see figure 23.9). If this is the case, the ring should face in the direction that positions the chainring teeth the furthest away from the surface the ring mounts against. When there are not offsets or recesses around bolt holes, there is no choice but to guess. The best guess is that any brand markings on an outer ring will face out, and that any tooth markings on inner rings will face in.



23.9 Cross-section of a chainring with offset mounting tabs.

- 32. [] If re-installing inner ring of double or middle ring of triple, put an "O" mark on outer face of ring at same location as "x" on inner face. If installing new inner ring of double or middle ring of triple, put an "O" mark on outer face of same ring in line with any manufacturer's rotational orientation mark (if any).
- 33. [] If re-installing outer ring of double or triple, put an "O" mark on outer face of ring at same location as "x" on inner face. If installing new outer ring of double or triple, put an "O" mark on outer face of same ring in line with any manufacturer's rotational orientation mark (if any).
- 34. [] Double- and triple-chainring sets, place sleeve nuts flange-side down on flat surface at spacing that approximates holes in chainrings.

In step #35, replace the spacers between the flange of the sleeve nut and the next-to-largest chainring, *if there were any there originally*. There is no reason for spacers to be in this position, so if they were here before it is likely that they were moved from between the chainring and the chainring-mounting arms, rather

than between the chainring and the sleeve-nut flanges. Typical offset between the outer chainrings is about 6.5mm. If there was a spacer in this position and the existing offset between the rings was below this range, then it is likely the spacer was misplaced.

- 35. [] Put spacers, *if any originally*, over sleeve nuts (see step 23 to check spacer position).

Lining the "O" mark up with the crank arm in steps #36 and #40 ensures that the original rotational position of the chainring is restored. This is often desirable, but not always. If the chainrings are round, do not have special teeth at certain points only to facilitate shifting, and do not have an over-shift peg, then it may be desirable to deliberately rotate the chainring(s) two to three positions either direction, so that the shift wear would continue on fresher parts of the chainring(s).

- 36. [] Place inner ring of double (or middle ring of triple) over sleeve nuts, with "O" mark up, then align sleeve nuts so they all fit through holes in ring.
- 37. [] Put spacers, *if any originally*, over sleeve nuts and on top of chainring (see step 23 to check spacer position).
- 38. [] Place crank arm (outer-face up), with arm over "O" mark, on top of sleeve-nut/chainring assembly.
- 39. [] Put spacers, *if any originally*, over sleeve nuts and on top of chainring-mounting arms (see step 23 to check spacer position).
- 40. [] With "O" mark facing up (or any over-shift peg facing up), slip outer ring over end of crank arm and rotate so "O" mark and/or over-shift peg is hidden behind crank arm and align chainring-bolt holes with sleeve nuts.

In step #41 and #46, oiling the chainring-bolt threads is recommended. This applies to steel chainring bolts. Treat aluminum-bolt threads with Loctite #242.

- 41. [] Oil chainring-bolt threads and thread all chainring bolts of correct length (see step 20) into sleeve nuts.

In step #42 and #46, the recommended torque minimum is 50in-lbs. This only applies to steel chainring bolts. Bolts of lightweight material should be torqued to a maximum of 35in-lbs (11lbs@3" or 9lbs@4").

- 42. [] Using Var 352 (substitute Shimano TL-FC20) to hold sleeve nuts from turning, snug all chainring bolts, then torque to minimum 50in-lbs (16lbs@3" or 12lbs@4").

NOTE: Skip steps 43–46 if crank has a double-chainring set.

- 43. [] If triple-chainring set, turn crank over on surface so outer face is down.

23 – CHAINRINGS

44. [] If triple-chainring set, put spacers, *if any originally*, over holes on inner face of chainring-mounting arms (see step 22 to check spacer position).
45. [] Place inner ring so “x” mark (if reinstalling original ring) is facing up and in line with crank arm. If installing new ring with manufacturer’s rotational orientation mark, install so that mark is in line with crank arm. (Rely on manufacturer’s information to determine whether marked face should be up or down.)
46. [] Oil chainring-bolt threads and thread all chainring bolts of correct length (see step 16) into crank arm. Torque to minimum 50in-lbs (16lbs@3" or 12lbs@4").

CHECKING OFFSET BETWEEN CHAINRINGS

In steps #47 through #54, re-measure the offset between the chainrings in order to compare the final result with the original conditions. Changes of .5mm or greater indicate that original equipment has been re-assembled wrong, or that changes need to be made to make replacement equipment work.

47. [] Place crank assembly face up on flat *surface* and stabilize so that chainrings are parallel to surface.
48. [] Using depth gauge of caliper, measure distance from front face of inner-ring teeth to surface and record here: _____mm
49. [] Using depth gauge of caliper, measure distance from front face of teeth of second ring to surface and record here: _____mm
50. [] Subtract measurement in step 48 from measurement in step 49 to determine offset from inner chainring to next chainring and record calculation here: _____mm
51. Compare calculation in step 50 to calculation in step 11 and check one of two following choices.
- [] There is <.5mm difference, there is no significant offset change.
- [] There is ≥.5mm difference, spacer is positioned wrong or one of different thickness must be substituted.
- NOTE:** Skip steps 52–54 if crankset does not have three chainrings.
52. [] If crank has three rings, use depth gauge of caliper to measure from front face of outer-ring teeth to surface and record here: _____mm

53. [] If crank has three rings, subtract measurement in step 50 from measurement in step 52 to determine offset from middle chainring to outer chainring and record calculation here: _____mm
54. Compare calculation in step 53 to calculation in step 13 and check one of two following choices.
- [] There is <.5mm difference, there is no significant offset change.
- [] There is ≥.5mm difference, spacer is positioned wrong or one of different thickness must be substituted.

INSTALLING CRANK ARM

55. [] If chainrings had no significant wobble (see step 1), then position crank arm in same position marked in step 3, then install crank arm by steps 33, 34, and 38–43 of *NORMAL CRANK-ARM REMOVAL AND INSTALLATION* procedure (page 20-11).
56. [] If chainrings had significant wobble (see step 10), or new chainrings are installed, then remove left arm also (if not removed already) and install crank arm by steps 19–43 of *NORMAL CRANK-ARM REMOVAL AND INSTALLATION* procedure (page 20-10).

CHECKING AND CORRECTING CHAINRING WOBBLE

Excess chainring wobble can cause problems with the front derailleur. At this point, bent chainrings and needing to mount the right crank arm in a better position should have been eliminated as causes of the problem. The only thing that can be causing chainring wobble is mis-aligned chainring-mounting arms. The condition has probably existed from the point the crank arm was manufactured. The following steps enable correction of this condition. The chainring-mounting arms should remain true unless they receive a direct blow from the side.

57. [] Position front derailleur so that nose of outer cage plate is directly over outer chainring teeth.
58. [] Rotate crank backwards rapidly and watch for wobbles, paying attention to whether they seem to deviate out or in from straight portion of chainring.
59. [] After finding wobbles and determining direction of error, slow down crank rotation to identify point wobble begins and ends.
60. [] Find chainring-mounting arm closest to center of wobble.

In step #61, it is recommended to use a specific wrench for leverage. If using an adjustable wrench, it *must* have smooth jaws at right angles to the handle. An adjustable wrench of this type is superior to any tool made specifically for chainring-mounting-arm alignment, because it can be adjusted to fit snugly on the chainring bolts rather than directly on the mounting arm (which inevitably scars the arm).

There are times when no tool will fit to apply leverage. Control is lost, but in this case there is no alternative but to use a plastic or rubber mallet directly on the chainring bolt or end of mounting arm.

61. [] Secure Diamond C79 (Headset-tool set) adjustable wrench to front and back end of chainring-bolt set on mounting arm at center of wobble, then lever up to correct outward wobble or down to correct inward wobble.

62. [] Remove wrench, spin crank again to check for under- or over-correction, or other wobbles that still need correction.

FRONT-DERAILLEUR ADJUSTMENT

If the number of teeth on the outer chainring has changed by any amount, the front derailleur needs to be moved up or down. This usually requires complete re-adjustment. If chainring offset has changed slightly (but acceptably), the limit screws and perhaps the cable tension for the front derailleur will need to be reset. If the offset between the chainrings is the same, but the whole set has moved in or out from the frame, then it is necessary to reset the limit screws and perhaps the cable tension for the front derailleur.

63. [] Adjust front derailleur if outer chainring size has changed, chainring offset has changed (steps 51 and 54), or chainring clearance has changed (compared to step 4).

CHECK FOR CHAIN-LENGTH PROBLEMS AND DERAILLEUR-CAPACITY PROBLEMS

Changing the size of the largest and/or the smallest chainring affects the capacity requirements for both the front and rear derailleurs. Operating derailleurs outside their capacities can damage them or cause poor shifting. Do not skip these steps if chainring sizes have changed.

64. [] If replacement outer ring of different size than original has been installed, position chain on outermost chainring and outermost rear cog to check chain length and correct as necessary. (See CHAINS chapter, page 26-11.)

65. [] If size of innermost or outermost chainring has changed, adjust chain length. Then, put chain in innermost-chainring/outermost-rear-cog combination to check that rear-derailleur capacity has not been exceeded. (See REAR DERAILLEURS chapter, page 32-7.)

66. [] If size of innermost or outermost chainring has changed, adjust chain length. Then, put chain in outermost chainring/innermost rear cog combination to check that rear-derailleur capacity has not been exceeded. (See REAR DERAILLEURS chapter, page 32-7.)

67. [] If size of innermost or outermost chainring has changed, reposition height of front derailleur (if outermost chainring size changed). Then, put chain in innermost-chainring/outermost-rear-cog combination to check that front-derailleur maximum capacity has not been exceeded. (See FRONT DERAILLEURS chapter, page 33-4.)

68. [] If size of middle chainring or outermost chainring of triple has changed, reposition height of front derailleur if outermost chainring size changed. Then, put chain on outermost chainring and check that front-derailleur minimum capacity has not been exceeded. (See FRONT DERAILLEURS chapter, page 33-5.)

CHAINRING TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>A popping sound or sensation is experienced once per crank-revolution, often on the down stroke of the right pedal.</i>	
Loose chainring bolt(s).	Check and secure chainring-mounting bolt(s).
Loose crank arm.	Check and secure crank arm.
Loose pedal-cage piece(s).	Check and secure pedal-cage piece(s).
Loose pedal mounting.	Check and secure pedal mounting.
Loose B.B. cups, lockrings, or retaining rings.	Check and secure B.B. cups, lockrings, or retaining rings.
SYMPTOM: <i>A popping sound or sensation is experienced once per crank-revolution, on one chainring.</i>	
Bent chainring tooth.	Inspect and bend back.

(Continued next page)

CHAINRING TROUBLESHOOTING (continued)

Cause	Solution
SYMPTOM: <i>A ticking or scraping sound is heard once per crank-revolution.</i>	
Chainring wobble is causing chain to intermittently rub inside of front-derailleur cage.	Check whether mounting arm in any of the other three positions reduces wobble. Check whether outer two rings wobble in unison and if so, align chainring-mounting arms. Replace bent ring if one ring is wobbling independently of all others.
Loose crank arm or bottom bracket is causing chainring wobble.	Check and secure crank arm.
Crank arm is hitting front-derailleur cage.	Re-adjust front-derailleur limit screws and/or rotational alignment.
SYMPTOM: <i>Chainrings, chainring-mounting bolts, or some other part of the crank-arm assembly is rubbing the chain stay continuously or intermittently when the crank is being spun when not under load.</i>	
Crank arms are worn out or a bad fit to the spindle.	Perform removal process, including fit inspections.
Bottom-bracket spindle is too short.	Replace spindle or cartridge bottom bracket with one that will position crank arm further out.
SYMPTOM: <i>Wear marks are found on the chain stay where they might be left by the chainrings, chainring-mounting bolts, or some other part of the crank-arm assembly, but no rubbing is evident upon visual inspection.</i>	
Clearance that is adequate without load is not adequate when crank assembly and/or chain stays flex under load.	Check for worn-out or misfit crank arm. Replace spindle or cartridge bottom bracket with one that will position crank arm further out.
SYMPTOM: <i>Chain shifts poorly from smaller ring to larger ring after checking chain for wear and checking that derailleur is properly adjusted.</i>	
Chainrings have excessive shift wear.	Replace ring(s) if substantial wear is evident.
SYMPTOM: <i>Chain suck occurs. Chain remains attached to chainring where it is supposed to release and return to the rear derailleur and jams into the chain stay.</i>	
Chain or chainrings are fouled with dirt.	Clean chain and chainrings.
Chainring is worn out from load.	Replace ring if substantial wear is evident.
SYMPTOM: <i>Chain is rubbing against sleeve-nut flanges of outer bolt set when chain is on innermost chainring of triple-chainring set.</i>	
Middle chainring is installed facing wrong way so that flanges are not fitting into recesses in chainring face.	Check for recesses in chainring face and reverse direction chainring is facing if recesses are not on side of chainring facing sleeve-nut flanges.
SYMPTOM: <i>Chain is rubbing against adjacent chainring.</i>	
Chainline is bad, with chainrings too far in relative to rear cogs.	Check chainline error. (See CHAINLINE chapter, page 27-5.)
Offset between chainrings is inadequate due to misplacement of spacers, chainrings facing wrong way, or replacement with non-compatible chainrings or crank arm.	Re-check offset measurements and add, remove, or move spacers to correct problem. Use compatible chainrings or crank arm, or modify with different spacers to eliminate compatibility problems.
SYMPTOM: <i>Chain is dropping completely in-between two chainrings when shifting.</i>	
Incorrect use of chainring spacers causing too much chainring offset.	Check and change location or use of spacers.
Non-SG/SGX/HyperDrive chainring used on SG/SGX/HyperDrive-type crank arm.	Replace with compatible chainring(s).
SYMPTOM: <i>Chain is rubbing against inner end of bolts of outer bolt set when chain is on innermost chainring of triple-chainring set.</i>	
Long bolts for inner ring have been used in location where short bolts for outer bolt set are required.	Switch bolts back if problem has been caused by reversing locations of the two bolt sets. Install new bolts if problem is caused by installation of wrong bolts.

24 – PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION

ABOUT THIS CHAPTER

This chapter is about removing and re-installing pedals, as well as installing replacement pedals. There are separate chapters about pedal-bearing service. After **PEDAL REMOVAL, REPLACEMENT AND INSTALLATION** is a section called **REPAIRING PEDAL -MOUNTING THREADS**. The mounting threads in the crank arm can be damaged, and this section enables repair of those threads. After **REPAIRING PEDAL -MOUNTING THREADS** is a troubleshooting chart.

GENERAL INFORMATION

TERMINOLOGY

Pedal cage: The plate or plates that support the foot on the pedal.

Shoe cleat: A device attached to the bottom of the shoe that helps fix the shoe to the pedal. There are two types. The traditional type is a block of metal or plastic that is slotted. The slot in the cleat engages the edge of the pedal-cage plate. A toe-clip and strap is used with this system to help retain the foot. The modern cleat snaps into a cleat-retention mechanism that is integrated into the pedal. No toe-clip or strap is used with this type.

Cleat-retention mechanism: The integral portion of the pedal that clips to a cleat on a shoe.

Toe clip (and strap): A cage attached to the front of the pedal that encloses the toe of the shoe. A strap goes through the pedal, over the arch of the foot, and through an eyelet in the top-end of the toe clip. This strap (called “toe strap”) secures the foot to the pedal.

PREREQUISITES

There are no prerequisites to being able to remove and install pedals.

INDICATIONS

Maintenance cycles

The only maintenance needed in regard to pedals is to periodically check that they are secure.

New pedals often have problems with loose bolts that retain the cage or cleat-retention pieces. These should be checked and secured when pedals are new.

Crank-arm service

Pedals must be removed when replacing crank arms. It is optional to remove pedals for crank-arm cleaning.

Chainring service

It is optional to remove the right pedal if removing the chainrings.

Symptoms indicating loose pedals or pedal parts

When poor installation technique fails to keep the pedal secure, the loose pedal may manifest itself by a once-per-crank-revolution click or clunk sound. The same symptom can be caused by a loose pedal-cage bolt or loose cleat-retention mechanism. This symptom can also be caused by bottom-bracket, crank-arm, and chainring problems. If securing the pedal and the pedal-cage-retention bolts does not solve the problem, be sure to consult the appropriate chapters regarding these other possible causes.

Symptoms indicating bent pedal shafts

A pedal shaft can be bent in a crash, or from abusive jumping. The symptom of a bent pedal shaft is an oscillating sensation in the ankle while pedaling. This oscillation may feel like the ball of your foot is twisting back and forth; or the outer edge of the foot is rocking up and down; or like both at once. The identical symptoms are caused by bent crank arms, which can easily be damaged by the same forces that damage the pedal. The first step is to remove the pedal and look at the end of the shaft as it rotates. If the end does not oscillate, then it is the crank arm that is bent. If the pedal shaft oscillates, install new pedals. If the symptom is still felt when riding with new pedals, then the arm is also bent.

24 – PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION

Symptoms indicating damaged pedal-mounting threads

Pedal-mounting threads can be damaged by improper pedal installation. The only symptom that will be encountered is difficulty threading in the pedal. It may be repairable, or it may be necessary to replace the crank arm.

TOOL CHOICES

In the accompanying table of tool choices, the tools shown in **bold** are the preferred choices. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When multiple tools of the same size are shown in **bold**, it means that each is the best under different circumstances.

TIME AND DIFFICULTY

Pedal removal and re-installation is a 1–2 minute-per-pedal job of little difficulty. In some cases, the pedal may be over-tightened and require patience and fortitude to break it loose.

If the pedal threads are damaged, it could take an additional 1–2 minutes to chase the threads.

If threads are stripped, it may take 10–30 minutes to install a thread bushing.

COMPLICATIONS

Difficult to break pedal loose

Pedals can be difficult to break loose because of over-tightening, corrosion, or from turning them the wrong direction. Penetrating oil, a good wrench, and good technique are the only solutions when the problem is over-tightness or corrosion.

The left-side pedal removes with a clockwise rotation!

Difficult to unthread pedal after breaking loose

When a pedal is difficult to unthread after it has been broken loose, it often indicates that the threads are stripped or cross-threaded. Use penetrating oil and frequent breaks to allow cooling. Inspect for damaged threads after removal.

PEDAL-REMOVAL/INSTALLATION TOOLS (table 24-1)

Tool	Fits and considerations
PEDAL WRENCHES	
Campagnolo 1101	Fits 15, 16, and 17mm, durable, poor hand protection and poor mechanical advantage
Cyclo 1329	Fits 15mm only, poor hand protection, poor durability
Eldi 61	Fits 15mm and 9/16", poor durability and hand protection
Hozan C200	Fits 15mm only, durable, good hand protection and good mechanical advantage
Park HCW-6	Fits 15mm only, poor hand protection, poor durability
Park PW-3	Fits 15mm and 9/16", acceptable durability and excellent hand protection
Zog's Pedal Wrench	Fits 15mm only, poor hand protection, good durability
THREAD-REPAIR TOOLS	
Eldi 2299	Oversize tap and thread-bushing set for repairing stripped mounting threads in crank
Park TAP-3	1/2"×20tpi left and right tap set
Park TAP-6	9/16"×20tpi left and right tap set
VAR 41A	1/2"×20tpi left and right tap set
VAR 41E	9/16"×20tpi left and right tap set
VAR 41F	14×1.25mm left and right tap set (virtually extinct French thread)

Difficult to start pedal threading in

When a pedal is difficult to start in, do not force it! Check whether the pedal is on the correct side, whether it is cross-threading, or whether the crank-arm threads should be cleaned with a tap.

Pedals previously cross-threaded

After removing pedals that were cross-threaded, run a tap in from the back side of the crank arm for a fully-effective repair.

Pedals previously installed on wrong side

After removing pedals that were installed on the wrong side, run a tap in from the back side of the crank arm for a fully-effective repair.

ABOUT THE REST OF THIS CHAPTER

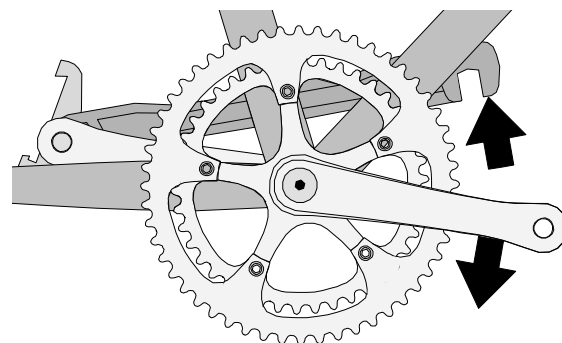
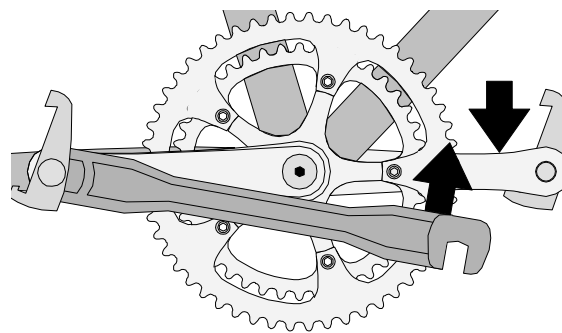
The rest of this chapter is divided into three parts: **PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION**, **REPAIRING PEDAL-MOUNTING THREADS**, and **PEDAL-MOUNTING TROUBLESHOOTING**.

PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION

PEDAL REMOVAL

Right-side pedals remove with a counterclockwise rotation. Left-side pedals remove with a clockwise rotation. This can get confusing, particularly if standing on the opposite side of the bike from the pedal being removed. To reduce this confusion, the following procedure specifies where to stand, the position of the crank arms, and which direction to move the wrench.

Another problem with pedal removal is that a great deal of force may be required to break a pedal loose. If the leverage of the opposite crank arm and other principles of mechanical advantage are not used, then it will be unnecessarily difficult. The following steps, if followed faithfully, provide the greatest mechanical advantage, so that it is as easy as possible to break loose a pedal. This is not to say that it is always easy. Pedals can be very difficult to break loose. Other than using the following technique and using penetrating oil, nothing helps more with difficult pedal removal.



24.1 *This is the correct orientation of crank arm and wrench, and the correct directions to apply force, to make a pedal as easy as possible to break loose.*

1. [] With bike elevated in bike stand and horizontal, stand on side of bike where pedal is to be removed, facing rear of bike.
 2. [] Position crank arm with pedal being removed pointing to rear axle.
 3. [] Reaching through or over frame with hand closest to bike, grasp end of crank arm on side that pedal is *not* being removed.
 4. [] Put wrench on pedal flats so that that it is as close as possible to horizontal and pointing straight forward.
 5. [] Push down on crank arm not having pedal removed and pull up simultaneously on end of pedal wrench until pedal breaks free.
- Once the pedal is broken loose, it will be awkward to unthread it the rest of the way by rotating the wrench around the pedal. It is easier just to use the wrench and pedal together to turn the cranks in the direction they turn when riding. The pedal will unthread automatically. Grasp the pedal wrench close to the pedal to make it easier to keep the wrench on the pedal while turning the crank.
6. [] Stand facing pedal being removed. Grasp pedal in one hand and grasp wrench with other hand and use both hands to turn crank in same direction that crank rotates when pedaling bike.
 7. [] Repeat steps 1–6 on other side of bike to remove second pedal.

24 – PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION

PEDAL REPLACEMENT

Determining thread compatibility of new pedals

There are three thread types (see table 24-2). Of these three, the BSC thread is almost universal. The American thread is found exclusively on inexpensive bikes with one-piece cranks and BMX bikes with one-piece cranks. Both have such a different diameter that there is no possibility of mismatching BSC and American threads. The French thread is close enough to BSC to confuse them without measurement, but it is so rare these days that it should not be a concern unless replacing pedals on a bicycle made in France before the late 1970s.

8. [] Measure thread pitch of old pedals with thread-pitch gauge. Record pitch here: _____ tpi/mm.
9. [] Measure O.D. of old pedal-mounting threads with caliper and record here: _____ mm.
10. [] Measure pitch of new pedal threads and compare to step 8. Pitch must be identical.
11. [] Measure O.D. of new pedal thread and compare to step 9. Difference must be <.3mm.

Checking cage-retention bolts or cleat-mechanism bolts

A common source of mysterious noises coming from the crank/pedal region is loose hardware on the pedal. Factories are notorious for not getting bolts tight. Once they are properly tightened, they should stay tight. If allowed to loosen up and fall out, they could cause damaged threads in the pedal body and damaged pedal cages (holes will not line up). It would be good insurance to remove the bolts and treat them with Loctite #222 or #242.

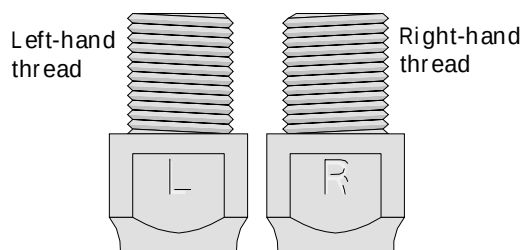
12. [] Check and secure all bolts holding pedal cage to pedal body or cleat-retention mechanism to pedal body. Torque to 50in-lbs (12lbs@3").

NOTE: Go to step 14 if not transferring toe clips and straps to new pedals.

13. [] Remove straps and toe clips (if any) from old pedals.

PEDAL INSTALLATION

Pedals that go in the right crank arm have a right-hand thread. Pedals that go in the left crank arm have a left-hand thread. There is usually, but not always, an “R” or “L” notation on the pedal. If other letters are there, or it is difficult to read the letters, the thread direction is easy to determine by observation, as indicated in step #14.



24.2 The threads sloping up to the left on the left example indicate that it is a left-hand thread. The threads sloping up to the right on the right example indicate that it is a right-hand thread.

14. [] Hold each pedal so that threaded shaft points up and examine which direction threads slope. (Threads sloping up to right, pedal installs on right. Threads sloping up to left, pedal installs on left.)

15. [] Grease pedal threads thoroughly.

It is best to start pedals threading in with fingers. This way no damage can be caused if they get installed on the wrong side of the bike, or cross-threaded. Once engaged at least one full turn, then use a tool to install them the rest of the way.

16. [] Using fingers, start each pedal in on its appropriate side (step 14) and thread in as far as possible without using pedal wrench.

PEDAL - MOUNTING THREADS (table 24-2)

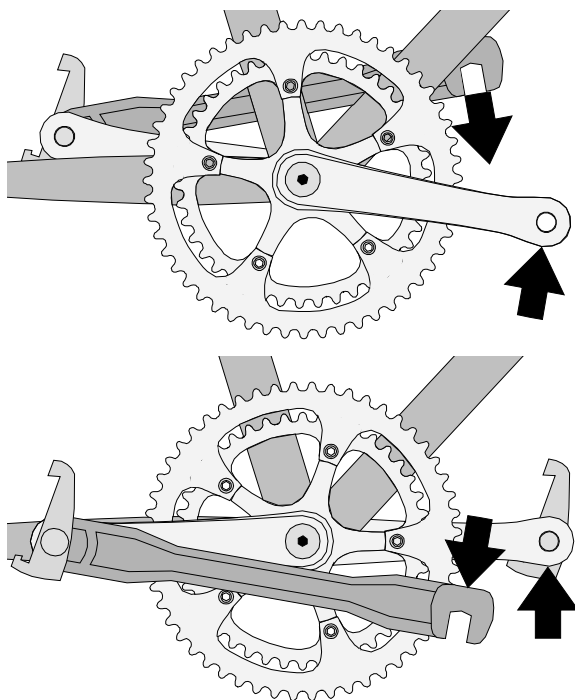
Nominal measurement (thread type)	Approximate axle-thread O.D.	Approximate mounting-hole I.D.	Typical occurrences
9/16" × 20tpi (BSC)	14.0–14.2mm	12.9–13.1mm	Most quality bicycles with conventional three-piece crank sets.
14mm × 1.25mm (French)	13.7–13.9mm	12.6–12.8mm	Older French-made bicycles from the late 1970s or earlier.
1/2" × 20tpi (American)	12.4–12.6mm	11.3–11.5mm	Bikes with one-piece crank arms including American-made department-store derailleur bikes, BMX bikes, and juvenile non-derailleur bikes. Also old Schwinn's.

24 – PEDAL REMOVAL, REPLACEMENT, AND INSTALLATION

It is awkward to rotate the wrench around the pedal to thread the pedal the rest of the way in. Instead put the wrench on the pedal and rotate the crank (one hand on wrench and one hand on pedal) backwards to thread the pedal the rest of the way in.

- 17. [] Stand facing pedal being installed. Place wrench on pedal flats. Grasp pedal in one hand and wrench with other hand and use both hands to turn crank in opposite direction than when riding. Stop when pedal begins to feel snug.**

If not set up and positioned correctly, it will be unnecessarily difficult to adequately secure the pedals. Steps #18–#22 are the easiest way to secure the pedals.



24.3 *With the crank arms and wrench in this position, apply force in the directions indicated to easily secure the pedal.*

- 18. [] With bike elevated in bike stand and horizontal, stand on side of bike where pedal is to be installed, facing rear of bike.**
- 19. [] Position crank arm with pedal being secured pointing to rear axle.**
- 20. [] Reaching through or over frame with hand closest to bike, grasp end of crank arm on side pedal is not being secured.**
- 21. [] Put wrench on pedal flats in way that it is as close as possible to horizontal and pointing straight forward.**

Many pedals have thin wrench flats that require the use of a special pedal wrench. Many others have wider wrench flats that fit any open-end wrench. The ones that require a special wrench must be torqued by

feel. A 15mm crow's-foot adapter for a socket wrench can be used on a torque wrench when the pedal wrench flats are wide. Using this technique reduces liability, and also improves development of the proper feel for tightening pedals that cannot fit a crow's-foot.

- 22. [] Pull up on crank arm not having pedal secured and push down simultaneously on end of pedal wrench with force of 300–360in-lbs (33–40lbs@9"). Reposition wrench if it rotates past 90° from crank arm before achieving torque.**

Tightening the pedal against the crank-arm face often creates a small sharp aluminum burr. If excess grease has oozed out, then this burr can be hidden in the grease. Avoid the painful experience of getting this burr in a fingertip later, by using a rag to wipe around the end of the pedal to remove any grease and any hidden burrs, as indicated in step #23.

- 23. [] Use rag to wipe excess grease away at point pedal enters crank arm.**
- 24. [] Repeat steps 17–23 for other pedal if necessary.**

TOE-CLIP AND STRAP INSTALLATION

NOTE: *Skip remaining steps if not installing toe clips and straps.*

- 25. [] Treat toe-clip-bolt threads with Loctite 222 or 242.**
- 26. [] Place toe clip on outside face of front side of pedal cage and install bolts and nuts (if any).**
- 27. [] Align toe clip laterally.**
- 28. [] Secure toe clip bolts to 24–36in-lbs (8–12lbs@3").**
- 29. [] Feed end of toe strap into hole on outer end of pedal cage/body.**
- 30. [] Twist toe strap one full twist, then thread end of strap through hole in inner end of pedal cage/body.**
- 31. [] Feed end of top strap through loop at top of toe clip and once through buckle.**
- 32. [] Repeat steps 25–31 for other side if necessary.**

REPAIRING PEDAL-MOUNTING THREADS

Pedal threads can be damaged in a number of ways, and the way that they are damaged determines whether or not the threads are repairable. If the pedal is poorly aligned and threaded in with a wrench, it will cross-thread the crank arm, which is repairable. If a wrench is used to start a pedal installation and it is the wrong pedal for that side of the bike, the damage will be repairable. If a pedal is improperly secured and unthreads, at some point it will rip out of the crank arm. How far it has threaded out and how much pressure there is on the pedal at the moment it rips out, determines how many threads in the crank arm are damaged. Depending upon the extent of the damage, this may or may not be repairable. Step #7 is an integrity test that determines, after attempting repair, whether the repair will hold, or not.

Thread chasing

1. [] Make sure that tap is correct for side of bike. (Right-hand thread for right side, left-hand thread for left side.)
2. [] Squirt cutting oil inside damaged threads and cover tap threads with cutting oil.
3. [] Thread tap into *back side* of crank arm that has damaged threads.
4. [] When encountering cutting resistance, advance tap no more than 1/4 turn before backing out 1/2 turn to clear cutting edge of fragment build-up. Add cutting oil repeatedly.
5. [] Continue advancing tap (adding cutting oil repeatedly) in this fashion until *tap comes fully out of front face of crank arm*.
6. [] Clean threads in crank arm with toothbrush and solvent.

If threads were stripped because the pedal came out while the bike was being ridden, perform the integrity test in step #7 to determine if the remaining threads are adequate. If the threads strip further during the test, then the crank is no worse off than before (still unusable). In this case, a thread bushing can be installed. The labor to install a thread bushing may be up to half an hour, so it may be cheaper to replace the damaged arm in some cases.

7. [] Install pedal normally but torque to 50ft.lbs. (67lbs@9") to test thread integrity.
8. Select one of two following choices:
 - [] Threads stripped in step 7, replace crank arm or install thread bushing.
 - [] Threads passed integrity test in step 7, loosen and torque normally.

Thread-bushing installation

Thread bushings can be installed in all aluminum crank arms that are threaded with a 9/16" × 20tpi thread. A special tool (Eldi 2299) is required. The tool reams the old threads out and then taps the arm to a new oversize-thread description. The thread bushing matches the new thread on the outside and the old thread on the inside.

The Eldi tool tends to ream slightly undersize. Using a 15mm or 19/32" drill bit should work better.

9. [] Use correct Eldi 2299 reamer/tap for side of bike and clean out all existing threads.
10. [] Using cutting oil generously, tap through crank arm with oversize tap.
11. [] Grease pedal-shaft threads and thread bushing by hand onto pedal shaft.
12. [] Treat outside threads of bushing with Loctite 242, 272, or RC680.
13. [] Thread in pedal (with bushing attached) same as normal pedal installation, but do not torque.
14. [] After Loctite has cured overnight, torque pedal normally.
15. [] File excess bushing material (if any) off back face of crank arm.

PEDAL-MOUNTING TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>When riding, one ankle feels as though the end of the pedal is rocking up and down, and/or it feels as though the surface of the pedal is rotating back and forth.</i>	
Pedal shaft is bent from a crash.	Remove pedal and inspect end of pedal shaft for oscillation when rotating. Replace if bad. If symptom persists when pedal shaft is good, crank arm is bent and should be replaced.
If pedal shaft is not bent, crank arm is bent.	Replace crank arm.
SYMPTOM: <i>A popping sound or sensation is experienced once per crank-revolution, often on the down-stroke of the right pedal.</i>	
Loose pedal-cage piece(s).	Check and secure pedal-cage piece(s).
Loose pedal mounting.	Check and secure pedal mounting.
Shoe cleat is moving on cage or in retention mechanism.	Check cleat wear and security.
Cleat-retention mechanism is loose.	Check and secure cleat-retention mechanism.
Loose crank arm.	Check and secure crank arm.
Loose chainring bolt(s).	Check and secure chainring-mounting bolt(s).
Loose bottom-bracket cups, lockrings, or retaining rings.	Check and secure bottom-bracket cups, lockrings, or retaining rings.
Bent chainring tooth.	Inspect and bend back.
SYMPTOM: <i>The pedal loosens up while riding</i>	
Pedal was improperly torqued.	Secure pedal to 300–360in-lbs.
SYMPTOM: <i>Looseness is felt in the pedal</i>	
Loose pedal mounting.	Check and secure pedal.
Loose cage-retention bolts or cleat-retention-mechanism bolts.	Check and secure cage-retention bolts or cleat-retention-mechanism bolts.
Loose bearing adjustment or loose bearing-unit retention.	See chapters 14 and 15.

25 – FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS

ABOUT THIS CHAPTER

This chapter is about removing and installing freehub mechanisms, thread-on freewheels, and the cogs that go on freewheels and freehubs. These items are removed for cleaning, replacement, access to spokes, and in the case of thread-on freewheels, access to the axle set and hub bearings. Some cartridge-bearing hubs are freehubs, but the freehub design is unique to the hub. This section only covers conventional freehub-mechanism designs. Special freehub mechanisms are covered in the procedure for the hub that uses the special design (see the **CARTRIDGE-BEARING HUBS** chapter, page 13-1).

GENERAL INFORMATION

TERMINOLOGY

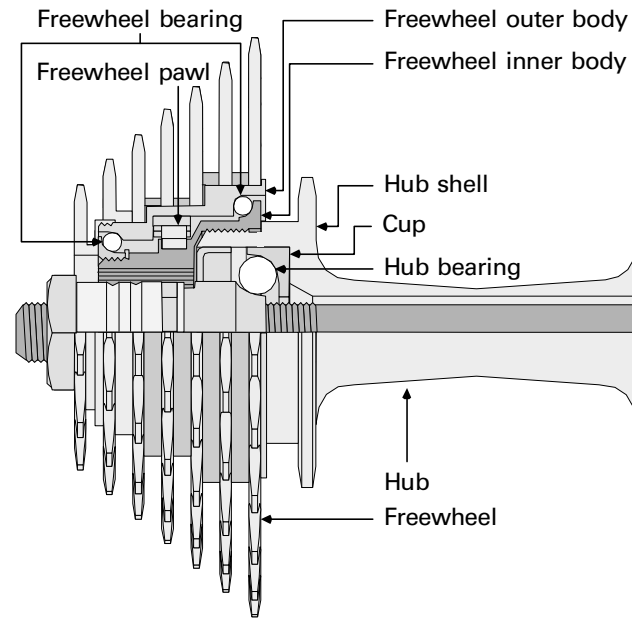
Some of these terms are confusingly similar, so it makes sense to spend a bit of time considering terminology and definitions before looking at the list of terms.

Thread-on freewheels

A thread-on freewheel is a mechanism consisting of a freewheeling mechanism and a set of cogs attached. The mechanism threads onto a hub shell, and is independent of the bearings of the hub. This means that the entire freewheel can be removed without disassembling the hub, and once it is removed the hub is still fully intact and functional.

The freewheel mechanism consists of a two-piece body, with the inner and outer body rotating independently of each other on sets of bearings. The inner body threads onto the hub shell and remains fixed to the hub shell. The outer body engages the inner body by means of pawls and a ratchet ring that cause the two body pieces to rotate as one when the chain drives the cogs attached to the outer body-piece. When the chain is not applying drive force and the bike is coasting, the pawls disengage the ratchet ring and allow the inner body to turn free of the outer body, so that the cogs do not drive the chain.

With this system, freewheeling-mechanism removal is generally required for hub-bearing adjustment or overhaul and for accessing spokes. Thread-on-free-wheel/hub systems allow independent selection of hub and freewheel brands and models. This does not create all the versatility that might be imagined because many indexing-derailleur systems require specific cogsets in order to function at peak performance, and in some cases these cogsets might be available only on a freehub mechanism.



25.1 A hub and thread-on freewheel in cross-sectional view.

Freehubs (freehub mechanisms)

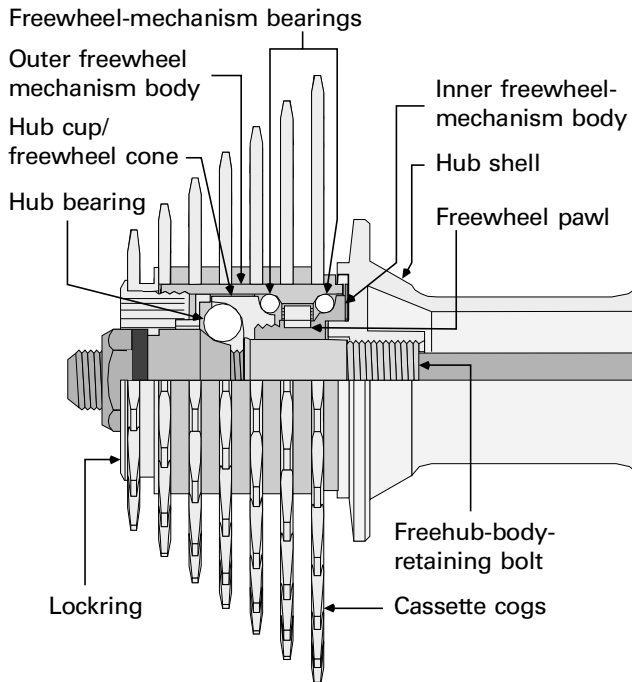
A freehub usually has the same freewheel-mechanism inner body, pawl and ratchet mechanism, freewheel-mechanism outer body, and cogs attached to the outer body. Some freehub mechanisms use alternative systems to the pawl and ratchet-ring design. The inner body still fixes to the hub shell, although not necessarily by threading on. When the hub has conventional cup-and-cone bearings, the inner body-piece has integrated into its outer end the right-side hub-bearing cup.

25 – FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS

This means that the freewheel mechanism and the hub bearings are not independent systems. The practical consequence of this is that it is not necessary to remove the freewheel mechanism to service the hub bearings, but it is necessary to remove the hub axle and bearings to remove and service the freewheel mechanism. To access spokes on a freehub rear wheel, it is not necessary to remove the freewheel mechanism. However, the cogs must be removed from the freewheel mechanism.

Freehubs may be required for use with certain indexing-derailleur systems because compatible cogsets are only available on a freehub. Freehubs have an advantage in their design due to the repositioning of the right-side hub bearing. The different position reduces the stack of spacers on the right end of the axle, which reduces the occurrence of bent axles (something that is problematic on thread-on-freewheel/hub combinations, particularly when exceeding six cogs).

Freehubs are sometimes called “cassette hubs,” but this is a misnomer; although, some freehubs have a cassette cogset. This means that the cogs are removed and installed as a group, rather than individually. Individual cogs can always be put back on where the cassette was removed, so there is no such thing as a cassette hub, or a hub that requires cassette cogs.



25.2 A freehub in cross-sectional view.

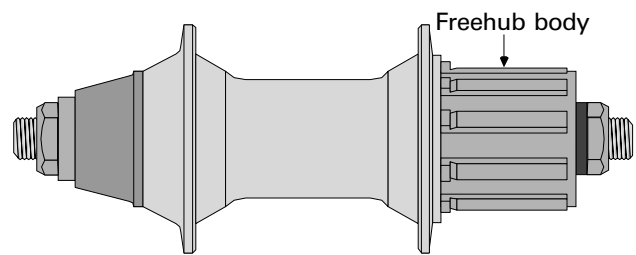
The following are the terms and definitions that are used in this chapter.

Freewheel: Used to describe a freewheel that threads onto a rear hub. (The freewheel mechanism and the hub bearings are independent systems.)

Freewheel mechanism: A mechanism that consists of two pieces that can rotate separately. Usually one has a ratchet ring and the other has pawls, so that they can rotate together when the outer piece is being driven, and independently when the inner piece is being driven. (See figures 25.1 and 25.2.)

Freewheel body: Used to describe the freewheel mechanism of a freewheel without the cogs attached.

Freehub: This applies to the complete integrated hub/freewheeling-mechanism with or without the cogs attached.



25.3 A freehub.

Freehub body: This applies to the freewheeling-mechanism portion of a freehub, without the cogs attached.

Cogs: Also *gears*, or *freewheel cogs*, this refers to the toothed gears that engage the chain, whether mounted on a freewheel body or a freehub body.

Pawl: A pivoting tooth that engages or slides over the teeth in a ratchet ring, depending on the relative direction of rotation.

Ratchet ring: A geared ring that has teeth pointing in one direction that engage a pawl if rotated one way and pass over the pawl if rotated the other way.

Cassette: Also *cassette cogs*. A set of cogs for a freehub that are removed, replaced, or installed as a set instead of individually.

Lockring: A threaded ring that holds cogs onto a freehub body.

PREREQUISITES

Wheel removal and installation

Wheel removal and installation is required for any type of freewheel or freehub work.

Rear-derailleur adjustment or replacement

Rear-derailleur adjustment or replacement may be required in several cases. If an identical model of freewheel or freehub cogs are being installed, but cog sizes

are different, derailleur adjustment will be required. If the derailleur's maximum capacity is exceeded, derailleur replacement will be required. Any time the brand, model, or number of cogs are changed, derailleur adjustment is required.

Axle removal and hub adjustment

Axle removal and consequential hub adjustment may be required for two reasons. The axle will need to be removed for certain difficult freewheel removals, and the axle will need to be re-spaced if changing the number of cogs when replacing a freewheel or freehub body.

Wheel dishing and truing

If the hub axle is re-spaced to accommodate a freewheel or freehub body with a different number of cogs, then it will be necessary to re-dish the wheel, and consequently re-true the wheel.

Frame alignment

If the hub is being re-spaced to accommodate a freewheel or freehub body with a different number of cogs, then it is likely that the wheel will no longer fit the frame correctly. In this case, it may be required to align the rear triangle of the frame.

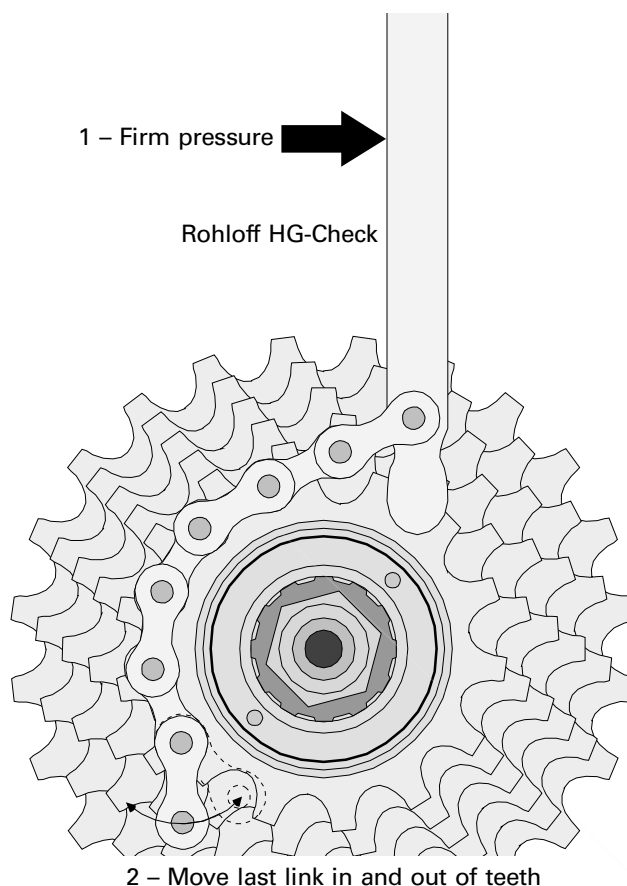
INDICATIONS

Maintenance cycles

There are two types of maintenance that need to be performed on freewheels/freehubs: external cleaning, and internal cleaning and oiling. External (cog) cleaning should be performed whenever the chain is cleaned. Differences in riding conditions make it impossible to put a time or mile value on this need. Internal cleaning and oiling should be done whenever there is a problem with the freewheel mechanism exhibiting symptoms of sticking (not freewheeling) or skipping (not engaging). In the case of freewheels, the internal cleaning will generally be done when cleaning the cogs because it is easiest to do both at once. In the case of freehubs, the cogs are generally removed from the freehub body to be cleaned, so internal cleaning and oiling is not done at that time. On the other hand, the freehub body is easiest to clean when doing a hub overhaul.

It is a common mistake to routinely oil the internals of the freewheel mechanism. This is a good way to introduce dirt to the inside. If there are negative symptoms, always assume that internal cleaning is needed, and only oil after cleaning. If negative symptoms are not present, there is no need for oiling.

It is recommended to periodically check the cogs for wear, particularly if replacing a chain or cogs, but not both at once. There is a tool (Rohloff HG-Check) that can be used for just this purpose. A shop should find this tool indispensable, but it is possible to determine cog wear without the tool. When putting a new chain on, pedal hard in every rear cog. If the chain jumps or skips, and the old chain did not, then the cog(s) that exhibits the symptom are worn out.



25.4 Use a Rohloff HG-Check to check cog wear. If any resistance is felt when moving the last link in or out of the cog, the cog is worn out.

Symptoms indicating worn-out cogs

If the chain slips or skips on a cog when pedaling hard, the cog or cogs may be worn out. With this problem, it may be possible to ride all day with the chain on a certain cog as long as pedal pressure is light. As soon as extra force is applied to the pedals, there is a loud metallic clunk that comes from the vicinity of the rear wheel and the pedals may seem to give way and then catch again after an inch or two of motion. Cog teeth wear from load, so that they eventually deviate from their original half-inch pitch (the distance from one tooth to the next). As long as the same chain is used,

there will probably be no symptom, because the chain wears to match the teeth. As soon as the worn chain is replaced, the symptom is more likely to occur.

When this symptom occurs, it calls for replacement of the worn cogs. If only a few cogs are worn and individual replacements are available, then it may make financial sense to only replace these cogs, but in general it is advisable or even necessary to replace whole freewheels, or cogs on a freehub in sets.

A similar symptom can occur when the pawl and ratchet mechanism inside the freehub-body/freewheel-body is malfunctioning. If the problem is cog-tooth wear, then the problem will happen on a specific cog or cogs. If it is a problem with the pawl and ratchet mechanism, it will happen in every gear but only when there is a high-level load.

A similar symptom may occur on a bike with an indexing rear derailleur when the indexing adjustment is borderline. In this case, what is actually happening is that the chain is jumping from one cog to the next when the shift lever is not being operating, and it should feel like the gear has changed after the symptom occurs.

Symptoms indicating need for internal cleaning or freewheel/freehub-body replacement

When freewheeling occurs when pedaling, constantly or intermittently, the freewheel mechanism may need internal cleaning or parts may have failed. The pawl and ratchet mechanism inside the freewheel body or freehub body is surprisingly delicate for the job it does of converting the pedaling load to the rear hub. Small parts are moved by hair-thin springs in tight, confining spaces. Dirt or rust can severely inhibit the motion of the pawls and create the symptom of the freewheel not engaging when pedaling force is applied. Cleaning and lubrication can potentially solve this problem. When they do not, it means the rust is too far advanced or the pawls or pawl springs are worn out or damaged. These parts are generally not available separately, so the normal solution is to replace the entire freewheel or freehub body.

Another symptom that may be experienced is when coasting, the cogs continue to turn with the wheel, pushing the chain. Dirt, rust, and worn or damaged pawls or pawl springs can cause this symptom. Sometimes this symptom is called “ghost rider” because while the rider’s feet are off the pedals, the pedals continue to turn on their own. If cleaning and lubricating does not solve the problem, then the pawls

or pawl springs have failed. These parts are generally not available separately, so the normal solution is to replace the entire freewheel or freehub body.

Symptoms indicating need of freewheel or freehub-body overhaul

Due to the lack of replacement parts availability, and due to the fact that freewheels old enough to have internal problems undoubtedly have limited life left in the cogs, overhauling the inside of freewheels or freehub bodies is not recommended. When cleaning and oiling does not eliminate symptoms, replace the freewheel or freehub body.

Symptoms indicating loose freewheel/freehub-body bearings

When a steady, light clunking sound comes from the freewheel in some gears more than others, and at some pedaling speeds but not others, it indicates the bearings are loose. If the freewheel/freehub-body-bearing adjustment gets too loose, it allows the outer body to float side-to-side and make a clunk when it reaches its limit each way. This happens in some gears but not others, and at some pedaling speeds but not others, because the direction and amount of load from the chain influences whether the outer body is free to float. All freewheel-mechanism bearings are designed to have some free play. It is too much only when this symptom occurs. The play in these bearings is not adjustable, so when the symptom occurs on a new mechanism it should be considered a warrantable failure, and when it occurs on an old mechanism it should be considered time to replace the freewheel or freehub body.

Symptoms indicating bad freewheel or freehub mounting

If the cogs appear to wobble side-to-side while coasting, it might seem as though there is a problem with the way the freewheel or freehub body is mounted. This is a normal condition due to a lack of precision in the freewheel/freehub-body bearings and is not a problem if the wobble does not occur while pedaling.

If the cogs appear to wobble side-to-side while pedaling, there may be a problem with the mounting of the freewheel or freehub body. This occurs for different reasons on thread-on freewheels and freehubs. It is only a problem if the degree of wobble interferes with making a good derailleur adjustment and getting the chain to run on one cog without rubbing on the next.

If the problem of wobbling-while-pedaling occurs on a hub with a thread-on freewheel, it generally indicates that the freewheel is cross-threaded, in which

25 – FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS

case the hub is probably destroyed. If the freewheel-mounting threads are in good condition, it indicates that the spoke guard is mounted off-center (try a new one or none at all), or that the hub or freewheel was mis-threaded from the factory (generally warrantable). It never has anything to do with a bent axle.

If the wobbling-while-pedaling problem is on a freehub, it indicates that the bolt that holds the freehub body to the hub shell is loose. Immediate service is required. To tighten the bolt, the axle must be removed from the hub.

Thread-on-freewheel-hub service

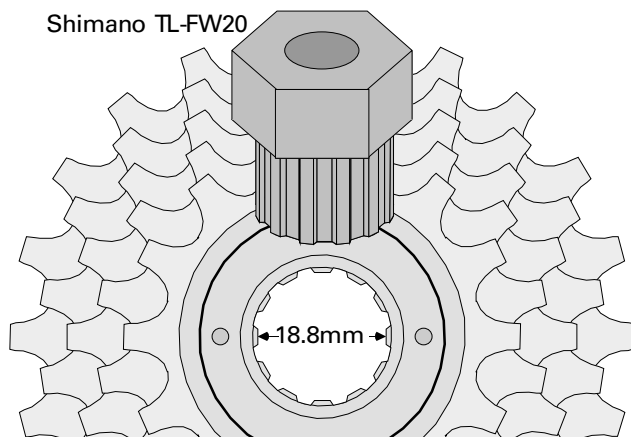
It is necessary to remove and re-install a thread-on freewheel if adjusting or overhauling a thread-on-freewheel hub.

Spoke access

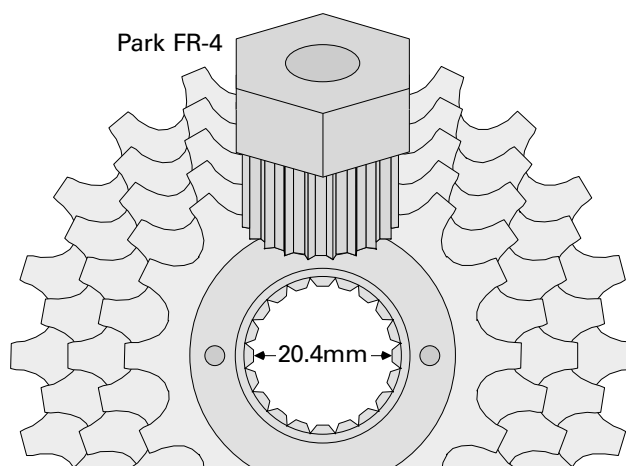
If replacing a spoke or rebuilding a wheel, the freewheel or cogs on the freehub block access to the hub flange. If it is a hub with a thread-on freewheel, the freewheel must be removed first. *It is important to note that there is no way to remove the freewheel reliably if the spokes are cut before the freewheel is removed.* If the hub is a freehub, the cogs must be removed from the freehub body to access the hub flange, but the freehub body need not be removed.

TOOL CHOICES

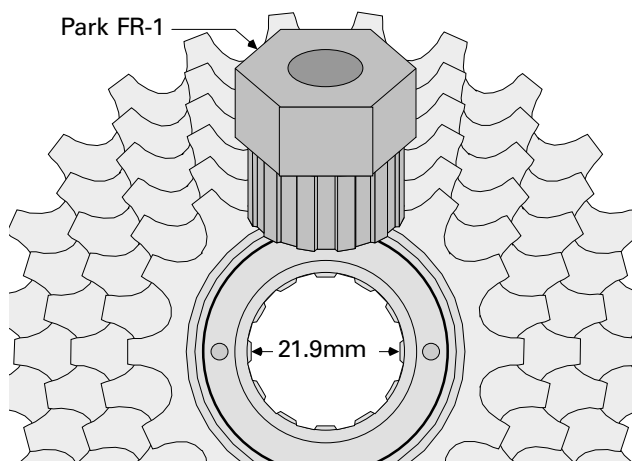
The design or brand of the freewheel/freehub will determine the tools needed. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is **bold**, it means that several tools are required for different configurations of parts. (See table 25-1, page 25-6.)



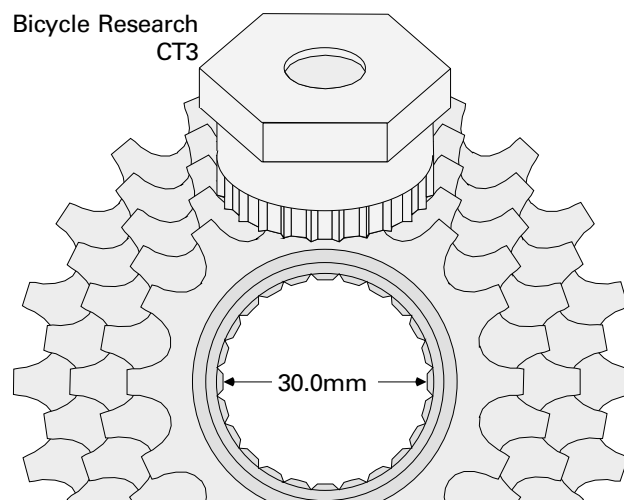
25.5 This Shimano splined-freewheel with an 18.8mm hole is rare. The preferred tool that fits it is shown.



25.6 This splined-freewheel with a 20.4mm hole is made by several manufacturers. The preferred tool that fits it is shown.

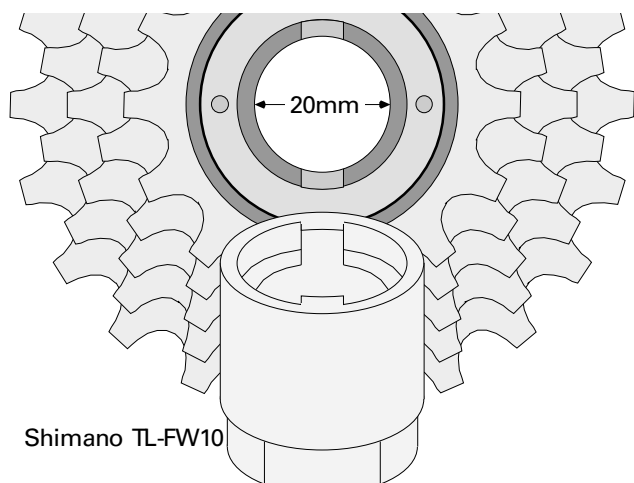


25.7 This Shimano splined-freewheel with a 20.4mm hole is the most recent configuration. The preferred tool that fits it is shown.

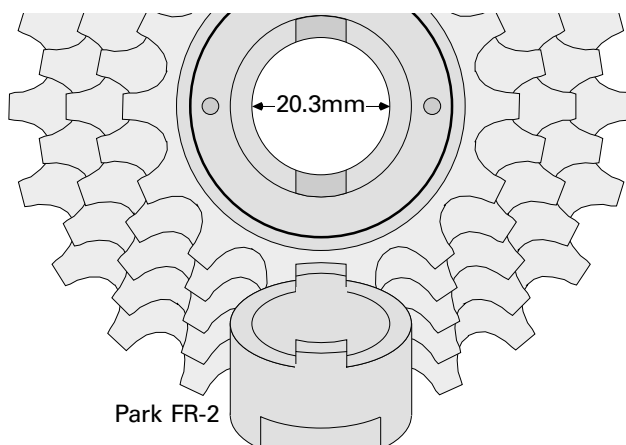


25.8 This is a Maillard/Atom/Sachs splined-freewheel with a 30.0mm hole. The preferred tool that fits it is shown.

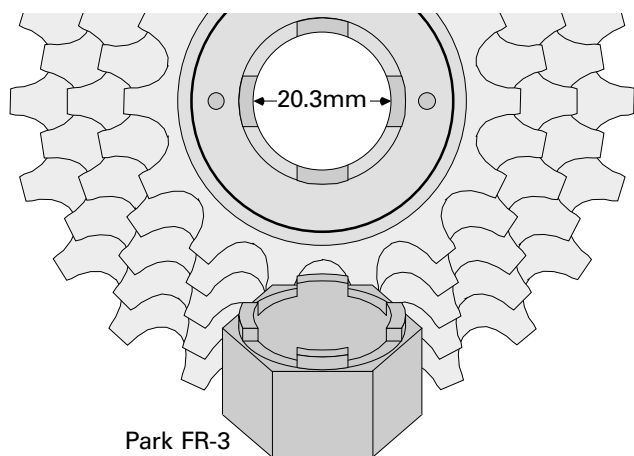
25 – FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS



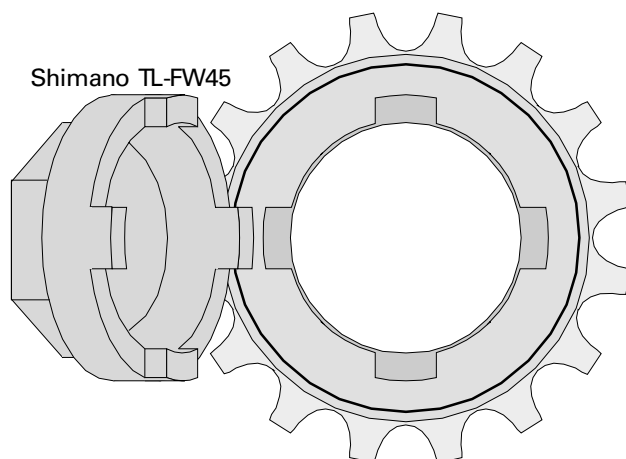
25.9 This older Shimano notched-freewheel with a 20.0mm hole sometimes requires removal of a plastic dustcap before the tool will fit. The preferred tool that fits it is shown.



25.11 This two-notch freewheel with a 20.3mm hole is an older variety made by SunTour. The preferred tool that fits it is shown.



25.10 This four-notch freewheel with a 20.3mm hole is the last configuration made by SunTour. The tool that fits it is shown.



25.12 This four-notch BMX freewheel with a large hole has been made by Shimano and SunTour. The tool that fits it is shown.

FREEWHEEL AND FREEHUB TOOLS (Table 25-1)

Tool	Fits and considerations
SPLINED-FREEWHEEL REMOVERS (see figures 25.5, 25.6, 25.7, and 25.8 on page 25-5)	
Bicycle Research CT2	Thick-wall tool fits Atom, Regina, & Zeus w/ 20.4mm hole (requires axle removal)
Park FR-4	Thin-wall tool fits Atom, Regina, and Zeus w/ 20.4mm hole
Phil Wood Atom tool	Thin-wall tool fits Atom, Regina, and Zeus w/ 20.4mm hole
Bicycle Research CT3	Fits Atom, Maillard, Normandy, Schwinn freewheels w/ 30mm hole
Bicycle Research CT4	Thick-wall tool fits old Shimano w/ 18.8mm hole (requires axle removal)
Shimano TL-FW20	Thick-wall tool fits old Shimano w/ 18.8mm hole (requires axle removal)
Bicycle Research CT6	Thin-wall tool fits Shimano and Sachs freewheels w/ 21.9mm hole
Bicycle Research CT6MB	Thick-wall tool fits Shimano & Sachs freewheels w/ 21.9mm hole (requires axle removal)
Park FR-1	Thin-wall tool fits Shimano and Sachs freewheels w/ 21.9mm hole
Shimano TL-FW30	Thin-wall tool fits Shimano and Sachs freewheels w/ 21.9mm hole
VAR 414	Thin-wall tool fits Shimano and Sachs freewheels w/ 21.9mm hole
Bicycle Research CT5	Fits rare TDC three-spline freewheel

25 – FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS

Tool	Fits and considerations
NOTCHED-FREEWHEEL REMOVERS (see figures 25.9, 25.10, 25.11, and 25.12 on page 25-6)	
Bicycle Research CT7	Fits SunTour 2-notch freewheels
Park FR-2	Fits SunTour 2-notch freewheels
Bicycle Research CT10	Fits SunTour 4-notch freewheels
Park FR-3	Fits SunTour 4-notch freewheels
Bicycle Research CT1	Fits Shimano/Regina 2-notch freewheels, <i>not recommended</i>
Bicycle Research CT600	Fits Shimano/Regina 2-notch freewheels, <i>not recommended</i>
Shimano TL-FW10	Fits Shimano/Regina 2-notch freewheels (plastic dustcap removal sometimes required on some Shimano 600 models)
Bicycle Research CT-9	Fits Campagnolo 2-notch
Campagnolo 0520/40	Fits Campagnolo 2-notch
VAR 404	Fits Campagnolo 2-notch
Shimano TL-FW45	Fits Shimano and SunTour 4-notch BMX freewheels
Shimano TL-FW40	Fits Shimano and SunTour 2-notch BMX freewheels
COG-REMOVAL/INSTALLATION TOOLS	
Park FR-5	Fits Shimano HG/IG lockrings
Shimano TL-HG15	Fits Shimano HG/IG lockrings
Stein HLW-2	Fits Shimano HG/IG lockrings, works best used with Stein HLW-1 wrench
Campagnolo 7130036	Fits Campagnolo freehub-cog-retaining lockrings
Park BBT-5	Fits Campagnolo freehub-cog-retaining lockrings
VAR 414B	Fits Campagnolo freehub-cog-retaining lockrings
Bicycle Research CV1	Freewheel vise holds freewheel for cog removal
Stein HLW-1	“Hyperhandle” holds sprockets while using Stein HLW-2 lockring driver
Hozan C62	Strongest sprocket remover made, with good leverage and hand protection
Pamir TW-1	Strong sprocket remover with excellent hand protection, hex fitting fits Shimano cog and lockring tools
Park SR-1	Strong sprocket remover with fair hand protection, also acts as handle for Park freewheel removers
Park SR-2	Similar to Hozan C62, slightly more expensive, bolts hold chains to tool
Wheels CRT-A1	Strong sprocket remover with fair hand protection with 3/32" chain
COG/BEARING-SERVICE TOOLS	
Rohloff HG-Check	Excellent tool for check cog wear on all brands and models of cogs
Park GSC-1	Cleaning tool for cogs
Shimano TL-FH40	For securing race or disassembling freehub body
Park SPA-2	Red pin spanner fits certain freewheel dustcaps and bearing cones
Morningstar FHB1	Adapter allows flushing Shimano (except Dura-Ace 6- & 7-speed) freehub bodies with solvent and air
Morningstar FHB2	Adapter allows flushing Shimano Dura-Ace (except 8-speed) freehub bodies with solvent and air
Morningstar FHB3	Adapter allows flushing pre-1991 SunTour freehub bodies with solvent and air
Morningstar FHB4	Adapter allows flushing SunTour freehub bodies with solvent and air
Morningstar J4M	Removes dustcap from Shimano freehub body
Stein FWG	Adapter allows flushing most freewheels with solvent and air
FREEHUB-BODY REMOVERS	
Shimano TL-FH10	For removing Dura-Ace freehub body
Shimano TL-FH30	For removing rare Dura-Ace AX and 600 AX freehub bodies
10mm Allen-bit socket	For removing most Shimano and SunTour freehub bodies

TIME AND DIFFICULTY

Freewheel removal/installation

Once the wheel is off, it is usually a simple matter to remove and install a freewheel. It normally takes 2–3 minutes and poses little difficulty. In cases where the freewheel is damaged where it engages the remover, the nature of the job changes completely; freewheel disassembly is required, a job that may take 10–15 minutes and is moderately difficult. In cases where the freewheel is so tight that thin-walled splined removers such as the Park FR-1 and FR-4 are failing before loosening the freewheel, it is necessary to remove the axle set so that a heavier-duty remover (that can only be used with the axle out) can fit. Removing and replacing the axle set is an additional 10–15 minute job of moderate difficulty.

Freehub-body removal and installation

Freehub bodies are only accessible when the axle set is removed from the hub. Removing and installing the axle is a 10–15 minute job of moderate difficulty. While the hub is apart, the freehub body can be removed and installed in 2–3 minutes with little difficulty.

Freewheel/freehub-cog removal and installation

Cog removal and installation is a 5–10 minute job of little technical difficulty, but a great deal of exertion may be required. At times, the cog-removal tool will break or bend before the cog will break loose.

Freewheel, freehub-body, and cog cleaning

Once the parts to be cleaned are removed and accessible, the cleaning will take 2–10 minutes. It is not technically difficult, but can take a lot of elbow grease.

COMPLICATIONS

Identifying freehubs versus threaded hubs with thread-on freewheels

The first complication is just to know whether it is a freehub or a threaded hub with thread-on freewheel that is being dealt with.

When the wheel is off, look at the face of the freewheel/freehub body. If the axle appears to come out of a hole in the body and the edge of the hole has two or four indentations (notches) in its inner perimeter, then it is a thread-on freewheel that takes a pronged freewheel remover. If the hole has splines (about 20) and the splines do not move when turning the cogs backward, then it is a thread-on freewheel that takes a splined remover. If the

splines turn with the cogs when the cogs are turned backward, then it is a freehub (probably a Shimano or Sachs). If it is none of these, it is probably a Sun Tour freehub or some lesser-known brand of freehub.

Damaged freewheel-removal system

Notched-freewheel-removal systems are prone to damage. The tool slips and the notches strip out. When this happens, the freewheel is a loss. Instead of removing it in the conventional manner, it will need to be disassembled for removal. This removal technique is described in detail later (page 25-12).

Prevention of this failure is always possible. Use of the correct removal tool and careful adherence to the recommended procedures will prevent virtually all failures.

Stuck freewheel won't break loose, or remover breaks

A freewheel can be so tight that it may take two people to remove. If the remover is the correct fit, properly secured, and the wheel is in a stable condition, then the worse that may happen is that the freewheel remover (thin-wall type) may break. If this occurs, there are heavier-duty removers that are more awkward to use, but effective.

Axle set interferes with freewheel remover

Thick-wall splined removers require locknuts and spacers to be removed from the right side first. Sometimes this hardware will just thread off the right side of the axle, but usually the axle must be stripped on the left side in order to be pushed out the right side.

Some cartridge-bearing hubs cannot have the hardware stripped off the right side and cannot have the axle pushed out the right side of the hub unless the freewheel is removed. In these cases, there are two options. The choices are to use a thin-wall remover, or to disassemble the freewheel to remove it without a remover (which destroys the freewheel).

No correct remover available for freewheel type

Almost all freewheels ever made still have removers available. In the unlikely event that there is no remover available, then the only option is to disassemble the freewheel to remove it without a remover (which destroys the freewheel).

Rim has been removed before freewheel

The leverage of the rim is required to turn the hub out of the freewheel. When the rim has been removed, there is a good likelihood that either the hub

or freewheel will need to be sacrificed. The section of this chapter about difficult freewheel removal describes all the options in detail (page 25-13).

Difficult threaded-cog removal

Threaded cogs are tightened by the rider's legs and consequently can be extremely secure. The result is that it can take the strength of two people or a large lever to break loose a cog. It is not unusual for the cog-removal tool to fail during removal of extremely difficult cogs. For this reason, it is important to never skimp on the quality of a cog-removal tool, and to always inspect it carefully before use. Furthermore, set the work up in anticipation of what might happen if something suddenly gave way.

Difficult lockring removal

Freehub-cog lockrings can be difficult to remove. Use of a proper tool and technique is critical. It is important to have the tool properly retained so that it does not slip out of place and it is necessary to resist the cogset rotation by using a cog-removal tool on the outermost cog. The larger inner cogs can easily warp if they are used to resist rotation during a difficult lockring removal.

Lockring will not engage after installing new cogset on freehub

If the lockring will not engage the freehub body after installing a new cogset, it usually means that the new cogset has more cogs than the freehub body is designed for.

Lockring secures, but new cogset remains loose on freehub body

Not all Shimano cogsets are compatible with all Shimano freehub bodies. In particular, installing a compact-drive cogset (usually with a 11 tooth cog) on a freehub body that was not originally designed for compact drive will result in this symptom.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into the following sections. First, ***FREEWHEEL REMOVAL, REPLACEMENT, AND INSTALLATION***. The next section is ***DIFFICULT FREEWHEEL REMOVAL***, which includes removing notched freewheels with stripped-out notches, and removing freewheels when there is no rim attached to the hub. This is followed by ***NON-LOCKRING FREEHUB-COG REMOVAL, REPLACEMENT AND INSTALLATION***. Next is the section ***LOCKRING-RETAINED COG REMOVAL, REPLACEMENT, AND INSTALLATION***. The next section is

FREEHUB-BODY REMOVAL, REPLACEMENT AND INSTALLATION. The next section is ***EIGHT- AND NINE-SPEED COMPATIBILITY***. The last section is ***FREEWHEEL AND FREEHUB TROUBLESHOOTING***.

FREEWHEEL REMOVAL, REPLACEMENT, AND INSTALLATION

REMOVAL

1. [] Use steps 1–16 of ***WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION (REMOVING A FRONT OR REAR WHEEL)*** to remove wheel (page 18-6).
2. [] Remove quick-release skewer or right-side axle nut from axle.
3. [] Mate freewheel remover to freewheel.
In the next step, use the quick-release skewer or axle nut to retain the remover against the freewheel-body face. Freewheel removal is a very high-force procedure and the potential for damaging the remover or the freewheel is high. *Stabilizing the remover minimizes any chance of damage, so do not skip this step, regardless of how many times this has been successfully attempted in the past!*
4. [] Install quick-release skewer or right-side axle nut and tighten to hold remover firmly against freewheel.
5. [] With wheel horizontal and freewheel-side down, put wrench flats of remover in vise and secure vise.
In the next step, a great force will be applied to the wheel to break loose the freewheel. *As soon as it breaks loose, stop turning the wheel and remove the skewer or axle nut.* The reason for this is that as the freewheel threads further off, the skewer or axle nut will be in the way. If the retaining device is left in place and the wheel is turned much past the break-free point, then the hub, the skewer, or the axle may be destroyed.
6. [] With hands positioned 180° apart, turn wheel counterclockwise *just until freewheel breaks loose*.
7. [] Remove wheel from vise and remove quick-release skewer or axle nut that is retaining freewheel remover.
8. [] Turn freewheel remover counterclockwise with fingers or wrench to thread freewheel off fully.

CLEANING AND LUBING

Skip to **REPLACEMENT** (page 25-10) if installing new freewheel, or skip to **INSTALLATION** (page 25-11) after performing other operations, or if freewheel is just being removed to enable hub or spoke work.

Some sources state that it is a bad idea to submerge a freewheel in solvent. This is the only practical way to clean the inside. The only reason not to submerge a freewheel in solvent is that if it is not dried thoroughly, the remaining solvent will break down the lubricants added.

Most Sachs freewheels have a special port for injecting solvent, compressed air, or lubricant into the inside of the body. This port is hidden underneath the cogs, which must be removed. With a Sachs freewheel, it is preferable to use this port than to use the techniques described in the following procedure for cleaning, drying, and lubing.

9. [] **Submerge freewheel in solvent and let it soak for as much time as is available.**
10. [] **With freewheel still submerged, rotate freewheel-mechanism inner body back and forth to agitate solvent and break loose dirt inside freewheel body, or use Stein FWG to force solvent through freewheel body.**
11. [] **Use Park GSC-1 to scrub outside of freewheel, cleaning cog teeth and inner and outer faces of freewheel body thoroughly.**

The ideal way to dry the inside of a freewheel is by blowing compressed air through it. This can do the job in minutes. For really fast cleaning and drying, install a Stein FWG on the back of the freewheel and force solvent and then air through the port in the tool. If a compressor is not available for freewheel drying, then patience is required. Out in the sun on a hot day, the inside of the freewheel might dry out in an hour or two. Left on a bench top with no direct sunlight, count on it taking at least overnight.

Contrary to popular opinion, the only lubricant needed inside a freewheel is oil. Grease can actually damage a freewheel, or inhibit its ability to function normally. Another popular mistake is to put too much oil in the freewheel. This causes oil to drip out, which leads to more problems with dirt on the freewheel and to a mucky mess on the spokes and perhaps the rim. Using an aerosol lubricant that does not have a rapid-evaporation base is a sure way to over-lube the freewheel. Test the aerosol by spraying a small amount on a surface and checking in 10 minutes to see if it has obviously dried. If so, it should be fine in the freewheel. If using a non-aerosol oil, drip in just 10–15 drops of oil on each face of the freewheel.

12. [] **Dry freewheel thoroughly, then squirt small amount of oil into crack between inner body and outer body, both on outer and inner face of freewheel body.**

REPLACEMENT

Skip to **INSTALLATION** (page 25-11) if installing the same freewheel that was removed.

Replacing a freewheel with a different one brings up all kinds of issues about compatibility. There are compatibility issues with the thread of the hub and the thread of the freewheel; with the width of the freewheel and the space on the hub for the freewheel to fit; with the size of the cogs and the capacity of the derailleur; with the spacing of the freewheel cogs and the adjustment of the rear derailleur; with the spacing of the freewheel cogs and the incrementation of an indexing shift system; and with the spacing of the freewheel cogs and the width of the chain.

Thread compatibility

Thread compatibility is important, but rarely an issue. Older French bikes had hubs with a 1mm thread pitch, and the only replacement freewheels available today are a 24tpi pitch. There are actually several thread descriptions that have a 24tpi pitch, but they are all acceptable to interchange, so only pitch need be considered in regard to thread compatibility. The procedure provides an opportunity to compare pitch of the old and new freewheel.

Freewheel width

If the new freewheel has a different number of cogs, or if changing from a narrow-spaced six-speed to a wide-spaced six-speed (or the reverse), then there will definitely be an issue of whether the freewheel width will fit with the existing space on the hub for the freewheel and whether the derailleur will need re-adjustment. If modifying the hub to fit the new freewheel, then the wheel needs to be re-dished and the frame needs to be re-spaced. Even when the new freewheel uses the same number of cogs, and does not change in spacing from narrow to wide (or vice versa), the spacing might be slightly different if the new and old freewheels are different brands or models. A derailleur adjustment may be required. The procedure provides an opportunity to detect whether the width of a new freewheel will require any of the above modifications. But if the modifications are required, refer to the appropriate chapters for the procedures for performing the modifications.

Freewheel size and derailleur capacity

Derailleurs are made to fit certain maximum cog sizes, and to take up a certain amount of slack chain, which is a function of the size differential between the smallest and largest freewheel cogs and the smallest and largest chainrings on the bike. This is most likely to be a problem if the bike is a road bike with narrow “racing” type gearing and the freewheel is being changed to get lower gear ratios, or if putting a freewheel with a 34-tooth cog on any bike. The procedure provides an opportunity to check for a problem with rear-derailleur capacity, but not until the new cogs have been installed and the wheel is back on the bike. The means to correct the problems that might occur with chain length and rear-derailleur capacity are covered in the **CHAINS** chapter and the **REAR DERAILLEUR** chapter (page numbers are provided when needed in the following procedure).

Index compatibility and chain-width compatibility

Problems with index-shifting compatibility are covered in the **REAR DERAILLEUR** chapter (page 32-5).

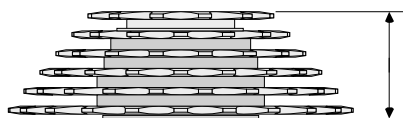
Problems with chain-width compatibility are covered in the **CHAINS** chapter (page 26-2 and 26-16).

13. [] With pitch gauge, measure pitch of old freewheel and new freewheel. If pitches match, freewheels are thread compatible.

If old and new freewheel are not identical model and number of cogs

NOTE: Skip to step 16 if new freewheel is same model and number of cogs as old freewheel.

14. Perform following calculation to determine width compatibility:
- [] Use caliper to measure width from inner face of inner cog to outer face of outer cog of old freewheel and record here: _____ mm.
 - [] Use caliper to measure width from inner face of inner cog to outer face of outer cog of new freewheel and record here: _____ mm.
 - [] Subtract first measurement from second measurement and record difference here: _____ mm.
- (Be sure to include negative sign if first measurement is larger than second.)



25.13 Measure freewheel width in this fashion.

15. Check one of following options to determine course of action, depending on type of width incompatibility:

- [] Difference in step 14 is between .5mm and –.5mm, freewheel is width-compatible and will require no hub re-spacing, wheel re-dishing, or frame re-spacing.
- [] Difference in step 14 is > .5mm, freewheel is not width-compatible and may require hub re-spacing, wheel re-dishing, frame re-spacing, and rear-derailleur adjustment.
- [] Difference in step 14 is a negative value below –.5mm, rear-derailleur adjustment is required.

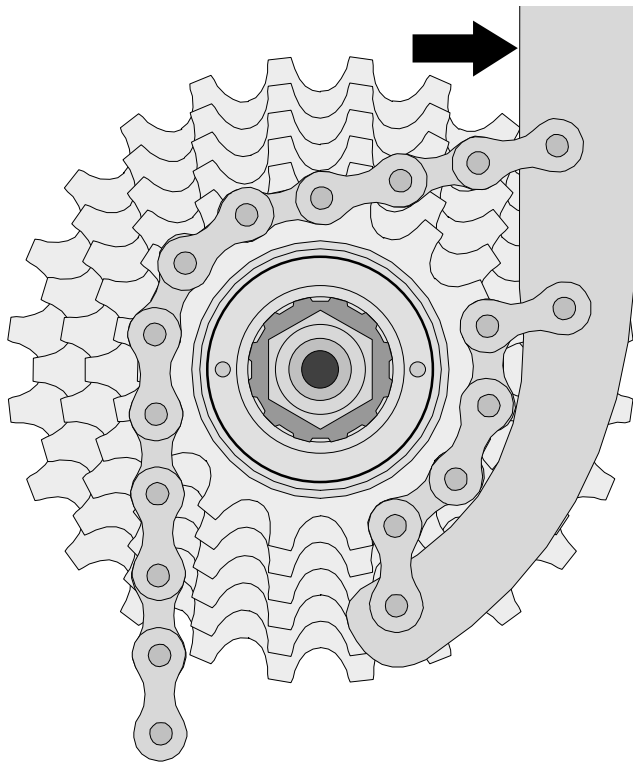
INSTALLATION

16. [] Thoroughly grease threads inside freewheel body.

It is easy to carelessly cross-thread a freewheel onto the hub. Once started wrong, it is very difficult to re-start correctly. In the following step, you install the freewheel while the wheel is horizontal and with the axle visibly centered in the hole in the freewheel to help prevent this. It is also important to use fingers and not a tool to thread on the freewheel, so that if the freewheel does begin to thread in crossed-up, the damage will be minimized.

17. [] With wheel horizontal and right end of axle facing up, drop freewheel onto hub, center axle in freewheel hole, and use *fingers only* to thread freewheel onto hub.

Once the freewheel is hand-threaded on, it does need to be tightened with a tool, particularly if a derailleur adjustment is to be performed. In the next step, secure the freewheel so that it is ready for derailleur adjustment and also makes sure that the outermost cog is secure — a common need with new freewheels. There is likely to be some confusion the first time you use a cog-removal tool on a cog. There are usually two pieces of chain and both must engage the cog. One section of chain is short and fixed at both ends to the tool. Engage this to the cog first. The other section of chain is long and is attached to the tool at one end only. This piece wraps around the cog in the opposite direction than the cog and freewheel will be turning. See figure 25.14, page 25-12.



25.14 Place cog-removal tool on outermost sprocket as shown, to simultaneously tighten outermost cog and freewheel.

18. [] Use cog remover on outermost cog to simultaneously secure outermost cog to free-wheel and freewheel to hub.

WHEEL INSTALLATION AND POST-INSPECTION

19. [] Use steps 9–20 of **WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION (INSTALLING THE WHEEL)** to install wheel (page 18-17).

The next step is needed only if the size of the outermost and/or innermost cogs has changed. These changes can affect chain length and derailleur capacity. The tests for chain length and derailleur capacity are given here without detailed explanation. If unfamiliar with these items, see **CHAINS** (page 26-6) and **REAR DERAILLEURS** (page 32-6).

20. *If replacement freewheel with different number of teeth on largest or smallest cog has been installed:*

[] Shift chain to outermost chainring and then shift chain to outermost freewheel cog to check and correct chain length. (See **CHAINS**, page 26-6.)

[] Shift chain to innermost chainring. Check whether chain hangs slack between top of freewheel and top chainrings, or whether chain touches itself or derailleur an extra time between lower jockey wheel and bottom of chainrings. Either condition indicates maximum-total-capacity of rear derailleur has been exceeded. (See **REAR DERAILLEURS**, page 32-7.)

[] Shift chain to innermost chainring (if not already). Shift rear derailleur to put chain on, and then off of, innermost freewheel cog and observe whether chain jams trying to go on or off innermost freewheel cog. If chain jams either way, rear-derailleur maximum-free-wheel-capacity has been exceeded. (See **REAR DERAILLEURS**, page 32-6.)

DIFFICULT FREEWHEEL REMOVAL

Freewheels can be difficult to remove because the freewheel fails, the tool fails, or the rim is no longer attached to the hub. This section is actually three separate procedures appropriate for each of these conditions.

Notches stripped-out where pronged freewheel-remover fits

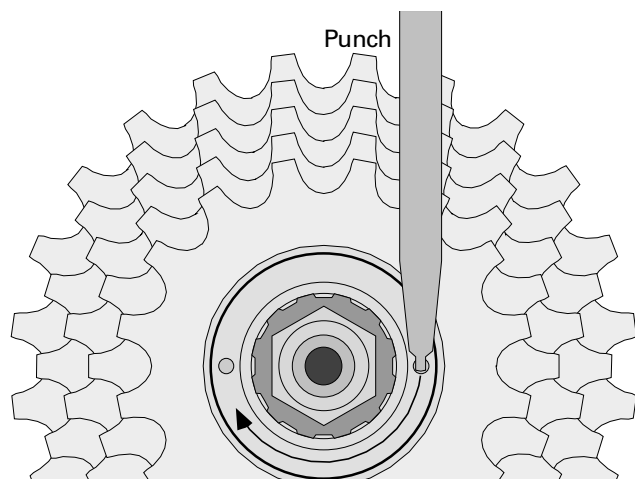
If the wrong remover has been used or the remover was not properly retained with the skewer or axle nuts, the notches in the innermost ring of the face of the freewheel can strip. First, try the correct tool properly retained to see if that will work. If further stripping occurs, the freewheel must be removed and replaced. To do this, the following procedure suggests disassembling the freewheel so that the inner body can be grasped directly in the vise to hold it while threading the hub out of the freewheel inner body.

1. [] **Remove freewheel remover if still in place.**

Most freewheels have a cone that is the flat ring just out from the innermost ring of the freewheel-body face (the one that has the removal notches). This cone typically has two small round holes in it for the engagement of a pin spanner. Although such pin spanners are made, they are rarely sturdy enough to remove a tight cone. A punch with a small pointed tip that will fit in one of the holes is the recommended tool. The cone is always a left-hand thread, so it must be turned clockwise to loosen it. Once the cone is off, there will be all sorts of tiny ball bearings and small pieces of metal called pawls that can be seen. Once

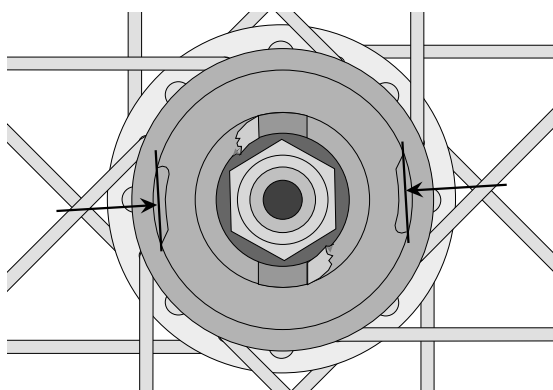
25 – FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS

the freewheel has been pulled apart, these little things are going to go all over the place, but don't worry about it because a new freewheel will be installed.



25.15 Removing the freewheel cone.

2. [] Use punch to drive cone clockwise to loosen it, then unthread completely.
3. [] Lift cogset and outer body of freewheel body off of inner body.
4. [] Remove pawls from inner body.
5. [] With wheel horizontal and freewheel on bottom side, grasp inner body of freewheel in vise jaws. Use recesses where pawls were removed to get best grip.



25.16 Grasp remaining piece of freewheel body (at points indicated) in vise, then turn wheel counterclockwise to unthread freewheel.

6. [] Turn wheel counterclockwise with both hands to break loose and unthread hub from freewheel inner-body.
7. [] Replace freewheel.

Thin-wall-splined remover blows-up without breaking loose freewheel

Freewheels that require a thin-wall-splined remover can be a problem if the remover fails before the freewheel breaks loose. *Make sure the remover is*

fully engaged to prevent this from ever happening! Once it has happened with the remover properly engaged, then more drastic measures need to be taken. Heavy-duty removers with thick walls are made that never fail, but they require removal of the axle set to be used, and that is a time-consuming inconvenience.

Some cartridge-bearing hubs with flanges on the axle require freewheel removal before the axle can be removed. Unfortunately, the only solution is to sacrifice the freewheel. In this case, just treat the freewheel as though it were one with damaged notches and disassemble the freewheel to remove it.

1. [] ***If hub has cartridge-bearing axle that requires freewheel removal before axle can be removed, the freewheel will have to be destroyed. Use procedure under Notches stripped out where pronged freewheel remover fits (page 25-12).***
2. [] ***If hub is adjustable-cone type, use steps 17–20 from ADJUSTABLE-CONE-HUB OVERHAUL & ADJUSTMENT PROCEDURE to remove axle from hub (page 12-9).***
3. [] Use Bicycle Research CT2 (20.4mm diameter, 20-spline hole) or Bicycle Research CT6MB (21.9mm diameter, 12-spline hole) to remove freewheel in normal way, except without using quick-release skewer or axle nut to retain remover.
4. [] ***If hub is adjustable-cone type, use steps 55–83 from ADJUSTABLE-CONE-HUB OVERHAUL & ADJUSTMENT PROCEDURE (page 12-13) to install axle and adjust bearings.***
5. [] ***If hub is cartridge-bearing type, use appropriate procedure for specific brand of hub from Chapter 13 to re-install axle.***

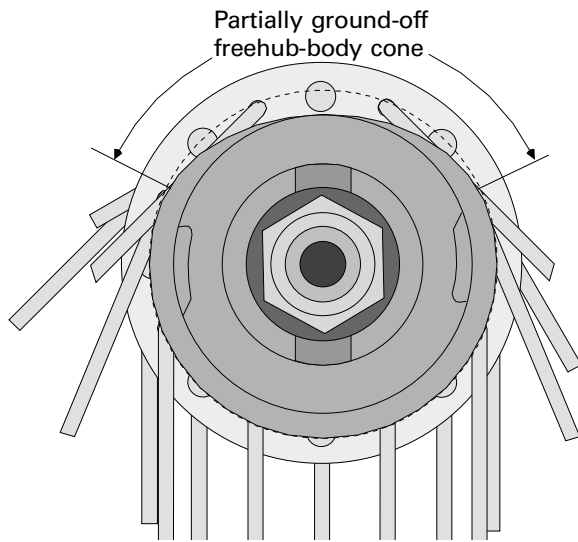
Rim has been detached from hub before freewheel has been broken loose

One of the worst bonehead mistakes a mechanic (or customer) can make is to cut the spokes or unlace a wheel before removing the freewheel from the hub. The leverage of the rim is required for freewheel removal. If the wheel is unlaced but the spokes have not been cut, it is worth the trouble to rebuild the wheel with the old spokes and rim and then remove the freewheel, because the only alternatives require sacrificing either the hub or the freewheel.

If the spokes are cut, decide whether to sacrifice the hub or freewheel, then pick the appropriate step. If the hub has large-diameter flanges, there is one alternative not shown in steps #1–#3; remove the cogs from the freewheel body, relace the hub and new rim together with new spokes, then remove the freewheel if necessary.

25 – FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS

1. *If spokes are still in hub and not cut:*
 - ☐ Rebuild wheel.
 - ☐ Remove freewheel normally.
2. *If saving hub and sacrificing freewheel:*
 - ☐ Use steps 1–4 under *Notches stripped out where pronged freewheel remover fits* to disassemble freewheel (page 25-12).
 - ☐ Use grinder to grind conical flange off of inner body of freewheel to expose spoke holes in hub flange.
 - ☐ Rebuild wheel.
 - ☐ Use steps 5–7 under *Notches stripped out where pronged freewheel remover fits* to complete freewheel removal (page 25-12).



25.17 Grind the inner body cone off as shown.

In the next step, the hub is held in the vise while the freewheel is removed. It does no harm to initially grasp the hub flanges as hard as possible without crushing them, and then attempting the removal. If the freewheel removes and the hub flanges are fine, then both are reusable. If the hub slips and it must be clamped tighter, then nothing has been lost by trying removal without destroying the hub first.

3. *If saving freewheel and sacrificing hub:*
 - ☐ Attach freewheel remover to freewheel and retain remover with quick-release skewer or axle nut.
 - ☐ Grasp hub shell firmly in vise, crushing flanges if necessary.
 - ☐ Use large adjustable wrench to turn remover counterclockwise to remove freewheel from hub.

NON-LOCKRING COG REMOVAL, REPLACEMENT, AND INSTALLATION

Cog removal for freewheels and non-lockring freehubs is similar, because in both cases some cogs slip onto the freewheel/freehub-body with a spline configuration, and these are retained by outer position cog(s) that thread onto the freewheel/freehub-body. Shimano Hyperglide freehubs and several others are different because all the cogs fit with a splined configuration and there is a lockring that threads into the freehub body to retain the cogs.

Depending on the specific model of freewheel/freehub, there may be from one to four cogs that thread on and the remainder will be splined. If the cogs are very dirty, it can be hard to see whether the one about to be removed is threaded or splined. After removing the first threaded cog, always assume that the next one is splined and attempt to remove it by pulling out on it. If it will not pull off, then it is a threaded cog.

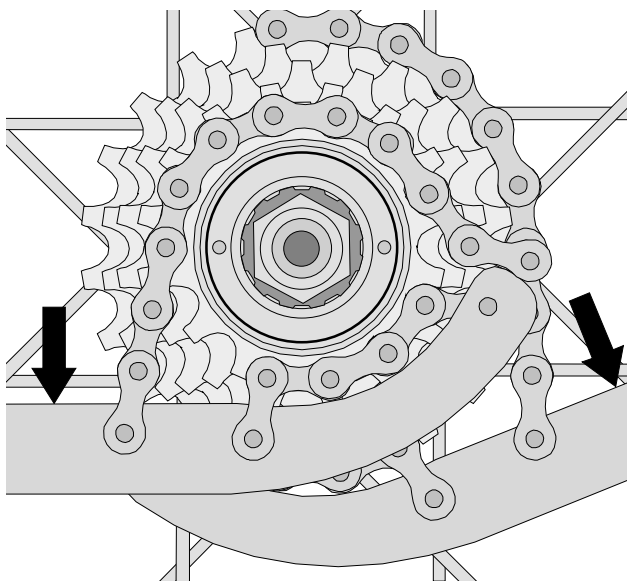
It is very important to maintain the orientation of the cog at all times while it is off. Most cogs can be installed facing either way, but only one way is correct. The differences may be very subtle and are not consistent enough from one brand to the next to be worth mentioning here.

Cogs from one freewheel brand or model are almost never interchangeable with another. It is even rare that cogs in one position on a freewheel are interchangeable with cogs in another position on the same freewheel. This means that if changing gear selection, a new cog generally must be installed in every position where changing the number of teeth. Some spacers are made to work specially with one size of cog. For example, if removing a 15-tooth cog in the second position and replacing it with a 14 tooth, it is likely that the spacer outward of the second position will also need to be changed. To help with all these problems, manufacturers generally make “maps” of their freewheels. Do not attempt customizing freewheels without a map or guide.

COG REMOVAL

1. ☐ Use steps 1–16 of *WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION* procedure (REMOVING A FRONT OR REAR WHEEL) to remove wheel (page 18-6).
2. ☐ Put wheel on floor and lean wheel against legs with freewheel facing out.

3. [] Put one cog-removal tool on next-to-innermost freewheel cog with long free piece of chain wrapped counterclockwise around cog and short fixed piece of chain pinched between tool handle and cog.



25.18 The correct setup for using the two cog-removal tools to break loose the outermost cog.

4. [] Rotate wheel as necessary to position cog-removal tool so that it is parallel to floor and on left side.
5. [] Put second cog-removal tool on outermost cog so that handle ends up parallel to floor, with long free piece of chain wrapped clockwise around cog and short fixed piece of chain pinched between tool handle and cog.

Cogs can be very difficult to break free. In the next step it is sometimes necessary to have a partner, each one pressing with two hands on one tool.

6. [] Press down firmly on both cog-removal tools simultaneously to break loose outermost cog, then thread outermost cog off.

Remember: as cogs come off, it is very important to keep track of where spacers came from, which way the cogs faced, and the order of the cogs. As cogs are removed, check for spacers stuck to the backside of the cog just removed and to the front side of the next cog to be removed.

7. [] Place cog on surface with outer-face facing up.
8. [] Check for spacer on face of remaining outermost cog and remove spacer (if any). Put spacer on surface so that its outer surface is facing up.

9. [] With fingers, pull outward on remaining outermost cog to check whether it is a slip-on cog or a thread-on cog. If cog slips off, check if next cog is also a slip-on type. Check for spacers between each cog pair. Put all cogs and spacers on surface in order, with outer face of each facing up.
10. [] Repeats steps 5–9 for each remaining thread-on type cog, if any.

COG REPLACEMENT

11. [] Substitute each cog to be replaced in layout with its replacement cog, being sure to put replacement cog in same position and with same side facing up.
12. [] Substitute each spacer to be replaced in layout with its replacement spacer, being sure to put replacement spacer in same position and with same side facing up.

COG INSTALLATION

13. [] One at a time and in order, starting with the largest cog, put all slip-on cogs and spacers onto freewheel body, making sure upper face ends up facing out in each case.
14. [] Lubricate threads on thread-on cogs.
15. [] Install, in order, remaining spacers and thread-on cogs, making sure upper faces end up facing out.
16. [] Put wheel on floor and lean wheel against legs with freewheel facing out.

Although thread-on cogs are self-tightening when the bike is ridden, if they are not deliberately tightened in the correct order, there can be problems the first time the bike is ridden after cog installation. *For this reason, secure each cog as best as possible as it is installed!*

17. [] Put one cog-removal tool on innermost thread-on cog with long free piece of chain wrapped counterclockwise around cog and short fixed piece of chain pinched between tool handle and cog, then rotate tool clockwise to secure cog as best as possible. Moving out one at a time, secure each additional thread-on cog in a similar fashion.
18. [] Use steps 9–20 of **WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION** procedure (INSTALLING THE WHEEL) to install wheel (page 18-17).

The next step is needed only if the size of the outermost and/or innermost cogs has changed. These changes can affect chain length and derailleur capacity. The tests for chain length and derailleur capacity are given here without detailed explanation. If unfamiliar with these items, see **CHAINS** (page 26-6) and **REAR DERAILLEURS** (page 32-5).

25 – FREEHUB MECHANISMS AND THREAD-ON FREEWHEELS

19. If replacement cogs of different sizes have been installed in the innermost or outermost position:

- [] Shift chain to outermost chainring and then shift chain to outermost freewheel cog to check and correct chain length. (See CHAINS, page 26-6.)
- [] Shift chain to innermost chainring. Check whether chain hangs slack between top of freewheel and top chainrings, or whether chain touches itself or derailleur an extra time between lower jockey wheel and bottom of chainrings. Either condition indicates maximum-total-capacity of rear derailleur has been exceeded. (See REAR DERAILLEURS, page 32-7.)
- [] Shift chain to innermost chainring (if not already). Shift rear derailleur to put chain on, and then off of, innermost freewheel cog and observe whether chain jams trying to go on or off innermost freewheel cog. If chain jams either way, rear-derailleur maximum-free-wheel-capacity has been exceeded. (See REAR DERAILLEURS, page 32-6.)

LOCKRING-RETAINED COG REMOVAL, REPLACEMENT, AND INSTALLATION

Shimano Hyperglide cogs (and other similar ones) have a special configuration to facilitate shifting under load. For this configuration to work, the cogs need to be synchronized with each other. For this reason, Shimano designed these cogs so that there is only one way that they can fit on the freehub body. This is done by means of making one spline fatter than the others and not centering it between the adjacent splines. This configuration makes cog installation simpler.

The complication comes if trying to replace individual cogs in a Hyperglide set. A 17-tooth cog marked S-17 is not compatible with a 17-tooth cog marked T-17. Only if all the cogs in the set have the same letter code is there assurance of compatibility. There are cases when letters can be mixed, but data on these are skimpy and subject to rapid change.

1. [] Use steps 1–15 of **WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION** procedure (REMOVING A FRONT OR REAR WHEEL) to remove wheel (page 18-6).

The Hyperglide tool closely resembles the most popular splined-freewheel remover, *but they are not interchangeable!* Make sure that if using a tool other

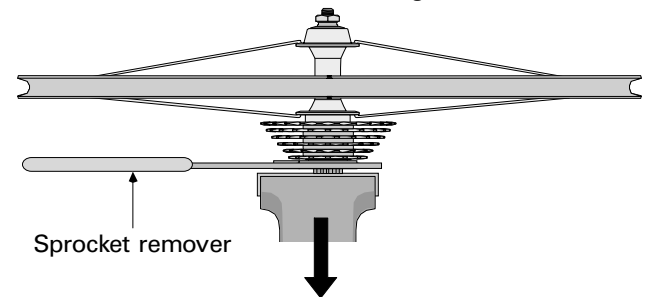
than the recommended Park FR-5 that it is Hyperglide compatible. If the diameter of the splines on the tool is at least 23.5mm, then the tool is appropriate.

2. [] Remove skewer and install Park FR-5 (or other Hyperglide-lockring tool) into splines of cog-retaining ring.

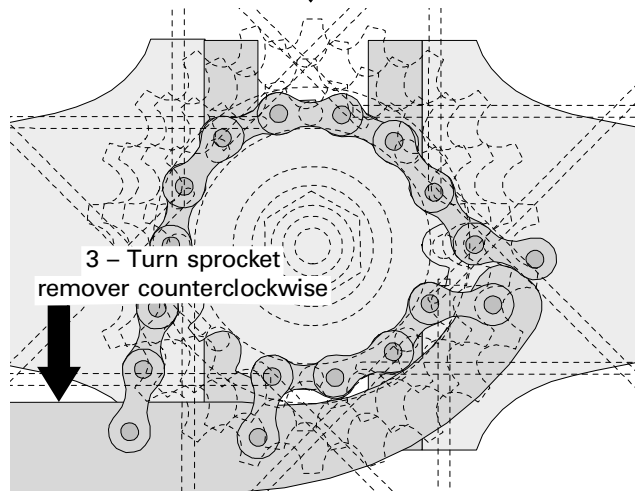
Even with a properly fit tool, engagement is poor for the forces involved. Be sure that the tool is fully engaged and firmly secured with the quick-release skewer.

3. [] Install skewer and thread adjusting nut until tight to secure FR-5 in place.
4. [] With wheel horizontal and cog-side down, grasp wrench flats of FR-5 in vise jaws.
5. [] Put cog-removal tool on next-to-outermost cog with long free piece of chain wrapped clockwise (viewed from above) around cog and short fixed piece of chain pinched between tool handle and cog.

1 – Place locking remover in vise, then wheel on locking remover



Sprocket remover



3 – Turn sprocket remover counterclockwise

2 – Place sprocket remover on lowermost cog in this fashion

25.19 This is a side-view and top-view of the proper setup for breaking loose a cog-retaining lockring. The top-view (at bottom) portrays the hub, cogs, and spokes in a see-through fashion with dashed lines so that you can see the proper orientation of the cog-removal tool.

The retaining ring's back face is deeply serrated and the face of what it tightens against is also deeply serrated. It will make a loud snapping or crackling sound when it is being broken loose. This is alarming but normal.

6. [] **Apply force to cog-removal tool in counter-clockwise direction (viewed from above) to break loose cog and continue rotating tool just until clicking noise stops.**
7. [] **Remove wheel from vise and remove skewer from wheel.**
8. [] **Facing cogset, turn FR-5 counterclockwise to remove ring completely.**
9. [] **Slip off cogs and spacers, placing them in order on surface with all outer-faces facing up.**

Some Hyperglide cogs come off one at a time, and others remove and install as a group held together by three bolts or rivets. The only reason they are grouped is to make factory installation quicker and easier. If not replacing individual cogs, there is no reason to separate the group. If replacing individual cogs, then separate the group but do not worry about reinstalling the bolts or rivets. To get the rivets out, grind or file off the head of each rivet and drive it out with a punch or nail.

10. [] **If replacing individual cogs and cogs came off as a cassette, unthread bolts from back of cogset to separate cogs and place them in order on surface with all outer-faces facing up.**

COG REPLACEMENT

11. [] **Substitute each cog to be replaced in layout with its replacement cog, being sure to put replacement cog in same position and with same side facing up.**
12. [] **Substitute each spacer to be replaced in layout with its replacement spacer, being sure to put replacement spacer in same position and with same side facing up.**

COG INSTALLATION

All the cogs have a fat, off-center spline that engages a fat, off-center groove in the freehub body so if a cog is rotated or facing the wrong way it will simply not go on. Stay out of trouble with spacers by making sure the three holes or notches in each spacer line up with the comparable holes or notches in each cog. If the spacers have tabs sticking out from one face, make sure that the tabs all face outward.

13. [] **Find fat spline on each cog and orient cog so fat spline is at 12:00. Find fat groove on freehub body and orient so fat groove is a 12:00.**

14. [] **One at a time and in order, starting with the largest cog, put all slip-on cogs and spacers in order onto freehub body, making sure fat splines go into fat groove.**

15. [] **Lubricate threads on retaining ring and thread into freehub body.**

16. [] **Put wheel on floor and lean wheel against legs with freewheel facing out.**

17. [] **Install FR-5 into retaining ring and install skewer to retain FR-5.**

In the next step, tighten the retaining ring. When it was removed, the FR-5 was held in the vise. The same thing could be done for installation but the potential to over-tighten the retaining ring is great. For this reason, in the next step, use a wrench with 8" of leverage (unless using a torque wrench) to minimize the potential of over-tightening.

18. [] **With large adjustable wrench or end of Park SR-1 tool on FR-5, tighten retaining ring to a torque of 265in-lbs (33lbs@8").**

19. [] **Remove skewer and FR-5, then reinstall skewer.**

20. [] **Use steps 9–20 of *WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION* procedure (INSTALLING THE WHEEL) to install wheel (page 18-17).**

The next step is needed only if the size of the outermost and/or innermost cogs has changed. These changes can affect chain length and derailleur capacity. The tests for chain length and derailleur capacity are given here without detailed explanation. If unfamiliar with these items, see **CHAINS** (page 26-6) and **REAR DERAILLEURS** (page 32-6).

21. **If replacement cogs of different sizes have been installed in the innermost or outermost position:**

[] Shift chain to outermost chainring and then shift chain to outermost freewheel cog to check and correct chain length. (See **CHAINS**, page 26-6.)

[] Shift chain to innermost chainring. Check whether chain hangs slack between top of freewheel and top chainrings, or whether chain touches itself or derailleur an extra time between lower jockey wheel and bottom of chainrings. Either condition indicates maximum-total-capacity of rear derailleur has been exceeded. (See **REAR DERAILLEURS**, page 32-7.)

[] Shift chain to innermost chainring (if not already). Shift rear derailleur to put chain on, and then off of, innermost freewheel cog and observe whether chain jams trying to go on or off innermost freewheel cog. If chain jams either way, rear-derailleur maximum-freewheel-capacity has been exceeded. (See **REAR DERAILLEURS**, page 32-6.)

FREEHUB-BODY REMOVAL, REPLACEMENT, AND INSTALLATION

The only time it is necessary to remove a freehub body is when replacing it. It is easier to clean the hub when doing a hub overhaul and easier to clean the freehub body when the freehub body is removed, but it is not necessary to remove the freehub body for these purposes.

1. [] Use steps 1–15 of **WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION** procedure (REMOVING A FRONT OR REAR WHEEL) to remove wheel (page 18-6).
2. [] Use steps 17–20 from **ADJUSTABLE-CONE-HUB OVERHAUL & ADJUSTMENT PROCEDURE** to remove axle from hub (page 12-9).

These instructions cover only the specific brands and models of freehubs indicated. Other brands exist, but are far less common. The methods to remove freehub bodies from other brands may be completely different, especially if the other brand has cartridge bearings. This section specifically does not cover Ringle, Hugi, Hope, or Mavic freehubs.

FREEHUB-BODY REMOVAL

3. [] If freehub is Shimano, non-Dura-Ace, 1985 or later, insert 10mm Allen wrench into freehub body and rotate counterclockwise to release freehub. A hollow bolt will come out and freehub body will slip off.
4. [] If freehub is Shimano Dura-Ace (any year, but excluding AX model), insert TL-FH10 into freehub body and rotate counterclockwise to release freehub.
5. [] If freehub is SunTour brand, insert 10mm Allen wrench through left side of hub shell and turn wrench counterclockwise to unthread retaining bolt. Freehub body will slip off right side.
6. [] If freehub is Shimano, non Dura-Ace, pre-1985 (or Dura-Ace AX), remove cogs from freehub body, thread TL-FH30 onto freehub body, and tighten shaft of TL-FH30 to pull freehub body off of hub shell.

FREEHUB-BODY CLEANING AND OILING

Skip to **FREEHUB BODY INSTALLATION** (page 25-18) if installing a new freehub body.

There is often a rubber seal in the back face of Shimano freehub bodies. It can be hard to see. It needs to be removed so that solvent, air, and oil can get into the freehub body. Once found, it can be pried out with a pin or needle. Be sure to get it back in before installing the freehub body on the hub shell.

7. [] Remove any rubber seal ring from back face of freehub body and submerge freehub body in solvent and let it soak for as much time as is available.
8. [] With freehub body still submerged, rotate freehub-body-mechanism inner body back and forth to agitate solvent and break loose dirt inside freehub body, or use Morningstar Freehub Buddy to inject solvent through body.
9. [] Use Park GSC-1 to scrub outside of freehub body, cleaning cog teeth (if still installed) and inner and outer faces of freehub body thoroughly.
10. [] Dry freehub body thoroughly, then squirt small amount of oil into crack between inner body and outer body, both on outer and inner face of freehub body. Replace rubber seal ring, if any.

FREEHUB-BODY INSTALLATION

When a separate bolt is used to hold a freehub body in place, unlike a regular freewheel, riding the bike will not tighten the body to the hub shell. For this reason, if the freehub body is held on by a separate bolt it is very important to tighten the bolt adequately. Loose bolts will loosen further, causing the cogs to wobble and ultimately leading to the rear wheel locking up.

11. If freehub is Shimano, non-Dura-Ace, 1985 or later:
 - [] Slip freehub body onto hub-shell splines.
 - [] Lubricate hollow-bolt threads and thread through freehub body and into hub shell.
 - [] Use 10mm Allen wrench to tighten bolt to 310in-lbs (52lbs@6").
12. If freehub is Shimano Dura-Ace (any year, but excluding AX model);
 - [] Thread freehub body into hub shell.
 - [] Use TL-FH10 to snug freehub body, pedaling torque will tighten freehub body fully.
13. If freehub is SunTour brand:
 - [] Slip freehub body onto hub-shell splines.
 - [] Lubricate hollow-bolt threads and thread through hub shell and into freehub body.
 - [] Use 10mm Allen wrench to tighten bolt to 310in-lbs (52lbs@6").

14. [] *If freehub is Shimano, non-Dura-Ace pre-1985 (or Dura-Ace AX);*
 [] Slip freehub body onto hub shell.
 [] Slip axle through hub and freehub body.
 [] Put installation washers from TL-FH30 onto ends of axle.
 [] Thread nuts or cones onto axle and tighten towards each other until freehub body is pressed fully on.
 [] Remove nuts, washers, and axle.

HUB ASSEMBLY AND WHEEL INSTALLATION

15. [] Use steps 55–82 from **ADJUSTABLE-CONE-HUB OVERHAUL & ADJUSTMENT PROCEDURE** to install axle and adjust bearings (page 12-13).
16. [] Use steps 9–20 of **WHEEL REMOVAL, REPLACEMENT, AND RE-INSTALLATION** procedure (**INSTALLING THE WHEEL**) to install wheel (page 18-17).
17. *If replacement cogs of different sizes have been installed in the innermost or outermost position:*
 [] Shift chain to outermost chainring and then shift chain to outermost freewheel cog to check and correct chain length. (See **CHAINS**, page 26-6.)
 [] Shift chain to innermost chainring. Check whether chain hangs slack between top of freewheel and top chainrings, or whether chain touches itself or derailleur an extra time between lower jockey wheel and bottom of chainrings. Either condition indicates maximum-total-capacity of rear derailleur has been exceeded. (See **REAR DERAILLEURS**, page 32-7.)
 [] Shift chain to innermost chainring (if not already). Shift rear derailleur to put chain on, and then off of, innermost freewheel cog and observe whether chain jams trying to go on or off innermost freewheel cog. If chain jams either way, rear-derailleur maximum-freewheel-capacity has been exceeded. (See **REAR DERAILLEURS**, page 32-6.)

EIGHT- AND NINE-SPEED COMPATIBILITY

Shimano has introduced nine-speed cogsets that fit on the same freehub body that fits eight-speed cogsets. No modifications of the hub or axle spacing are necessary to make this conversion.

Because the nine-speed cogset has less space between the cogs than the eight-speed cogset, it is necessary to change the chain to a nine-speed compatible model when making this conversion.

Although there are nine-speed specific derailleur models for MTBs, it is not always necessary to change the derailleur. The reason for this is that at the same time that Shimano introduced the nine-speed configuration for MTBs, the company also increased the maximum cog size to 34 teeth (from the traditional 32 teeth). If the nine-speed cogset being installed has a largest cog size of 32 teeth or less, then there is no need for a derailleur change.

Of course, any time the number of cogs is changed, it is necessary to replace the shift-control mechanism with one designed for the matching number of gears.

In the unlikely case that a nine-speed configured bike were being converted to eight-speeds, then the only change other than the cogs would be the shift-control mechanism. The nine-speed chain is compatible with eight-speed cogsets, and a nine-speed rear derailleur would be compatible, as well.

FREEWHEEL AND FREEHUB TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Chain slips or skips on a cog when pedaling hard.</i>	
Fresh chain not meshing with worn cog.	Replace cog or cogs.
Pawls are not catching on internal ratchet ring because they are dirty, rusty, worn, or broken.	Clean and oil freewheel/freehub-body and replace if symptom persists.
SYMPTOM: <i>Freewheeling occurs while pedaling, constantly or intermittently.</i>	
Pawls are not catching on internal ratchet ring because they are dirty, rusty, worn, or broken.	Clean and oil freewheel/freehub-body and replace if symptom persists.
SYMPTOM: <i>While coasting, the cogs continue to turn with the wheel, pushing the chain.</i>	
Pawls are not riding over teeth of internal ratchet ring because they are dirty, rusty, fouled with grease, worn, or broken.	Clean and oil freewheel/freehub-body and replace if symptom persists.
SYMPTOM: <i>A steady light clunking sound comes from the freewheel in some gears more than others and at some pedaling speeds but not others.</i>	
Freewheel-bearing adjustment is loose because cone has come loose.	Turn cone ring on face of freewheel counterclockwise to secure it.
Freewheel-bearing adjustment too loose because bearing parts are worn.	Check for loose cone. If tight, replace freewheel.
SYMPTOM: <i>The cogs appear to wobble side-to-side while coasting.</i>	
Normal occurrence due to lack of precision in bearings.	Ignore it.
SYMPTOM: <i>The cogs appear to wobble side-to-side while pedaling and the derailleur cannot be adjusted to eliminate cyclic rubbing of the chain against adjacent cog(s).</i>	
Spoke guard has oversize hole and is off-center.	See if wobble goes away when spoke guard removed, and if it does replace spoke guard.
Freewheel is cross-threaded onto hub.	Remove freewheel and check threads on hub. Hub will probably need to be replaced.
If spoke guard and cross-threading are not the cause, hub-threading or freewheel-threading are defective.	Try substitute freewheel to determine whether hub or freewheel threads are bad and try to get warranty satisfaction for bad part.
SYMPTOM: <i>Cog teeth are broken.</i>	
Teeth are extremely worn and are being ripped off by chain when pedaling load is high.	Check cogs for wear and replace cogs or freewheel.
Extreme abusive shifting under load, or impact to teeth.	Avoid abusive behavior.
SYMPTOM: <i>Cog teeth appear to be bent or not in line with each other.</i>	
Normal condition for Hyperglide/IG teeth.	Ignore.
Teeth bent from impact.	Avoid abusive behavior.
SYMPTOM: <i>No matter how the rear derailleur is positioned, the chain seems to rub against the adjacent cog(s).</i>	
If happening on most cogs, particularly if after replacing chain or freewheel, wide chain is being used with narrow-spaced freewheel.	Use appropriate chain.
If happening on one cog only, particularly if cogs were removed and installed, improper spacer between cogs.	Check and replace spacers.
If happening in outer positions only, chainline is poor.	See CHAINLINE chapter to identify error (page 27-6) and correct chainline error (page 27-7).

26 – CHAINS

ABOUT THIS CHAPTER

This chapter is about removing, replacing, installing, cleaning, and lubricating chains. Bikes without derailleurs typically have chains with master links. Master links are covered in a separate section, as well as information about sizing and tensioning chains on non-derailleur bicycles.

GENERAL INFORMATION

TERMINOLOGY

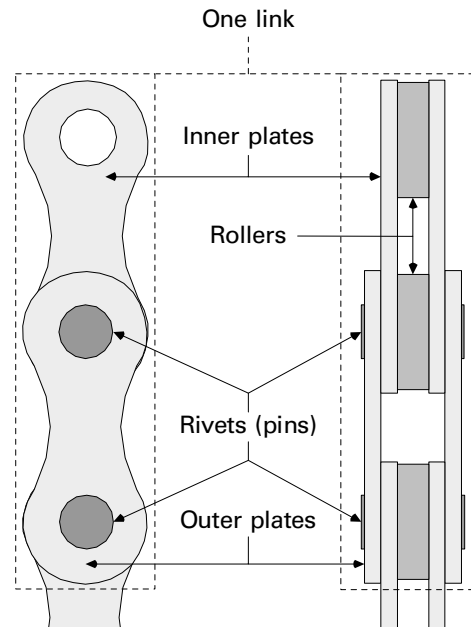
Side-plates: The usually dog-bone-shaped plates that are seen when looking at the chain from the side. Side-plates come in two versions on every chain: inner side-plates and outer side-plates. The outer side-plates are the ones that are seen in their entirety when viewing the chain from the side. The inner side-plates are the ones hidden partially by the outer side-plates.

Rollers: The metal cylinders that are between the inner side-plates.

Bushings: Not all chains have bushings. Bushings are metal cylinders that are inside the rollers and cannot be seen when the chain is assembled. Normally there is no need to be concerned with whether a chain has bushings or not.

Rivets: The round metal rods that protrude just beyond the face of the outer side-plates. Each roller goes through an outer side-plate, an inner side-plate, the roller, another inner side-plate, and another outer side-plate. The rivets are what hold the chain together. They work by friction and are jammed into undersized holes in each outer side-plate, but slip easily through the inner side-plates and the roller.

Link: The smallest complete section of chain. It consists of two outer side-plates, two inner side-plates, two rollers, and two rivets. If a unit with only two inner side-plates was removed or added (one roller and one rivet), then the chain would be left with both ends ending in outer side-plates, which cannot be joined together. A full link, including four side-plates, has an effective length of one inch, measured from the center of the rivet at one end to the center of the rivet hole at the other end.



26.1 These are the parts of the chain.

Half-link: A section of chain including only two side-plates.

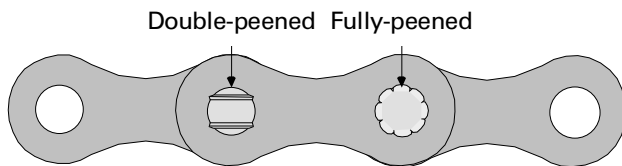
Narrow chain: Chains for derailleur bicycles have been made in several widths. The widest part of the chain is the rivet, so the chain width is a measurement of the rivet length. A narrow chain's rivet length cannot exceed 7.4mm. All modern chains have a narrow configuration, and narrow chains are compatible with all derailleur bicycles, even those made when the only chains that existed were wide chains.

Wide chain: The original chains for derailleur bicycles had a width (measured by measuring the length of the rivet) of 7.6mm or more. These are sometimes called *normal* because they existed first, but they have become extremely rare, so in this book the designation *wide* is used. Wide chains are only compatible with bikes that have wide spacing between the rear cogs and between the chainrings. It is not important what this spacing is because virtually all replacement chains today have a narrow configuration. Narrow chains are compatible with freewheels and chainrings that were made for wide chains.

Peened: When a rivet is installed at the factory, the ends of it are deformed so that they become fatter and will not pass through the hole in the outer side-plate as

26 – CHAINS

easily. Sometimes this deformation is created by striking the pin at two points with a chisel-like tool. This is called *double-peened*. When a rivet is double-peened, the end of it will have two parallel grooves in it. A rivet can also be *fully-peened*. A fully-peened rivet has been deformed all the way around its perimeter. This may be visually apparent if it has been done in a crude fashion, but it may not be obvious. If a rivet does not appear to be double-peened, then assume it is fully-peened.



26.2 The left rivet is the end of a double-peened rivet. The right one is fully-peened.

Chain stretch: As chains are used, they become longer. This is often called *stretch*, which is a misnomer because nothing actually stretches. The reason that chains become longer is that wear occurs between the rollers and the bushing, or rivet inside the roller. This wear creates slop or free play between the various parts of the chain, which makes the chain longer. More important than the change in length is the fact that the distance from roller-to-roller increases minutely from the original half inch, which means that the chain will not mesh well with the gear teeth, which are spaced at half-inch intervals. As a consequence of this wear, the chain also develops more lateral flexibility, which affects its shifting performance long before the poor mating to the gear teeth becomes an issue.

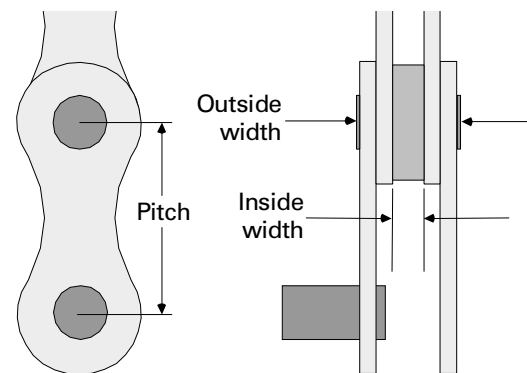
Hyperglide-compatible chain: Shimano makes freehubs and freewheels that are called Hyperglide. These have a special configuration to the teeth that make it possible for the chain to simultaneously engage two cogs when being shifted. Non-Hyperglide systems work by the chain disengaging one cog, before engaging the next. When Hyperglide-compatible is used with regard to a chain, it implies that the shaping and strength of the chain are suitable for use with a Hyperglide cog set. Shimano does not provide other manufacturers with any standards for what makes a chain Hyperglide compatible, so it is up to the manufacturers of Hyperglide-compatible chains to define that compatibility. There is no guarantee that a chain called Hyperglide-compatible will perform in the same way as a Shimano Hyperglide chain.

Hyperglide-compatible chain tool: The term “Hyperglide-compatible” is also used in regard to chain tools. The Shimano Hyperglide chains have special shap-

ing to the side-plates and unusually tight rivets that put special demands on a chain tool. Once again, Shimano does not provide any standards to other manufacturers in this area, so the term Hyperglide-compatible does not guarantee proper results. The fact that a tool is described as Hyperglide-compatible never makes it less suitable for non-Hyperglide chains, and often makes it a better choice for a non-Hyperglide chain.

IG chain: The latest descendant to the Shimano Hyperglide chain. All information about Hyperglide chains with regard to tools and rivet techniques applies to IG chains.

CHAIN DIMENSIONS AND TYPES



26.3 Chain dimensions.

There are two basic types of chains: $1/2" \times 3/32"$ (derailleur bikes), and $1/2" \times 1/8"$ (non-derailleur bikes). A bike must use a $1/2" \times 1/8"$ chain if the teeth on either the front or rear gears are wider than 2.6mm (usually approximately 2.7mm). All bikes with coaster brakes, most bikes with internally-geared hubs, some BMX bikes with freewheels, and some track bikes require the $1/2" \times 1/8"$ size.

These numbers that name the chain size (for example, $1/2" \times 3/32"$) refer to the pitch of the chain and the inside width. See figure 26.3 above to determine the parts of the chain to which these dimensions apply.

The $1/2" \times 3/32"$ derailleur-bike chains vary in outside width. These outside widths fall into three categories: wide chains, narrow chains, and super-narrow chains.

Wide chains

Wide chains are virtually unused today, except on older bikes. They have an outside width of 7.6mm or more, but are generally wider than 8mm. Narrow and super-narrow chains can always be used where a wide chain is being replaced.

Narrow chains

Narrow chains have an outside width of 7.2mm to 7.4mm. They are *required* for use on most 6-speed cog sets and all 7-speed cogsets. They are adequate for use on most 8-speed cogsets, although they may be slightly noisier than super-narrow chains.

Super-narrow chains

Super-narrow chains always have an outside width of about 7.2mm. They are preferred, but usually not required, on 8-speed cog sets. They can be used on any other cog sets just as well.

Nine-speed chains

Nine-speed chains have an outside width of 6.6–6.8mm. They are required on 9-speed cog sets. They can be used on any other cog sets just as well.

PREREQUISITES

There are no prerequisites to chain removal, replacement, installation or service.

INDICATIONS

Maintenance cycles

There are two types of maintenance that need to be performed on chains. The first is cleaning and lubricating. Chain cleaning should be performed whenever the chain is obviously dirty. Differences in riding conditions make it impossible to put a time or mile value on this need. It could even be after every ride. This is especially true of mountain-bike chains. Lubricating should be done whenever the chain is cleaned, or whenever it develops a chirping or squeaking noise and is not dirty. On the other hand, routine chain oiling can lead to a chain getting dirty faster, so only oil when there is need.

The second type of maintenance is routine checking for excessive chain wear. Waiting for symptoms to develop will lead to increased wear of expensive rear cogs and chainrings. Replacing chains *before* they get worn out is more economical than getting full life out of them, and prevents problems with shifting performance. Check chain wear every 500 miles on road bikes, and every 100 miles on off-road bikes.

On a new bike, it is important to make a simple inspection to determine whether all the rivets are correctly installed. It is not unusual for the factory to fail to install a rivet completely, which eventually leads to the chain breaking. Look on both faces of the chain for any rivet protruding significantly more than the others.

New chains (and chains on new bikes) are coated with a rust-preventive compound that is usually a less-than-ideal chain lubricant. The stickiness of this compound makes it inclined to collect dirt. To maximize chain life, clean and lubricate new chains or chains on new bikes immediately. This cleaning time might be difficult to cost-justify, in which case it should turn into a recommendation to the customer.

Symptoms indicating worn chain

Poor shifting can result from a worn or dirty chain. If after performing all possible derailleur service and cleaning the chain, the shifting is still not as good as when the chain was new, wear is probably significant.

When a chain wears too much, the distance from roller to roller increases to the point that the chain and gear teeth do not fit together properly. Chain wear is usually detected when installing a new freewheel or cog(s) while keeping a used chain, or installing a new chain on worn cogs. In these situations, a loud metallic “clunk” is heard from the rear of the drive train, and the pedals jump forward and catch again. This symptom is strictly experienced when there is high load on the chain. What is actually happening is that as the chain feeds on to the bottom of a rear cog, a roller sits on top of a tooth instead of between the teeth. When this roller reaches the top of the cog, the load on the chain forces the roller on top of the tooth to drop down between the teeth, so the chain suddenly jumps forward a quarter inch or so. This makes a loud noise. Depending on the size of the chainring that the chain is on when this occurs, the pedals will seem to slip forward an inch or two and then catch again.

Symptoms indicating need of lubrication

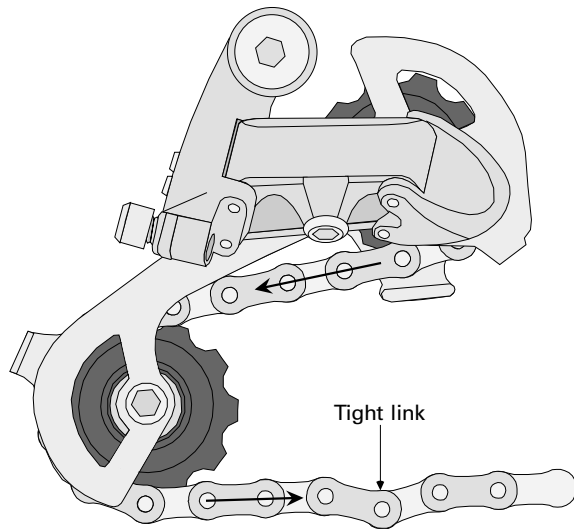
Chirping or squeaking sounds may come from the chain while pedaling. This is a sure sign that the chain is overdue for lubrication. Initially the sounds may be intermittent, occurring at an interval that takes more than one crank revolution to reoccur. This is because the link that needs lubrication is most likely to make noise as it passes through the rear derailleur. When the chain has just been cleaned and oiled and this symptom occurs, it indicates that there is still solvent in one or more of the links that is displacing the lubricant, or that the chain was not completely lubricated.

Symptoms indicating a tight link

A tight link is a link that does not pivot freely, and manifests itself as a clunk that occurs once per chain revolution. With the bike in the stand, pedal backwards slowly, then look for a link holding its bend at the point the chain comes out of the rear derailleur.

26 – CHAINS

This could be caused by three things: 1) if only one tight link develops immediately after installing a chain, it means that the four side-plates where the rivet was pressed in are tightly compressed against each other and the symptom will go away once a tight-link-elimination procedure is performed; 2) dirt can cause a tight link, and the only solution will be to clean the chain; 3) lack of lubrication or rust can cause a tight link. If rust is the cause, try adding oil. If this solves the problem, fine. If rust is present and oiling does not eliminate the tight link, then the chain needs to be replaced.



26.4 Pedal backwards and watch the lower pulley wheel to detect a tight link. As the tight link goes by each pulley wheel, it may cause the derailleur cage to jump a little. If you stop pedaling right away, the tight link should be visible just in front of the lower pulley.

Symptoms indicating need of cleaning

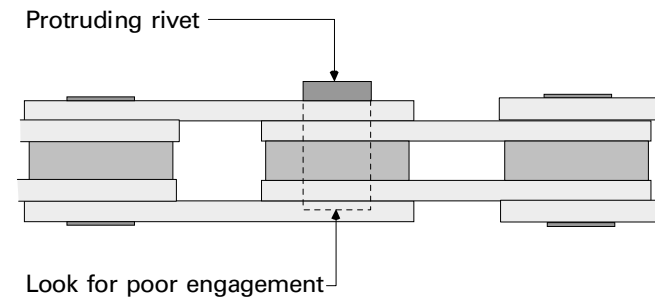
New chains (and chains on new bikes) are coated with a rust-preventive compound that is usually a less-than-ideal chain lubricant. The stickiness of this compound makes it inclined to collect dirt. Cleaning and lubricating new chains or chains on new bikes will maximize chain life, but whether the time spent cleaning would be considered cost effective is another matter.

A dirty chain will cause an advanced rate of wear, so do not wait for a symptom to lead to cleaning a chain. A dirty chain will develop tight links, will shift poorly, and contributes to “chain suck,” a condition where the chain remains stuck to the small chainring and jams into the chain stay.

Symptoms indicating damaged chain or protruding rivet

A clunk or click may come from a chain at regular intervals less than once per crank revolution. If this symptom is not caused by a tight link, then it

could be caused by twisted side-plates or a protruding rivet. First, inspect both faces of the chain for a rivet protruding farther than the others. If this is not found, then remove the chain and hang it vertically. If the chain develops a twist over its length, so that the uppermost links do not face the same way as the lowermost links, then the chain has one or more twisted side-plates and should be replaced. Twisted side-plates usually are caused by the chain jamming somewhere when there is a mis-shift (chain comes off gears).



26.5 When a rivet is installed inadequately, the protrusion at one end is more obvious, but the less obvious poor engagement at the other end is what leads to chain failure.



26.6 This chain is twisted.

Deraileur removal and installation

It is optional to remove and re-install the chain when installing or removing either deraileur. The cage of either deraileur can be opened instead of separating the chain.

Freewheel or cog replacement

It is a good idea to replace an even moderately-worn chain whenever installing new rear cogs. A worn chain greatly accelerates the wear on the cog teeth.

TOOL CHOICES

The design or brand of chain will determine the tools needed. Table 26-1 (page 26-5) covers all the tools for the job. The preferred choices are in **bold**. A tool is preferred because of a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is **bold**, it means that several tools are required for different configurations of parts.

Shimano chains have a design that is very demanding on the chain tool. If the wrong tool is used, then the chain or the tool is likely to be damaged. The damage to the chain may be subtle and could result in a

mysterious chain break at a later time. Several tool manufacturers make “HG-compatible” chain tools, but none of these tools work as well as the Shimano tool designed for the job (and most are completely unacceptable). The Shimano chain tool that is recommended in the list is very expensive by chain-tool standards, but has proven to work well on virtually *all* chains, is durable, and is a pleasure to work with. Despite information that might be seen in print elsewhere, it is perfectly suitable for non-HG chains. Few mechanics that have ever used the Shimano TL-CN31 in the shop have ever considered it to not be worth the money.

TIME AND DIFFICULTY

Chain removal and installation

Chain removal and installation is a 3–5 minute job of little difficulty, but if not done with care it is easy to damage the tool or the chain.

Chain cleaning

Chain cleaning is a 5–15 minute job of little difficulty, but does require elbow grease in some cases. Additional time is required if not using compressed air to remove the solvent from the chain. Thorough drying is critical, and it could take a few hours in the hot sun or all day and overnight to thoroughly dry a chain on the bench top or on the bike.

CHAIN TOOLS (table 26-1)

Tool	Fits and considerations
INSTALLATION AND REMOVAL TOOLS	
Campagnolo 1130020	Plier-type tool, not HG/IG compatible
Cyclo Rivoli 158	Consumer use only
Cyclo Rivoli 158R	Use for tight-link removal only, non-HG/IG chains only
Finish Line Chain Pup	Consumer use only
Hozan C301	Screw-type tool, not HG/IG compatible
Hozan C320	Plier-type tool, not HG/IG compatible
Lifu 60UO	Consumer use only
Off Dirt Quick Link QL4	Consumer use only
Park CT-2	Plier-type tool, not HG/IG compatible
Park CT-3	Screw-type, HG/IG compatible, best for tight-link removal
Park CT-5	Consumer use only
Rohloff Revolver 2	Screw-type tool, not HG/IG compatible, prevents occurrence of tight links
Shimano TL-CN22	Consumer use only, HG/IG compatible, 9-speed compatible
Shimano TL-CN31	Screw-type tool compatible with all chains (inc. 9-speed), durable, easy to use
VAR 06	Screw-type tool, not HG/IG compatible
VAR 303	Plier-type tool, not HG/IG compatible
VAR 303ST	Plier-type tool, not HG/IG compatible
WEAR-MEASUREMENT TOOLS	
Park CC-2	Numerical gradations, accurate and consistent
Rohloff Caliber 2	Simple “no go” gauge, accurate and consistent
Speedtech CW-1089	Measures four degrees of wear, difficult to get consistent results
CLEANING TOOLS AND COMPRESSORS	
“On-the-bike” chain cleaners, all brands	Useful for cosmetic cleaning or consumer use only
Park GSC-1	Good stiff brush for cleaning chains and cogs
Off Dirt QL1	Compresses chain for working on without tension, unneeded if using TL-CN31
VAR 424	Compresses chain for working on without tension, unneeded if using TL-CN31

COMPLICATIONS

Identifying chain as narrow or wide

When performing certain operations, it is important to know whether the chain is wide or narrow. It is not essential to distinguish the difference between narrow and super-narrow chains for the purposes of the following procedures. Determining chain width is simply a matter of measuring the rivet length. If the measurement is 7.4mm or less, the chain is narrow.

Identifying whether a chain is Hyperglide/IG or non-Hyperglide/IG

When performing certain operations, it is important to know whether the chain is a Hyperglide chain or not. With extremely few exceptions, a Hyperglide chain will have the marking “HG” or “IG” stamped on the outer side-plates. Some early models of the chain were marked “UG,” but not all UG chains are Hyperglide. If a narrow chain marked UG is assumed to be a Hyperglide chain and it is treated as such, no serious consequences will arise if you are wrong. On the other hand, if a Hyperglide chain marked UG is treated as though it were a non-Hyperglide chain, rivet failure may be experienced. If you treat any narrow chain marked UG or HG as a Hyperglide chain, there shouldn’t be any problems.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is in four parts. These are **DERAILLEUR-CHAIN SERVICE**, **NON-DERAILLEUR CHAINS**, **CHAIN TROUBLESHOOTING**, and **EIGHT- AND NINE-SPEED COMPATIBILITY**. Derailleur-chain service includes length inspection, wear identification, removal, cleaning, sizing, lubrication, installation, and inspection of chains. **NON-DERAILLEUR CHAINS** covers master links and tensioning of chains. Information about rivets, cleaning, and lubrication of non-derailleur chains is the same as derailleur chains, so it is not repeated.

DERAILLEUR-CHAIN SERVICE

CHAIN-LENGTH INSPECTION AND WEAR IDENTIFICATION

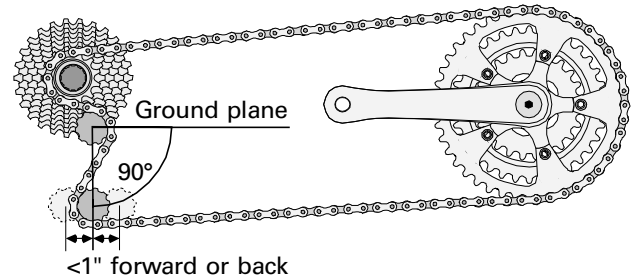
It is a good idea to inspect whether the length of the chain is correct before removing it (for cleaning or other service). If during the service it is determined that a new chain is needed, then there is no need to go

through the process of determining the size by testing. If the old chain was the correct size, the new chain can just be cut to match. New chains all come in one uniform length which is long enough for all bikes, and usually must be sized to fit.

Length inspection

1. [] **Shift chain onto outermost chainring in front and outermost cog in rear.**

There are several legitimate methods to determine whether a chain is an acceptable length. The method here is universal and should always get a close enough result. “Perfect” length is when in the specified gear combination, and with the bike at the angle it would be in if on level ground, the line through the center of both the rear derailleur pulley wheels is perpendicular to the ground. It is not necessary or always possible that the length be perfect, and in most cases, it is acceptable if the chain is up to one inch shorter or longer than perfect. If it is not possible to get the chain length close to perfect, then it is necessary to test for unacceptable chain length. If the chain cannot be sized to pass both the too-long and too-short tests, it means that the gear combination of the front chainrings and the rear cogs exceeds the maximum total capacity of the rear derailleur.



26.7 With the bike in the “on-ground” position, and with the chain in the outermost position front and rear, this is the alignment of the two rear derailleur pulley wheels when the chain length is perfect.

It is not unusual for bike manufacturers to supply a bike with a derailleur that does not have the proper capacity for the gears that come on the bike, particularly on high-performance mountain bikes. The customer may also elect to install a rear derailleur that does not have the capacity for all possible gear combinations. If the customer is aware of the limitations of running a chain that is too short or too long and can limit gear selection to avoid the consequences, then the customer may choose to keep a chain that is the wrong length. If the chain is left too long, that means that when the chain is on the smaller chainring it will be slack on one or more of the outermost rear cogs. If these combinations are avoided, there will be no prob-

lem. If the customer rides with the chain slack, there is a chance it will come off, or possibly come out of position in a way that it will jam in the rear derailleur and damage the rear derailleur. However, too long is a better choice than too short.

If the chain is left too short, it can have two consequences. It can reduce shift performance of the rear derailleur, particularly when on the large chainring and shifting onto one of the innermost rear cogs. The circumstance that the customer must avoid *at all times* is shifting into a large chainring/large rear cog combination that exceeds the capacity of the derailleur. The consequence is that the derailleurs can jam so badly that they cannot shift out of the unacceptable gear combination, or worse yet, the rear derailleur can be destroyed.

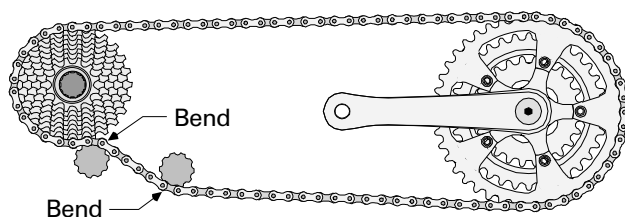
In step #2, the bike must be in the position that it is in when both wheels are on and the bike is on level ground. If the bike is in a stand and the top tube of the frame is not sloped, then simply level the top tube. If the top tube is not known to be level, adjust the angle of the bike so that both hub axles end up equidistant from the ground.

2. With bike in the “on ground” position, put a straight edge against center of rear derailleur’s upper pulley wheel, so that straight edge is perpendicular to ground, and check one of following options:

- ☐ Center of lower pulley wheel is ≤ 1 " in front of or behind straight edge, chain length appears acceptable.
- ☐ Center of lower pulley wheel is > 1 " in front of straight edge, go to step 3 to check for chain too short.
- ☐ Center of lower pulley wheel is < 1 " behind straight edge, go to step 4 to check for chain too long.

3. To check for chain too short:

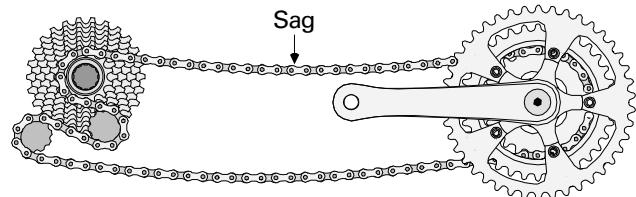
- ☐ With chain on outermost chainring, shift chain to innermost rear cog.
- ☐ Check whether chain bends twice passing through rear derailleur cage. If not, chain is **too short** (circle if so).



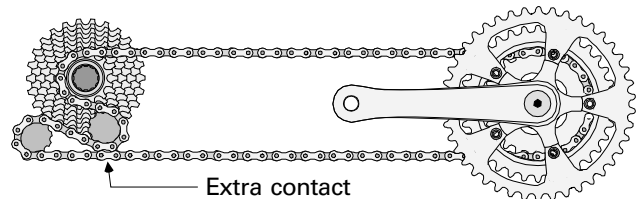
26.8 With the chain on the innermost rear cog and outermost chainring, this is what the chain and rear derailleur will look like if the chain is not too short. The chain must bend past each pulley wheel.

4. To check for chain too long:

- ☐ With chain on outermost rear cog, shift derailleur to put chain on innermost chainring.
- ☐ Check whether chain hangs slack between top of rear cog and top of chainring. If it does, chain is **too long** (circle if so).
- ☐ Check whether chain contacts itself or any part of rear derailleur after leaving bottom side of lower pulley wheel on way to bottom of chainring. If it does, chain is **too long** (circle if so).



26.9 With the chain on the outermost rear cog and the innermost chainring, this is what the chain will look like if it is too long, in some cases. Note that the top section of chain is dangling.



26.10 With the chain on the outermost rear cog and the innermost chainring, this is what the chain will look like if it is too long, in some cases. Note that the chain touches itself under the upper pulley wheel.

Wear inspection

5. ☐ Place Park CC-2 on top of chain with both pegs on underside of tool inside of a link. Gauge should be on left end of tool.
6. ☐ Push gauge up as far as it will comfortably go and inspect whether both pegs are pressing against rollers and not against the end of an inner side-plate.
7. Read number on gauge in window of tool and check one of following options:
 - ☐ Reading 0 – .5, chain is fresh.
 - ☐ Reading .5 – < .75, chain is medium worn.
 - ☐ Reading .75 – < 1.0, chain is highly worn.
 - ☐ Reading 1.0, chain is worn out.

CHAIN REMOVAL

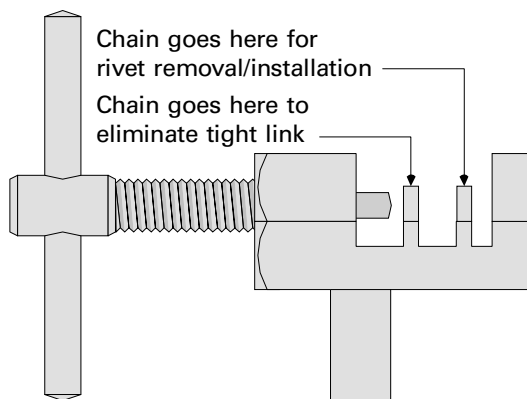
8. ☐ Spin chain-tool shaft to check whether rivet-driving pin of tool is bent.
9. ☐ Shift chain to smallest chainring and smallest rear cog to reduce tension on chain.

26 – CHAINS

The biggest problem mechanics have with chain-
rivet extraction is not making sure the chain is in the
tool correctly before beginning the rivet extraction. The
chain must be in the tool cradle completely, so that it
does not shift around under load. The driving pin of
the tool must be straight and centered on the chain rivet.
Although this procedure requires high force in some
cases, *be sensitive* and stop if it seems excessive. If the
force does seem excessive, stop and double check every-
thing. Failure to exercise proper care will result in the
destruction of a chain link and/or the chain tool.

On certain chains, not all rivets are removable. In
these cases, attempting to remove the wrong rivet can
lead to chain failure. In general, any rivet that is double-
peened is removable. Shimano Hyperglide/IG chains
feature special replacement rivets (no double-peening)
that must not be removed. The Sedis ATB chain fea-
tures a single black half-link that includes *the only rivet*
that should be displaced and reinstalled, but any rivet
other than this special rivet should be removed to
shorten the chain. There are other lesser-known chains
that can have special rivets, so check any literature that
comes with a chain for this information.

Some chain tools have two cradles on which to
seat the chain. One of these cradles is for rivet removal
and installation and the other is for eliminating tight
links. If the wrong cradle is used, it will damage the
chain and the tool. In all cases where there are two
cradles, the one furthest from the rotating tool handle
is for rivet removal and installation.

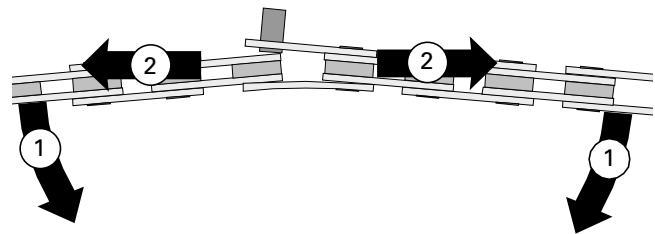


26.11 This is a side view of a chain tool with two cradles. Note which one is for rivet removal and installation.

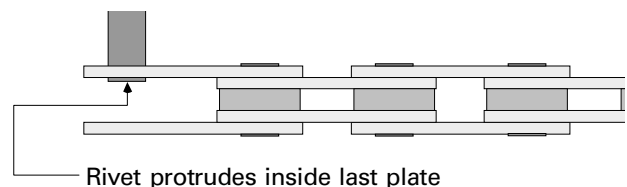
10. [] Engage tool to lower section of chain and turn handle just until tool pin contacts chain rivet and make sure that tool pin is centered on chain rivet and that chain rollers are seated fully in cradle in chain tool.

In the next step, push a chain rivet *partially* out. A common mistake is to push it too far, which causes all kinds of trouble. It is better to push it too little than too much. The correct amount to push the rivet is so that the end being pushed clears the first outer side-plate, the first inner side-plate, the roller, and no more than half the second inner side-plate. When the links are separated, the rivet should be left protruding about .5mm to 1.0mm in the inner face of the second outer side-plate. This protrusion is used to hold the links together temporarily when sizing the chain, or when preparing to drive the rivet back in. Even with Hyperglide chains, with which the rivet is eventually replaced, it is an advantage to leave the rivet protruding in this fashion.

Most chain tools have a thread pitch on the tool shaft of 1mm. By counting the half-turns of the tool handle from the point it begins to push on the rivet, it is possible to control the amount that the rivet is pushed. Before starting the rivet extraction, measure the rivet length to determine whether the chain is a narrow or wide chain. If the handle is turned ten half-turns, it should push the rivet out just enough for a narrow chain. Eleven half-turns should be the correct amount for wide chains. It would not be a bad policy to stop a half-turn early and attempt to separate the links. Only if they are too difficult to separate should the rivet be pushed out 1/2 turn more. To separate the links, flex them sideways while pulling them apart.



26.12 When the rivet is pushed out enough, flex the chain in this direction while pulling to get the links to separate.



26.13 Once the links are separated, the rivet will protrude inside the outer side-plate if it was pushed out the correct amount.

11. [] **Note starting position of tool handle and turn handle appropriate number of turns to drive rivet through 2-1/2 side-plates. (If tool shaft has normal 1mm pitch, for narrow chains turn handle 10 half-turns, wide chains 11 half-turns. Park CT-3 has circlip on tool shaft to stop rivet removal at correct point.)**
12. [] **Loosen tool shaft until pin is out of chain and disengage tool from chain.**
13. [] **Flex chain laterally while pulling both directions from link with pushed-out rivet to complete separation of chain.**
14. [] **Pull on end of chain with protruding rivet to remove chain from bike.**

CHAIN CLEANING

15. [] **To control chain properly while cleaning, fold chain in half and coil with loose ends at center of coil.**

If a chain is neatly coiled and contained in a container that is correctly sized to prevent uncoiling, then the chain is much less likely to end up tangled. A short can that has a diameter of 4.5–5.0 inches should fit most chains. A typical half-pound peanut can is just the right size.

16. [] **Submerge chain in can of solvent and let soak as long as possible.**
17. [] **Drain off solvent until chain is only slightly submerged, but can be easily seen.**

If a chain has been dirty a long time, then it may not be possible to clean it thoroughly. Clumps of hard dirt that cannot be dislodged by a stiff-bristle brush develop on parts of the link where metal-to-metal contact does not normally occur. Do not worry too much about removing this kind of dirt. The Park GSC-1 is a good brush for this purpose, which is also a recommended tool for freewheel cleaning.

18. [] **Use stiff-bristle brush to clean side of chain that is facing up.**
19. [] **Turn chain coil over and scrub second face in a similar fashion.**

The most important part of the chain to clean is the rollers. The chain must be uncoiled to access the rollers and laid out full length, or folded in half. It will not be possible to contain it in a container of solvent when it is extended in this fashion. If not using a full-size solvent tank, spread out several thick sections of newspaper on a large work surface big enough to cover the length of the entire chain. Make sure that the newspaper is thick enough to absorb all the solvent, or put a layer of plastic under the newspaper. The left-over sol-

vent from the side-plate cleaning may be enough to use while scrubbing the rollers, but periodically refresh the scrub brush in fresh solvent, if necessary.

20. [] **Remove and uncoil chain put it on its edge (rollers visible from directly above).**
21. [] **Use stiff-bristle brush to scrub rollers and inside of inner side-plates, periodically dipping brush in fresh solvent.**
22. [] **Turn chain over and scrub other edge in same fashion.**

Scrubbing the side-plates and the rollers does not remove the dirt from the chain, it has merely dislodged it. In the next step, rinse the chain repeatedly to get the dislodged dirt out of and off of the chain.

23. [] **Rinse chain thoroughly in fresh solvent.**

It is very important that the chain be *totally* dry before lubricating it. If solvent is inside the rollers when oil is added, then the solvent will displace or break-down the oil and the most important part of the chain to be lubricated will not be lubricated. If using compressed air for the drying, blow air over the entire chain on both edges and both faces repeatedly until there is no solvent creeping out from the overlapping side-plates or from between the rollers and the inner side-plates. If not using compressed air, it is difficult to know when the chain is dry, because the last and most critical part to dry is inside the rollers. Experience has shown that two hours in the direct sun on a warm day should be adequate, or 24 hours otherwise. Do not use application of heat to evaporate solvent because of the risk of fire and of the possible generation of toxic fumes.

24. [] **Use compressed air to dry chain *completely* (or 2 hours in direct sun, or 24 hours without direct sun or compressed air).**

CHAIN LUBRICATION

There is probably more voodoo about chain lubrication than there is about any other subject regarding bicycle mechanics. The function of chain lubrication is actually very simple. The lubricant must remain between the moving parts to reduce friction and to keep rust from developing where moving parts touch each other, and it must remain as clean as possible because the contaminants create friction. The loads on bicycle chains are not so unusual that exotic lubricants are required to reduce wear and friction. If an exotic oil with outstanding friction-reducing properties evaporated or broke down quickly, or promoted the accumulation of dirt, then it would not be a better lubricant for a chain.

There are two important properties to chain lubricants: they must minimize the accumulation of dirt, because dirt accelerates wear and chain cleaning is a hassle; they must also be durable, because lack of lubricant increases chain wear. Durability is the less significant factor because it is relatively easy to repeatedly lubricate a chain. In general, oils that are marketed specifically as bicycle-chain lubricants are going to be superior to all non-bicycle-specific products, including those general household and handyman oils that are *also* recommended for bicycles.

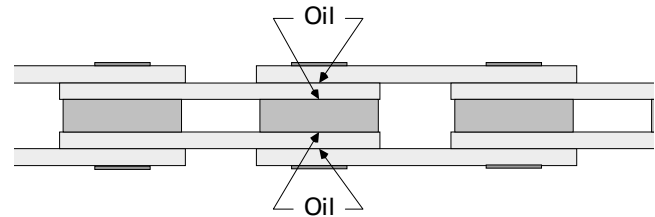
One of the factors that promotes dirt accumulation is the quantity of oil on the chain. Avoid oiling too frequently. Oil only when there is need. Avoid using certain aerosols, because they promote over-oiling. Always wipe off excess oil thoroughly with a clean rag.

Some aerosols are more of a problem than others. When considering some aerosol lubricants, perform a simple test. Squirt an equal quantity of each lubricant being considered on a clean, flat, metallic or glass surface. After 10 minutes, see if any of the lubricants have dried noticeably. This test simply identifies whether a lubricant has an evaporative base, or not. Those that stay wet are going to make the chain a gooey mess because the aerosol guarantees over application and the excess wet oil will be great at accumulating dirt. The same lubricant might be excellent in a drip container, because with a drip container it is possible to avoid over-application.

If the bike is ridden in conditions that expose the chain to water frequently, be concerned with whether the lubricant will wash off the chain too easily. A lubricant that does not hold up well to water will cause the chain to squeak within half an hour of riding after being in the rain. Historically, the lubricants that are best at remaining on after exposure to water are the worst about accumulating dirt. It may be best to compromise. Keep in mind that is always easier to add more lubricant (even in mid-ride) than it is to clean a chain.

When lubricating, there are four points at each rivet that need lubrication: between each overlap of an outer side-plate and an inner side-plate, and between the inner side-plates and each side of the roller. These are the four points where metal slides against metal. Oil is needed inside and on the surface of the rollers as well, but it will get there automatically when oiling each edge of the roller. The mistake is to think that the external surface of the chain needs oil. This just increases the mess and dirt accumulation. If using a spray lubricant, everything that needs lubrication will

get it in one quick pass of the nozzle over the chain. If using a drip lubricant, put a drip between each side-plate overlap and on each side of each roller.



26.14 *Lubricate each link at the four points shown.*

- 25. []** Apply lubricant to chain so that it penetrates every overlap between an inner side-plate and an outer side-plate, and so that it penetrates between roller and where each roller contacts an inner side-plate.
- 26. []** If chain is installed, backpedal for 30 seconds, or if chain is off bike, wiggle it like snake for 30 seconds to help lubricant penetrate into crevasses.
- 27. []** Use clean rag (terry cloth preferred) to thoroughly wipe excess lubricant off of chain.

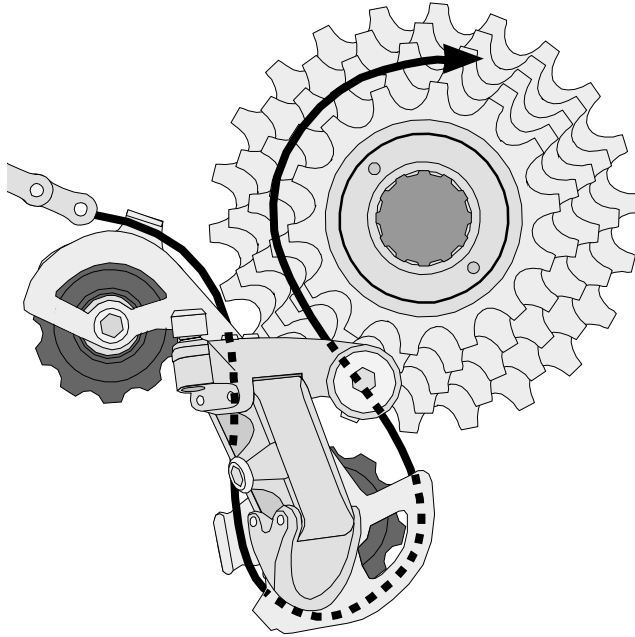
CHAIN INSTALLATION

- 28. []** If replacing chain and existing chain was an acceptable length in step 2, remove links from new chain so that number of links in new chain matches number of links in old chain.
- 29. []** Position rear derailleur under outermost rear cog and front derailleur over innermost chainring.

When threading a chain through the derailleurs and around the gears, you will need to start with the end of the chain that has no rivet sticking out from a side-plate. Consider this the “no-rivet” end. It’s a handy technique to make sure that the rivet that is sticking out faces away from the bike once the chain is installed. This makes use of the chain tool less awkward.

Getting the chain correctly through the rear derailleur and around the gears can be confusing. Grab the end of the derailleur and rotate the cage until it is approximately straight up and down. See that the cage has a lower pulley wheel and an upper pulley wheel. The chain will go through the derailleur in a reverse “S,” and it will be fed from the bottom to the top. Once it has gone around the front and over the top of the upper pulley wheel, it goes up and around the back side of the outermost rear cog. When ready to put the no-rivet end through the front derailleur cage and around the large chainring, it is easiest if there is about

a foot of the end of the chain dangling from your fingertips to drop through the derailleur cage. Once it lands on the teeth, rotate the crank to pull the chain through.



26.15 Follow the arrow to feed the chain through the rear derailleur and around the rear cog.

30. [] Feed no-rivet end of chain up around backside of lower rear derailleur pulley wheel, through derailleur cage, up and in front of upper pulley wheel, up and over backside of outermost rear cog, and down through front derailleur cage and onto innermost chainring (rotating crank to help pull chain through once chain falls on chainring teeth).
31. [] Join ends of chain temporarily together between bottom of chainring and rear derailleur by slipping end of chain with no rivet over rivet protrusion on other end of chain. (Inner half-link will be *outside* of an outer plate.)

CHAIN SIZING

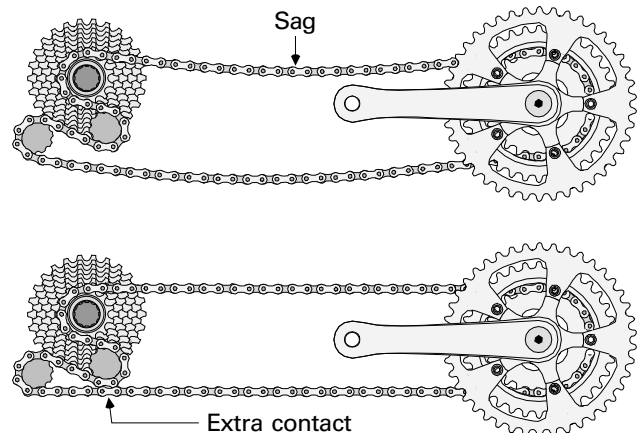
NOTE: If reinstalling an old chain that was an acceptable length and not installing a new chain, new rear derailleur, new-size chainrings, or new-size rear cogs, skip to **RIVET INSTALLATION**.

If chain length was not acceptable originally, then it is necessary to perform some tests to determine the best length. There is no standard number of links, formula, or table that can be used because there are too many variables. Chain length is set in a specific gear combination, with the chain on the outermost rear cog and innermost chainring. In this gear combination, if the chain is too long it will exhibit one of the

symptoms in figure 26.16. If one of these symptoms is exhibited, then adjust the length by one inch (two link) increments until the symptom just disappears.

Chain length is always important because it affects rear-derailleur shift performance. When there is a significant deviation from the recommended length, or when the rear-derailleur total capacity is being stretched to its limit, chain length is even more important because too short or long of a chain can lead to a damaged rear derailleur.

A common misconception about chain length is that it is adjusted to change the tension on the chain, particularly in the lower section of chain between the rear derailleur and the bottom of the chainrings. This is not adjustable, except by changing the rear derailleur's internal springs. The tension on the lower section of chain is also not of any great significance.



26.16 With the chain on the outermost rear cog and the innermost chainring, this is what the chain will look like if it is too long, in some cases. In the top example, note that the top section of chain noticeably sags. In the bottom example, note that the chain touches itself under the upper pulley wheel.

32. If existing chain is wrong length, or if replacing wrong-length chain with new chain:
 - [] Inspect chain for sag in top section.
 - [] Inspect chain for extra contact at upper pulley wheel.
 - [] Adjust chain length one link at a time until sag or extra contact is just eliminated.

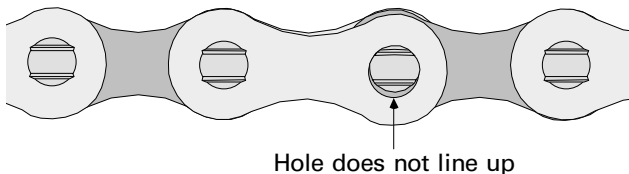
RIVET INSTALLATION

NOTE: Steps 33–38 are for non-Hyperglide chains only. For Hyperglide/IG chains skip to Shimano HG/IG rivet installation.

Non-Shimano HG/IG rivet installation

Before putting the chain on the chain tool to push in the rivet, join the ends of the chain together. If the rivet is protruding inside the outer side-plate, as it is supposed to, this can be awkward. Put the no-rivet end between the outer side-plates until it bumps into the protruding rivet. Use the no-rivet end as a lever to spread apart the outer side-plates, then force the no-rivet end past the protrusion of the rivet.

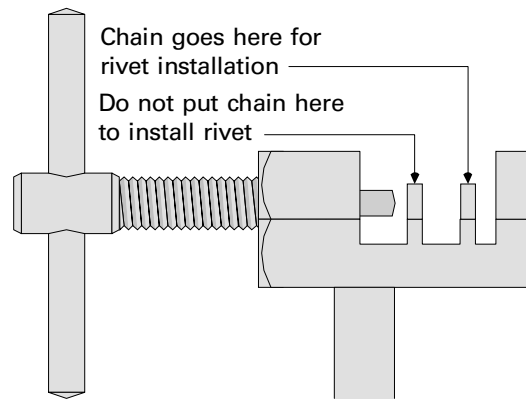
Mechanics get in trouble for several reasons when pressing in the rivet. First, they do not make sure that the holes in the four side-plates all line up before pushing in the rivet. This jams the rivet into the last side-plate it goes through and deforms the side-plate and bends the tool's driving pin. Second, they do not make sure that the chain is well seated in the tool cradle, so the rivet does not get pressed straight in, causing it to jam and damage the link or the tool. Finally, they do not make sure that the tool pin is straight and centered on the rivet, which causes the rivet to jam and damages the side-plates or the tool.



26.17 This is what it looks like when the four side-plates do not line up.

Although high force may be required to push in the rivet, *be sensitive* to any excess force that indicates things are not lined up and the rivet is jamming.

Some chain tools have two cradles on which to seat the chain. One of these cradles is for rivet removal and installation and the other is for eliminating tight links. If using the wrong cradle, it can damage the chain and the tool. In all cases where there are two cradles, the one furthest from the rotating tool handle is for rivet removal and installation.



26.18 This is a chain tool with two chain cradles. Put the chain on the cradle indicated when preparing to push in the rivet.

33. [] Join ends of chain together and put chain tool on chain so that rollers are fully down in cradle and turn tool shaft in until tool pin is just touching protruding end of chain rivet. Check that tool pin is centered on rivet.

34. [] Inspect that side-plates appear to be properly lined up.

When pressing in the rivet, look to see when to stop turning the tool handle. The objective is to end up with equal amounts of rivet protruding out past each outer side-plate. If the rivet is pushed too far, remove the chain tool and switch it to the other side.

35. [] Turn tool handle until same amount of rivet is showing outside each outer side-plate, being careful not to force rivet when side-plates are not properly lined up.

36. [] Loosen tool handle and remove tool from chain.

Pressing the rivet through all four side-plates at once causes the side-plates to compress against each other and pinch on the roller, which causes the link to be tight and hold a bend. Step #37 spreads the side-plates apart by flexing the chain laterally (perpendicular to the direction the links pivot). Chains are very strong, so do not be afraid to flex the chain vigorously.

If the flexing technique does not work, a chain tool is needed that has a tight-link-removal feature. This is always a tool that has two cradles on which to mount the chain. The one for tight-link removal is always the cradle that is closest to the rotating handle of the tool. When the chain is on this cradle, only the first two plates (closest to the tool pin) are supported by the tool. When the rivet is pressed further, it is moved further only through the first two side-plates. Since the rivet is moving through one outer plate, and is remaining unmoved in the other outer side-plate, the distance between the two outer side-

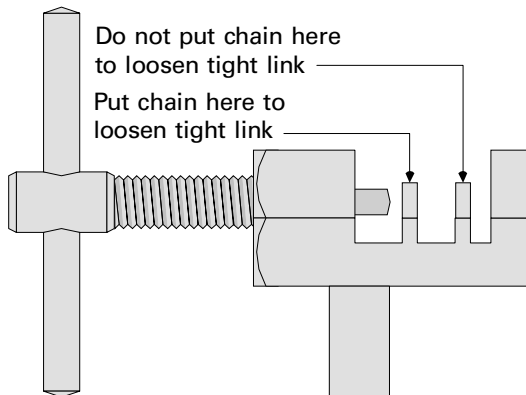
plates is increased. This eliminates the bind on the roller. A very little amount of displacement of the rivet is required to achieve this.

37. [] Pivot chain at rivet just installed and release slowly to see if chain holds bend.

38. If chain holds bend in previous step (tight link), perform these two steps (second one only if necessary):

[] Grasp chain firmly on both sides of tight link and flex chain vigorously side-to-side (at right angles to direction chain is meant to pivot) and test for tight link again.

[] If side flexing did not eliminate tight link, put chain on correct cradle of tight-rivet-removal tool, turn in tool shaft just until tool pin is firmly against rivet, turn tool 1/3 to 1/2 turn, and check again for tight link.



26.19 This is a chain tool with two chain cradles. Put the chain on the cradle indicated when preparing to loosen a tight rivet.

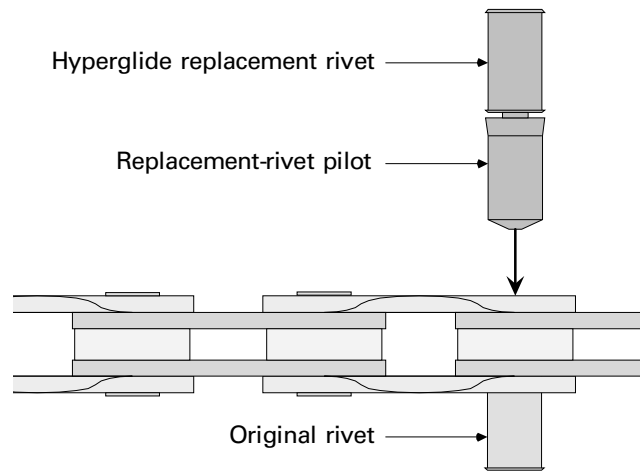
NOTE: Skip to **CHAIN INSPECTION** if not installing rivet in Hyperglide chain.

Shimano HG/IG rivet installation

Hyperglide and IG replacement rivets require a great deal of force to install, and a great deal of resistance occurs at the final outer side-plate that the rivet goes into. If not done carefully, this procedure can easily damage the tool and the chain. Lubricating the rivet reduces the force required, which makes it easier to tell if something is jamming and actually reduces the amount of deformation of the outer side-plates that always occurs. A Hyperglide-compatible chain tool supports the outer side-plate in a way that reduces the deformation that occurs, as well.

The Hyperglide replacement rivet consists of two parts, a pilot shaft that has a tapered tip and a flare at the other end, and a flanged rivet that is a tighter fit than the rivet it replaces. The pilot shaft guides the rivet into place, expands the holes in the outer side-

plates to accommodate the larger rivet, and pushes the old rivet the rest of the way out. Once the replacement rivet is in place, the pilot shaft easily snaps off.



26.20 This is a Hyperglide replacement rivet.

39. [] Oil full length of Hyperglide replacement rivet.

40. [] Join ends of chain and insert tapered end of pilot shaft of Hyperglide replacement rivet through side-plates until replacement pilot shaft is butted against old rivet.

41. [] Put chain tool on chain so that rollers are fully down in cradles and turn tool shaft in until tool pin is just touching replacement rivet. Check that tool pin is centered on rivet.

As the leading end of the replacement rivet passes through each outer side-plate, there is more resistance than when the leading end of the replacement rivet is passing through the inner side-plates and the rollers (which have larger holes than the outer side-plates). When starting the replacement rivet in with the tool, expect an initial high resistance, followed by less resistance, and then an increase in resistance as the rivet begins to go through the final outer side-plate. When an equal amount of rivet protrudes from both outer side-plates, stop. However, stopping early will cause a tight rivet.

42. [] Turn tool handle until full length of replacement-rivet pilot shaft is exposed on far side of chain and equal amounts of replacement rivet are exposed outside both outer side-plates.

43. [] Loosen tool handle and remove tool from chain.

44. [] Use plier to grasp and snap off replacement rivet pilot shaft.

45. [] Pivot chain at rivet just installed and release slowly to see if chain holds bend.

A tight rivet on a Hyperglide chain is usually caused by incomplete installation of the replacement rivet. In any case, try side-flexing the chain first. If that does not work, use step #46 to center the rivet.

46. If chain holds bend in previous step (tight link), perform these two steps (second one only if necessary):

[] Grasp chain firmly on both sides of tight link and flex chain vigorously side-to-side (at right angles to direction chain is meant to pivot) and test for tight link again.

[] Inspect replacement rivet to see if either end is sticking out more than the other and put chain tool on to push that end of rivet further in.

CHAIN INSPECTION

When finished with chain installation, check to make sure that everything has been done correctly, but also whether any previous work was done incorrectly. This inspection is a good idea, particularly for new bikes. Virtually 100% of chain failures can be attributed to improper installation of rivets. With proper inspection, about the only thing a customer will ever use a chain tool for when on a ride is fixing other people's chains.

47. [] Inspect both outer side-plates where rivet was installed for deformation (bulging) around rivet hole or metal shards from fractured edge of rivet hole. Replace link if either problem is found.

In step #32, when the chain was sized, it was set at the longest acceptable length. If there is a problem with derailleur capacity, or an error was made in sizing the chain, there is a possibility it is now too short. The next step tests for whether the chain is too short. If at its original length (as of completion of step #32) the chain was too short, then the maximum total capacity of the rear derailleur has been exceeded. Ideally, the derailleur or the size of the chainrings/rear-cogs should be changed. If this is not an option, reinstall a link and check again for symptoms of a short chain. Go back to the section **CHAIN SIZING** (page 26-11) to consider the implications of running a chain that is too short or too long.

48. [] Put chain on innermost rear cog and outermost chainring and check whether chain bends twice as it passes through rear derailleur cage. If chain exhibits signs of being too short (not bending twice), and chain was too long when it was one link longer, it indicates maximum capacity of rear derailleur has been exceeded.

49. [] Inspect both faces of chain thoroughly for any rivet protruding significantly more than others and correct as necessary.

50. [] With chain on innermost chainring and outermost rear cog, rotate crank slowly backwards and look for tight links coming out of rear derailleur, and correct as necessary.

NON-DERAILLEUR CHAINS

MASTER LINKS

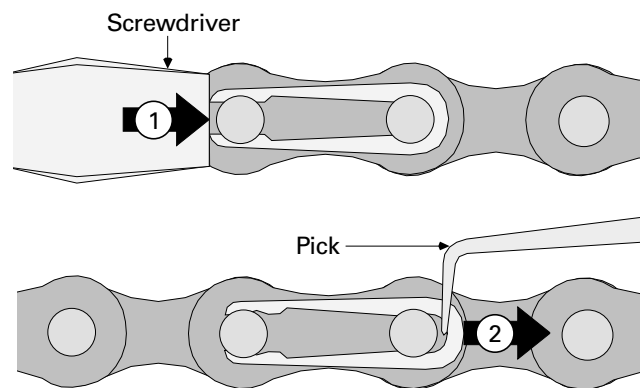
With the exception of track bikes, virtually all bikes without derailleurs have a chain with a master link. Master links are occasionally used on derailleur chains.

Master links come in several varieties, although only two that are generally encountered. These are the clip-on variety and the snap-on variety.

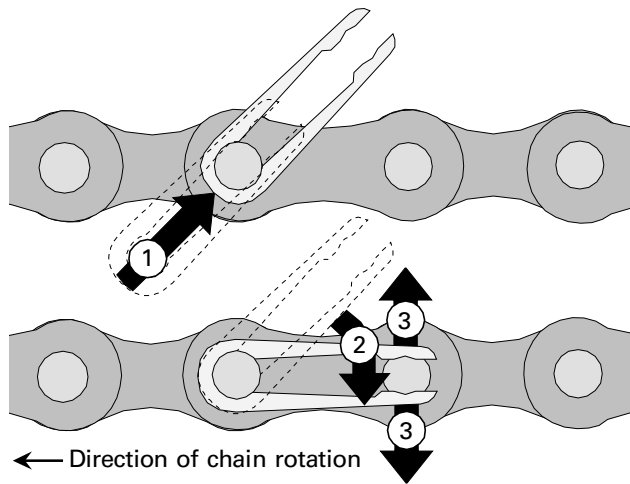
Clip-on master links

The clip-on master link consists of three parts. One part is an outer plate with two rivets permanently fixed. Another part is an outer plate with two holes for rivets. The third part is an elongated circlip that clips into grooves in the ends of both rivets. See the following illustrations for removal and installation methods.

It is good practice (and makes for easier maintenance) to install the clip on the outer face of the chain, with the closed end of the clip pointing in the direction of the chain's rotation.



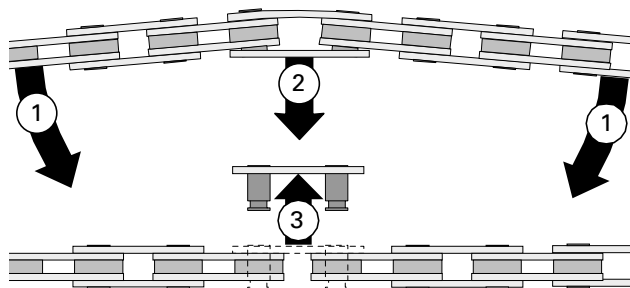
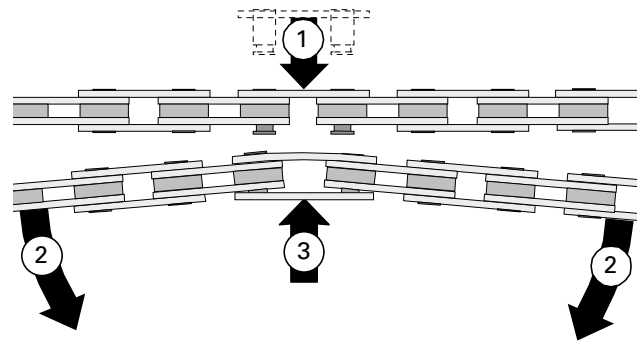
26.21 Removing the clip from a clip-on master link.

26.22 *Installing the clip on a clip-on master link.*

Snap-on master links

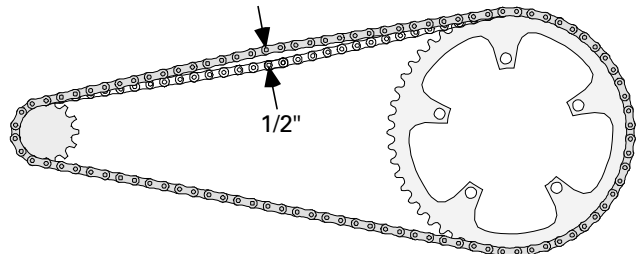
The snap-on master link consists of two parts. One part is an outer plate with two rivets permanently fixed. The other part is an outer plate with two holes for rivets. The rivets on one outer plate have grooves that engage the holes in its counterpart. The rivets are fixed so that their ends are slightly farther apart than the holes in the outer plate. The plate with the rivets must be flexed to move the rivet ends close enough together to insert the rivets into the other plate. Once joined together, the outer plate with holes is trapped in the grooves in the rivets. Although this design has existed for decades on chains for non-derailleur bikes, a new version by Taya is available with dimensions that are compatible with derailleur chains. The Taya version differs in two minor respects other than dimension: the assistance of a screwdriver may be needed to pry the plates apart, and Taya is adamant that a link that has been removed should not be reinstalled.

It is good practice to install the plate with holes on the outer face of the chain.

26.23 *Removing the snap-on master link.*26.24 *Installing snap-on master link.*

CHAIN TENSION

If the chain tension is too tight, it will not operate smoothly. If it is too loose, it will fall off. Because gears are not perfectly round, chain tension will vary depending on the point of rotation of the crank. Find the point at which the chain is tightest and adjust the wheel forward or backward until the chain will move up and down 1/2" at the point halfway between the front and rear gears.

26.25 *Proper chain tension on a non-derailleur chain.*

CHAIN TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Chain slips or skips on a cog when pedaling hard.</i>	
Fresh chain not meshing with worn cog.	Replace cog or cogs.
Worn chain not meshing with fresh cog(s).	Replace chain.
Pawls are not catching on internal ratchet ring because they are dirty, rusty, worn, or broken.	Clean and oil freewheel/freehub body and replace if symptom persists.
SYMPTOM: <i>The top section of chain hangs slack when the chain is on an outermost rear cog and the innermost chainring.</i>	
Chain is too long.	Put chain in correct gear and check chain length.
If chain length checked to be correct, rear-derailleur maximum total capacity has been exceeded.	Change gearing or derailleur to match capacity, or learn to ride with limits of a chain that is too long.
SYMPTOM: <i>The bottom section of chain touches itself or the derailleur cage just below the upper pulley wheel when the chain is on an outermost rear cog and the innermost chainring.</i>	
Chain is too long.	Put chain in correct gear and check chain length.
If chain length checked to be correct, rear-derailleur maximum total capacity has been exceeded.	Change gearing or derailleur to match capacity, or learn to ride with limits of a chain that is too long.
SYMPTOM: <i>The derailleur jams going on to or off of the innermost rear cog, only when the chain is already on the outermost chainring.</i>	
Chain is too short.	Put chain in correct gear and check chain length.
If chain length checked to be correct, rear-derailleur maximum total capacity has been exceeded.	Change gearing or derailleur to match capacity, or learn to ride with limits of a chain that's too short.
SYMPTOM: <i>The chain seems to skip or jump regularly, but at a cycle that is equal to once every several crank revolutions.</i>	
Tight link.	Rotate crank backwards and check for tight link where chain comes out of rear derailleur.
Protruding rivet on inner face of chain.	Inspect inner face of chain for rivet(s) protruding more than others.
Twisted side-plates from chain jamming during catastrophic over-shift off gears.	Replace chain.
SYMPTOM: <i>A tight link cannot be eliminated by the side-flexing technique or by using the tight-link-removal feature of the chain tool.</i>	
Chain is rusty, dirty, or needs lubrication.	Clean and oil chain. Replace if problem persists.
SYMPTOM: <i>A rivet has come out and the link has blown apart while riding the bike.</i>	
Rivet was incompletely installed.	Replace link if chain new, otherwise replace chain.
A pebble or other small hard object was jammed inside the link with the gear tooth and spread the outer side-plates too far apart.	Replace link if chain is new, otherwise replace chain.
SYMPTOM: <i>Chain seems to rub against next cog inward in most or all gears.</i>	
Wide chain is being used with narrow-spaced rear cogs if symptom happens in most gears.	Replace chain with narrow chain.
Spacing is wrong between two cogs, particularly if symptom only happens in one gear and cogs have recently been removed and re-installed from freewheel/freehub body.	Check and correct spacers between cogs.

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Chain doesn't squeak but seems to be noisier after cleaning than before.</i>	
Excessively dirty, gummy chain was muffling normal chain noise.	Start worrying when it gets quiet again, and then clean it again.
SYMPTOM: <i>Chain makes a regular chirping or squeaking sound after being cleaned and oiled.</i>	
Certain links were not oiled.	Back pedal slowly and stop as soon as chirping occurs. Un-oiled link is now in rear-derailleur cage or has just moved out of the rear-derailleur cage.
Chain was not thoroughly dried of solvent and solvent is displacing or breaking down lubricant in certain links.	Back pedal slowly and stop as soon as chirping occurs. Noisy link is now in rear-derailleur cage or has just moved out of the rear-derailleur cage. Flood offending link with lubricant. If this fails, remove and clean chain again and dry thoroughly.
SYMPTOM: <i>Chain seems to stick to inner chainring and does not release to go to rear derailleur, then jams between chainring and chain stay.</i>	
Chain or chainring is fouled with dirt.	Clean chain and chainring.
Chainring is worn out and has hooked teeth.	Replace chainring (steel preferred).
Thick aluminum chainring is intolerant of certain chains.	Replace inner chainring with narrow-steel model.

EIGHT- AND NINE-SPEED COMPATIBILITY

DIMENSIONS

Nine-speed chains are technically $1/2" \times 3/32"$ chains, just like all other derailleur chains. Even before nine-speed chains were introduced, the dimensions for derailleur chains in this size category varied (see **CHAIN DIMENSIONS AND TYPES**, page 26-2), but the variations were small enough that all chains still fit on most cogs and chainrings. The nine-speed chain has an outside width of approximately 6.6–6.8mm, .5mm less than any other type of chain. This narrower width allows the cogs on a nine-speed rear cog set to be spaced much closer together, so that the nine cogs fit in almost the same total space as eight cogs.

COMPATIBILITY

The nine-speed chain is still close enough to the dimensions of other derailleur chains that it fits eight-speed and lesser configurations. However, the lesser spacing between cogs on nine-speed cog sets makes it impossible to use anything other than a nine-speed chain on nine-speed cog sets.

Shimano nine-speed drive trains have other differences in addition to the chain and spacing between cogs. Spacing between chainrings has been reduced, and the width of the front derailleur cage has been reduced as well. As a result, chains that are not the nine-speed dimension are not compatible with chainrings and front derailleurs that are designated as nine-speed configurations.

The nine-speed chain can be used with other than nine-speed chainrings and front derailleurs. Due to design differences more than dimension differences, performance might be slightly compromised, but this combination will be functional.

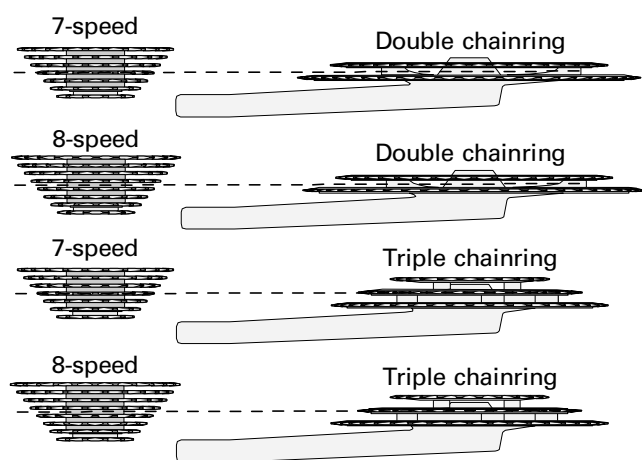
At the time of this writing, Shimano nine-speed chains have a different design from their previous chains, not just different dimensions. Most current Shimano chains that are not nine-speed type are the IG design. This design has side-plate shaping that is designed to optimize shifting from smaller to larger-diameter gears and additional shaping that is designed to optimize shifting from larger to smaller-diameter gears. The nine-speed chain is an HG design, which only has the shaping designed to optimize shifting from smaller to larger-diameter gears. Consequently, the

nine-speed chain, whether used on a nine-speed drive train or a drive train that is other than nine-speed, will not shift as well from larger to smaller-diameter gears (particularly under high load).

27 – CHAINLINE

ABOUT THIS CHAPTER

This chapter is about chainline. Chainline is the alignment between the chainrings and the rear cogs. By centering the rear cogs to the center of the chainring set, the chain will experience the minimum lateral deflection as it is used in all the possible gear combinations. The benefits of minimizing chain deflection are less drive-train noise, less drive-train wear, and better shifting.



27.1 Examples of perfect chainline.

Chainline is different from other aspects of bicycle mechanics. If two out of five indications point to a bottom bracket needing an overhaul, it would be prudent to overhaul the bottom bracket. The same applies to adjusting a derailleur, truing a wheel, or just about any other procedure; however, it is not prudent to adjust chainline if it is uncertain that there is a problem. The difference is that chainline error is difficult to measure accurately and extremely complicated to correct. Most bikes are quite tolerant of some chainline error, so it is a big mistake to measure for chainline error and then correct it only because a quantifiable error exists. Unlike other procedures in this book, the procedure in this chapter starts with an inspection to determine whether any significant symptoms exist, and only goes further if symptoms are detected. Arbitrary correction of any detectable chainline error is usually a mistake!

GENERAL INFORMATION

TERMINOLOGY

Chainline: The alignment between the rear cogset and the front chainring set (see figure 27.1).

Rear-cogset center: The point halfway between the innermost and outermost cogs. If the cogset has five cogs, the center is the third cog from either end. If the cogset has six cogs, the center is the third space between cogs, counting from either end. If the cogset has seven cogs, the center is the fourth cog, counting from either end. If the cogset has eight cogs, the center is the fourth space between cogs, counting from either end. (See figure 27.1)

Chainring-set center: The center of the chainring set is the point halfway between the innermost and outermost chainrings. If there are two chainrings, the center is the center of the space between the two chainrings. If there are three chainrings, the center is the center of the middle chainring. (See figure 27.1)

Chainrings-out error: When there is an error in chainline, it could be because the chainrings are too far out from the center of the bike compared to the freewheel. This could be called either *chainrings-out* error or *rear-cogs-in* error. Although they are the same thing, *chainrings-out* error is used because chainline adjustments are easier to make by moving the chainrings than by moving the rear cogs.

Chainrings-in error: When there is an error in chainline, it could be because the chainrings are too far in toward the center of the bike compared to the freewheel. This could be called either *chainrings-in* error or *rear-cogs-out* error. Although they are the same thing, *chainrings-in* error is used because chainline adjustments are easier to make by moving the chainrings than by moving the rear cogs.

Lateral deflection (of chain): The twist of the chain (in or out) that occurs when the chain goes from a chainring to a rear cog that is not directly in line with the chainring. Lateral deflection increases chain friction, wear, and noise.

PREREQUISITES

There are no prerequisites to determine whether there is a chainline error, what direction it is, and what size the error is. Correcting chainline can include moving the chainrings, moving the freewheel, and aligning the rear triangle of the frame. Each of these general procedures can require several more specific procedures, which are outlined below.

Crank-arm removal

In order to correct a chainline error, it may be necessary to replace a bottom bracket or bottom-bracket spindle. Crank-arm removal is necessary to perform these procedures.

Bottom-bracket overhaul

In order to correct a chainline error, it may be necessary to replace a bottom bracket or bottom-bracket spindle.

Front-derailleur adjustment

If the chainrings are moved in or out to correct a chainline error, the front derailleur will need to be re-adjusted.

Freewheel removal

In order to correct a chainline error, it may be necessary to move the freewheel in or out. This is done by changing the spacers on the hub axle. To overhaul the hub and change the spacers, it will be necessary to remove the freewheel. If the hub is a freehub, then go directly to hub overhaul without removing anything in regard to the rear cogs.

Hub overhaul

In order to move the freewheel in or out, it may be necessary to re-space the hub axle, requiring a hub overhaul.

Rear-derailleur adjustment

If the freewheel is moved in or out to correct a chainline error, it will be necessary to re-adjust the rear derailleur.

Wheel truing

If re-spacing the hub, then the wheel may require re-dishing.

Rear-triangle alignment

A chainline error is often caused by a misalignment of the rear triangle. Although an alignment problem can be compensated for by moving the chainrings or rear cogs, the ideal place to start is by correcting any rear-triangle-alignment error. If this is not done and the chainline error is corrected by other means, then when

the rear triangle gets aligned later for other reasons, the chainline could be lost. Frame alignment can only be done with steel frames. With titanium, aluminum, and carbon-fiber frames, the first choice of chainline-error correction should be moving the chainrings. If repositioning the chainrings does not solve the problem, then change the chainline by moving the freewheel.

If re-spacing a hub to move the freewheel to fix a chainline error, it is possible that the overall hub width will change, and it will no longer fit the frame. In this case, frame alignment would also be needed.

INDICATIONS

Chainline does not have to be perfect, so measuring chainline just for the sake of preventative maintenance is not recommended. Think about chainline only when there are symptoms that indicate chainline error, or when making a change to a bike that can introduce chainline error.

There are a great number of changes that can be made to a bicycle that can introduce symptoms of chainline error. Each time a change is made in one of the following areas, operate the bike and observe whether any symptoms of chainline error have developed.

Change: New crankset

Whether the crankset is going on an existing bottom bracket or comes with a new bottom bracket, there is no way to know whether the chainring position will be the same until after installation. If the position of the chainrings is different, check whether chainline-error symptoms have developed.

Change: New right crank arm

If replacing the right crank arm with one that is not identical, it may move the position of the chainrings. If the position of the chainrings is different, check whether chainline-error symptoms have developed.

Change: New bottom bracket

If replacing the bottom bracket with one that is not identical, it may move the position of the chainrings. If the position of the chainrings is different, check whether chainline-error symptoms have developed.

Change: New or reversed bottom-bracket spindle

If replacing the bottom-bracket spindle with one that is not identical, or just reversing an old one to improve the chainring or crank-arm clearance, it may change the position of the chainrings. If the position of the chainrings is different, check whether chainline-error symptoms have developed.

Change: New rear wheel

If replacing the rear wheel with one that is not identical, then the wheel may move the rear cogs further out or in. If the position of the rear cogs from the frame is different, check whether chainline-error symptoms have developed.

Change: New freewheel or freehub body with different number of cogs

Anytime the number of rear cogs is changed, there is a new center to the cogset. Check whether chainline-error symptoms have developed.

Change: New spacing on rear hub

If changing the spacing on the rear axle to change the fit of the wheel to the frame, or to accommodate a different freewheel or freehub body, or to correct a clearance problem between the outermost rear cog and the frame, the position of the rear-cogset center will change. Check whether chainline-error symptoms have developed.

Change: New chain

As chains wear, they develop greater lateral flexibility. The degree of lateral flexibility differs from one model of chain to another. A chain's lateral flexibility determines to what degree certain amounts of chainline error will be tolerated. Check whether chainline-error symptoms have developed after installing a new chain.

Change: New rear-derailleur pulley wheels or new rear derailleur.

One of the symptoms of chainline error is that the chain derails from the lower derailleur pulley wheel. Different pulley wheels engage the chain in varying degrees of effectiveness. Anytime pulley wheels are changed, on an old derailleur or by installing a new derailleur, check whether chainline-error symptoms have developed.

Change: Newly aligned frame rear triangle

If changing the rear-triangle alignment to fix a tracking error, or to have it fit the rear wheel differently, it will move the center of the rear cogset. Check whether chainline-error symptoms have developed.

Symptom: Chain derails to outside of lower rear-derailleur pulley wheel only in certain gear combinations.

This symptom, which is one of the most likely symptoms resulting from the chainrings being too far out relative to the rear cogs, is most likely to occur when the chain is on an outer chainring in front and

one of the inner rear cogs. If it only happens when back pedaling and self-corrects when pedaling forward, ignore it. If significant chainline error cannot be found after experiencing this symptom, it could be caused by an incompatibility between the chain and pulley wheel, an alignment error to the rear-derailleur hanger, or damage to the rear derailleur that affects the alignment of the rear-derailleur cage.

Symptom: Chain makes popping or snapping sound as it feeds onto a chainring only in certain gear combinations.

This *chainrings-out* symptom is most likely to occur when the chain is on an outer chainring in front and one of the inner rear cogs. If it goes away when shifting the chain further out on the rear cogs and there is an identifiable chainline error, then it is fair to assume the problem is chainline. If significant chainline error cannot be found after experiencing this symptom, it could be caused by a low-quality chain or chainring.

Symptom: While shifting, chain derails to inside of chainrings, and front derailleur cannot be adjusted to eliminate problem.

This *chainrings-out* symptom requires a very severe chainline error on the average bike, but road-racing bikes with eight-speed cogsets can be very sensitive to this error and may exhibit this symptom even when the error is not large. The symptom generally occurs when the chain is on the innermost rear cog and shifting the front derailleur to put the chain on the innermost chainring. Because this symptom can be caused by poor derailleur alignment and limit-screw settings, first check the derailleur adjustment. If the derailleur cannot be adjusted to eliminate the symptom without introducing the symptom where the chain is hesitant to shift to the innermost chainring (or rubs the chain after the shift), then chainline is likely to be the cause. With some of the eight-speed road-racing bikes, the symptom will not go away until the front-derailleur cage is modified to make it wider at the tail.

Symptom: While pedaling, chain derails to inside of chainrings.

The symptom generally occurs when the chain is on the innermost rear cog and the middle or innermost chainring. It is most likely to occur when the chain is under high load, or when pedaling very fast (low load) and the chain is bouncing (due to rough

terrain or choppy pedaling style). It is less likely to occur with the bike in the stand, but will happen particularly at high pedaling speeds.

Symptom: Chain derails to inside of lower rear-derailleur pulley wheel only in certain gear combinations.

This symptom, which is one of the most likely symptoms resulting from the chainrings being too far in, relative to the rear cogs, is most likely to occur when the chain is on an inner chainring in front and one of the outer rear cogs. If it only happens when back pedaling and self-corrects when pedaling forward, ignore it. If significant chainline error cannot be found after experiencing this symptom, it may be caused by an incompatibility between the chain and pulley wheel, an alignment error to the rear-derailleur hanger, or damage to the rear derailleur that affects the alignment of the rear-derailleur cage.

Symptom: Chain rubs against adjacent rear cog only in certain gear combinations.

This *chainrings-in* symptom is most likely to occur when the chain is on an inner chainring and one of the outer rear cogs. If this symptom is caused by incorrect spacing between rear cogs or use of a wide chain with narrow-spaced cogs, it will not go away when the chain is shifted to an outer chainring.

Symptom: Chain rubs against adjacent chainring only in certain gear combinations.

This *chainrings-in* symptom is most likely to occur when the chain is on an inner chainring in front and one of the outer rear cogs. If the chainrings have been recently installed on the crank arm, then spacers may be out of place. If the chainrings and crank arm did not come together as a set, they may be incompatible.

TOOL CHOICES

There is one tool, the Park CLG-2, that is not recommended due to limitations of its accuracy and limited conditions in which it fits well.

There are two alternate procedures for measuring chainline in this chapter. The first (pages 27-6 through 27-7) requires the following tools. None of them are bicycle-specialty tools.

Caliper

Quick Grip clamp (hardware stores or United Bicycle Tool)

2' long 3/8" square bar stock (hardware store)

The square bar stock is used as a straight edge. A conventional straight edge made from flat stock (like a ruler) will not work. Instead of a solid bar stock, square tubing may be used. The stock or tubing may be 1/2" instead of the preferred 3/8" size.

The alternate procedure (page 27-13) uses a new tool, the Stein CLC-1. The procedure utilizing this tool is both easier and more accurate than the first procedure.

Another tool used in the procedure is the Park FAG-2. This tool is used to measure the rear-triangle alignment of the frame. It is a recommended tool in the chapter **FRAME AND FORK ALIGNMENT AND DAMAGE**.

TIME AND DIFFICULTY

Chainline-error inspection

It only takes a couple of minutes to put the bike in a stand and run it through all the gear combinations to see if there are any symptoms. There is no difficulty.

Chainline-error identification

Measuring chainline error takes only 3–5 minutes. The job has moderate difficulty.

Chainline-error correction

All the difficulty with chainline comes with correction. At the minimum, chainline correction is a matter of overhauling a bottom bracket to reverse the spindle or put in a different one. With crank-arm removal and installation and re-adjustment of the front derailleur, this could easily be a 45–60 minute job of moderate to high difficulty. It may be necessary to overhaul the rear hub to re-space the rear axle, and that will also require rear-derailleur adjustment and re-dishing the rear wheel. This could be 75–100 minute and the difficulty would be high. Neither of these options includes alignment of the rear triangle, which could add an additional 15–30 minutes.

COMPLICATIONS

Chainrings will not move far enough

In some cases, there may not be a long enough bottom-bracket spindle available to move the chainrings out far enough to correct the chainline error. In other cases, in order to move the chainrings in far enough to correct the chainline error, the chainrings or crank arm might end up rubbing against the frame. In all these cases, after correcting chainline at the chainrings as far as is possible, the chainline correction needs to be continued by changing the rear-cogset position (which could include hub re-spacing, wheel dishing, and frame alignment).

Poor frame alignment is causing the problem, but frame cannot be aligned

Non-steel frames and many full-suspension frames cannot be aligned. This limits correction to moving the chainrings and shifting spacers from one side of the hub to the other in order to move the cogset.

Moving chainrings solves chainline symptom, but front derailleur will not adjust to new position

If the chainrings end up too far out or too close in, the front derailleur may have difficulty shifting to the innermost or outermost chainring. In this case, the derailleur may need to be changed, or the chainrings moved less and additional chainline correction done at the rear cogs.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into five parts. The first three parts are procedures that are combined together. In order, the procedures are inspecting for chainline-error symptoms, measuring chainline error, and determining a course of action for chainline-error correction. After determining the course of action to be taken, refer to the appropriate chapters for crank-arm removal, bottom-bracket service, and front-derailleur adjustment; or hub overhaul, wheel dish, and rear-derailleur adjustment. The fourth part of this chapter is a troubleshooting chart. The fifth part is an alternate procedure for measuring chainline.

CHAINLINE-ERROR INSPECTION, MEASUREMENT, AND CORRECTION

INSPECTING FOR CHAINLINE-ERROR SYMPTOMS

It is unnecessary and not recommended to correct chainline error unless there is a symptom indicating one exists. Do not skip the steps to determine if symptoms exist unless already experiencing one of the symptoms, or troubleshooting in another chapter has led you to this chapter to correct a chainline error.

Any of these symptoms can be caused by something other than a chainline error. After determining the symptom exists, identify if a significant error exists in a direction that is consistent with the symptom. If this cannot be done before correcting any chainline error, check and correct any other possible causes of the symptom(s).

NOTE: *If symptom indicating chainrings-out or chainrings-in error is already known, skip to step 7.*

1. [] Shift chain onto outermost chainring and innermost rear cog and pedal fast, then slow, and observe whether chain rides off of lower pulley wheel of rear derailleur. If yes, go to **MEASURING CHAINLINE ERROR** and check for **chainrings-out error**.
2. [] Shift chain onto outermost chainring and innermost rear cog and pedal slow, and observe whether chain side-plates catch on top of chainring teeth before chain rollers settle between teeth. If yes, go to **MEASURING CHAINLINE ERROR** and check for **chainrings-out error**.

If a chain refuses to shift down to the innermost chainring without jumping off all the way to the bottom-bracket shell, chainline error can be the culprit. This is tested for in step #3. It can also be caused by poor front-derailleur adjustment, including inner-limit screw too loose (allowing too much inward travel of the front derailleur) and poor rotational alignment of the front derailleur. This symptom has been experienced on road-racing bikes with eight-speed rear cogsets where the derailleur adjustments and chainline were good. In this case, the only solution is to deform the front-derailleur cage so that its tail end is 2–3mm wider, and then re-adjust the rotation and limit screws of the front derailleur.

Because this next symptom can't even be considered as a chainline-error symptom unless all these front-derailleur considerations are eliminated, attempt everything possible with the front derailleur before performing the test in step #3.

3. For this next test, it is important that front derailleur be in known good adjustment.
 - [] Shift chain onto innermost rear cog and innermost chainring and check that inner plate of front-derailleur cage clears inner face of chain by $\leq 1\text{mm}$.
 - [] Shift chain onto next chainring outward.
 - [] Shift chain back to inner chainring and observe whether chain drops past chainring and onto bottom-bracket shell. If yes, go to **MEASURING CHAINLINE ERROR** and check for **chainrings-out error**.

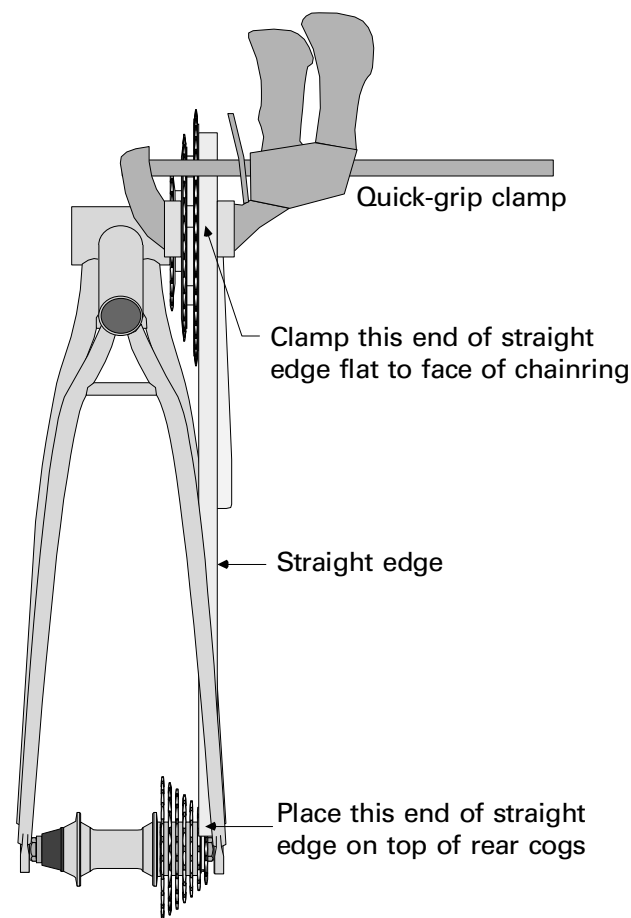
27 – CHAINLINE

4. [] Shift chain onto outermost rear cog and innermost chainring and pedal fast, then slow, and observe whether chain rides off of lower pulley wheel of rear derailleur. If yes, go to **MEASURING CHAINLINE ERROR** and check for *chainrings-in* error.
5. [] Shift chain onto outermost rear cog and innermost chainring and pedal slow, and observe whether chain rubs against the next rear cog. If yes, go to **MEASURING CHAINLINE ERROR** and check for *chainrings-in* error.
6. [] Shift chain onto outermost rear cog and innermost chainring and pedal slow, and observe whether chain rubs against the next front chainring. If yes, go to **MEASURING CHAINLINE ERROR** and check for *chainrings-in* error.

MEASURING CHAINLINE ERROR

7. [] Shift chain to any middle cog in rear, and drop chain off inside of innermost chainring.

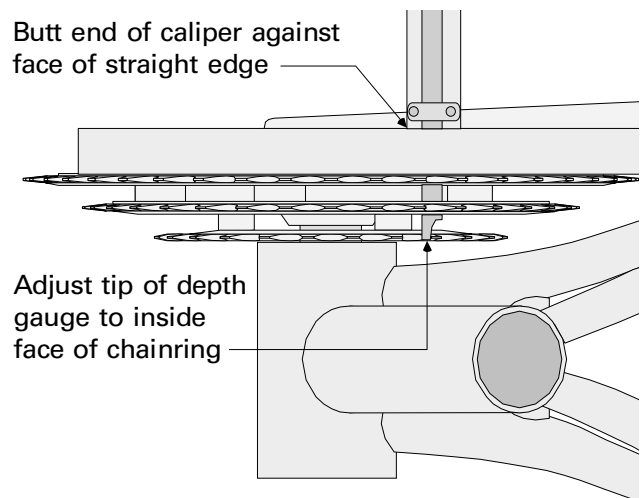
Attaching the straight edge



27.2 Attaching the straight edge to the outer chainring with a Quick Grip clamp.

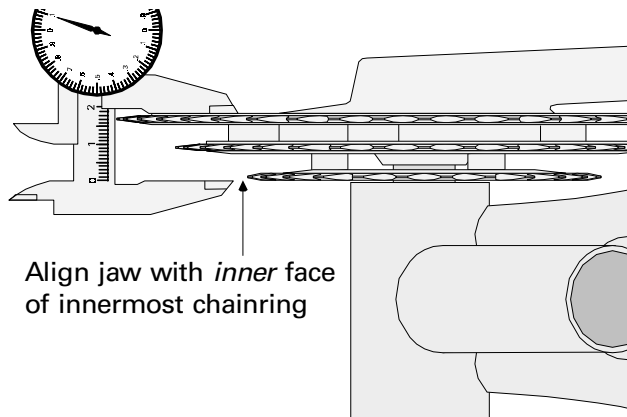
The following procedure is only as accurate as the outer chainring is straight. Every effort should be made to align the outer chainring as straight as possible before measuring the chainline error (chainring alignment is described in the **TAPER-FIT CRANK ARMS** chapter [page 20-10] and the **CHAINRINGS** chapter [page 23-12]). Most chainrings have a reasonably flat outer face; chainrings that have bumps and protrusions on their face will make this procedure less accurate. The straight edge needs to be clamped against the face of the outer chainring near the top, and the left end of the straight edge should extend back as far as possible without encountering resistance from the seat stay or dropout (see figure 27.2).

8. [] Attach straight edge against outer face of outermost chainring so that end of straight edge stops just short of rear dropout, and straight edge goes across face of chainring at whatever point enables straight edge to sit flat.
9. [] Use caliper to measure from outside face of straight edge to inside face of innermost chainring and record here: _____ mm



27.3 Measure from outer face of straight edge to inner face of innermost chainring.

In the next step, use the long jaws of the caliper to measure from the outside face of the outermost chainring to the inside face of the innermost chainring. Take care to hold the calipers perpendicular to the plane of the chainrings.

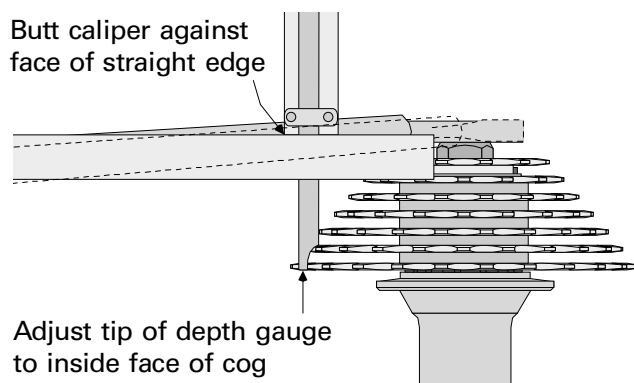


27.4 Measure from the outside face of the outermost chainring to the inside face of the innermost chainring with calipers.

10. [] Measure width of chainring set with caliper from outer face of outer chainring to inner face of inner chainring, then record here and divide by 2: width: _____ ÷ 2 = _____ mm

11. [] Subtract result at end of step 10 from step 9 and record sum here:
FRONT CENTER FACTOR = _____ mm

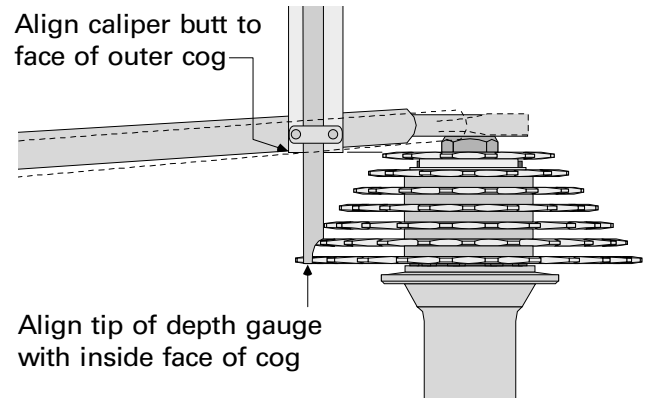
In the next step, use the depth gauge of the caliper to measure from the outside face of the straight edge to the inside face of the innermost rear cog. Take care to hold the calipers perpendicular to the plane of the cogs.



27.5 Measure from the face of the straight edge to the inside face of the innermost rear cog with calipers.

12. [] Use caliper to measure from outside face of straight edge to inside face of innermost rear cog and record here: _____ mm

In the next step, use the depth gauge of the caliper to measure from the outside face of the outermost rear cog to the inside face of the innermost rear cog. Take care to hold the calipers perpendicular to the plane of the cogs.



27.6 Measure from the face of the outermost rear cog to the inside face of the innermost rear cog with calipers.

13. [] Measure width of rear cogset with caliper from outer face of outer cog to inner face of inner cog, then record here and divide by 2: width: _____ ÷ 2 = _____ mm

14. [] Subtract result at end of step 13 from step 12 and record sum here:

REAR CENTER FACTOR = _____ mm

15. [] Repeat **FRONT CENTER FACTOR** from step 11 here: _____ mm

The sum in step #16 may end up as a positive or negative number. If the number is positive, then the chainrings are further out from the bike center than the rear cogset. Chainline-error symptoms consistent with a *chainrings-out* condition might be fixed by correcting the problem, unless the error is insignificant (less than 1mm). If the number is negative, then the chainrings are closer in to the bike center than the rear cogset. Chainline-error symptoms consistent with a *chainrings-in* condition might be fixed by correcting the problem, unless the error is insignificant (less than 1mm).

16. [] Subtract step 15 from step 14:
CHAINLINE ERROR = _____ mm

DETERMINING COURSE OF ACTION FOR ERROR CORRECTION

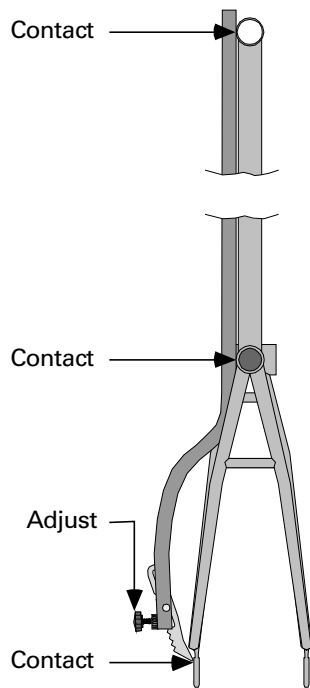
If frame will not be aligned

If not intending to align the frame, even if there is an error, then skip to step #23. This may be because the frame is not steel or because the shop does not align frames.

Measuring rear-triangle-alignment error

The procedure in steps #17–#22 is an abbreviated procedure for checking rear-triangle alignment. In the **FRAME AND FORK ALIGNMENT AND DAMAGE** chapter there is a detailed procedure and diagrams of this process (page 8-5). It is strongly recommended that you be familiar with rear-triangle alignment before performing steps #17–#22. These steps are also mentioned in the **PREREQUISITES** section of this chapter (page 27-2).

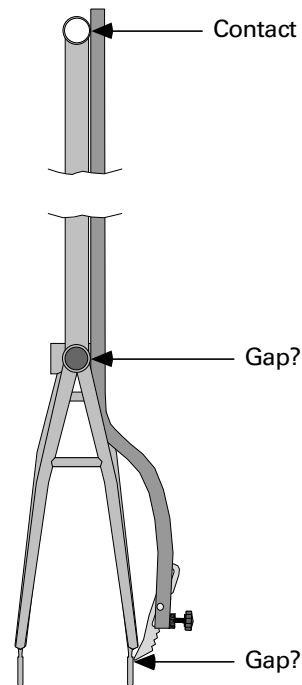
When measuring the rear-triangle-centering error, there will be a measurement that tells the difference in one dropout position relative to the central plane of the bike compared to the other dropout's position relative to the central plane of the bike. This measurement will be arrived at by measuring the gap between the adjustable tip of the tool and the face of a dropout. Whatever the gap is, the cogs will move by one half the amount of the gap when the rear triangle is aligned perfectly. If the gap is found at the right dropout, the rear cogs will move to the right. If the gap is at the left dropout, the rear cogs will move to the left.



27.7 This drawing shows the initial set up of the FAG-2 on the left side of the bike.

17. [] Place long flat section of Park FAG-2 against left side of head tube and seat tube so that adjustable tip is overlapping face of rear dropout, and adjust tool tip so that it gently contacts dropout face.

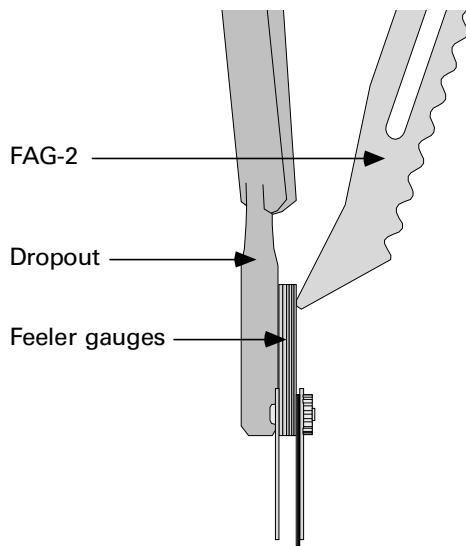
It is arbitrary which side to start on when using the FAG-2 tool, but the procedure starts on the left. If the rear triangle is off-center to the left, then it will show up as a gap at the right dropout. If the rear triangle happens to be off to the right, then a gap will show up at the seat tube on the right side. In this case, since the error cannot be quantified at this point, it will be necessary to reset the tool on the right so that the gap will show up at the left dropout.



27.8 Transfer the tool to the right side of the frame, check whether there is a gap, and check whether it is at the seat tube or dropout.

18. Transfer FAG-2 to right side of bike and observe whether:

- [] Tool contacts simultaneously at head tube, seat tube, and right rear dropout face. There is no rear-triangle-centering error.
- [] Tool contacts at head tube and right rear dropout and has gap at seat tube. There is some rear-triangle-centering error and adjusting tip must be set so that tool contacts at three points on right side, then transferred to left so error can be measured at left rear dropout. Check third part of this step also.
- [] Adjustable tip shows gap at rear dropout face (either). With stack of feeler gauges or caliper, measure gap between tip of FAG-2 and dropout face and record here: _____ mm *left side?* or *right side?* (circle one).



27.9 When a gap at the dropout is found, measure the gap with feeler gauges.

19. [] If measurement in step 18 is $\leq 2\text{mm}$, the effect of rear-triangle alignment on chainline error would be negligible. Leave rear triangle as is and skip to step 24.
20. [] If gap is between FAG-2 adjustable tip and *right* dropout face, correcting rear triangle will move rear cogset *out* by half amount of gap recorded in step 18. This would have same effect as moving chainrings *in* by same amount.
21. [] If gap is between FAG-2 adjustable tip and *left* dropout face, correcting rear triangle will move rear cogset *in* by half amount of gap recorded in step 18. This would have same effect as moving chainrings *out* by same amount.
22. [] If rear-triangle-alignment error is significant and frame is steel, consider aligning rear triangle before doing any other chainline-error corrections.
23. [] If rear triangle has been aligned after discovering chainline error, repeat steps 1–16 to determine if symptoms remain and amount and direction of remaining chainline error.

Calculate maximum correction possible for moving chainrings in

If performing a frame alignment has not solved the chainline error, then the best place to continue to solve the chainline error is at the chainrings. If there is no frame-alignment error, then the best place to start making chainline-error corrections is still at the chainrings. If you are not aligning the frame because the frame is not suitable (or it is not shop policy to align frames), the best place to start making chainline-

error corrections is at the chainrings. Chainrings may be moved in or out by changing the bottom-bracket spindle. The only practical limit to how far the chainrings can be moved *out* is the sizes of the available spindles. The limit to how far crank-arm/chainrings can be moved *in* is the potential of the crank arm or chainrings to rub the frame. The clearance between the frame and the crank-arm/chainrings must be 2mm or more to account for the amount that the chainrings, crank arm, and frame flex under load. The next steps measure the existing clearance and determine the maximum amount the chainrings can move in.

If the maximum amount the chainrings can move is not enough to eliminate the symptom, then resort to the more difficult solution of moving the rear cogs. Keep in mind that the chainrings do not necessarily have to be moved enough to make the chainline perfect, only enough to eliminate the symptom. For this reason, always move the chainrings as much as possible to achieve perfect chainline, and then test for symptoms before deciding to make any additional correction at the rear cogs.

24. [] Use stack of feeler gauges to measure gap between chain stay and closest part of right crank-arm/chainring assembly and record here: _____ mm.
25. [] Subtract 2mm from number in step 24 and record answer here: _____ mm.
26. [] Number in step 25 is maximum chainring correction. If this number is more than 1mm less than the number in step 16, moving chainrings in to limit will not complete chainline-error correction (continue at cogset).
27. [] If number in step 25 is $< .5\text{mm}$, chainline correction by moving chainrings is not possible. Skip to step 35.

Determine best replacement bottom-bracket spindle to correct chainline error

Bottom-bracket-spindle interchangeability is complex. The next steps simply accumulate the necessary information to calculate what bottom-bracket spindle would be better, but do not do actual calculations. To calculate the appropriate replacement spindle, use the spindle-interchangeability procedure in the **ADJUSTABLE-CUP BOTTOM BRACKETS** chapter (page 9-13).

28. [] If *chainrings-in* error exists, number in step 14 is amount new bottom-bracket spindle should move chainrings out. Record again here: _____ mm.
29. [] If *chainrings-out* error exists, smaller of two numbers in steps 12 & 24 is amount new bottom-bracket spindle should move chainrings in. Record again here: _____ mm.

30. [] Remove bottom-bracket spindle and record all markings that might identify existing bottom-bracket spindle. Record brand and markings here: _____
31. [] Go to SPINDLE INTERCHANGEABILITY in ADJUSTABLE-CUP BOTTOM BRACKETS chapter (page 9-13) to determine acceptable replacement spindles.

Determine if symptoms remain after correcting chainline error by moving chainrings

Once the chainrings are moved, it is necessary to see if symptoms persist. If the error was fully corrected but the symptoms persist, look for other causes. If the error was not fully corrected but the symptoms are gone, chainline correction is done. If the error was not fully corrected and the symptoms remain, go ahead to moving the rear cogs to further correct chainline.

32. [] Repeat steps 1–6 to determine if chainline-error symptoms remain after making full or partial correction of error by moving chainrings.
33. [] If error symptoms remain, repeat steps 8–16 to determine direction and amount of remaining error. If error is $\leq 1\text{mm}$ or is in wrong direction to create symptom, see INDICATIONS (page 27-2) or CHAINLINE TROUBLESHOOTING (page 27-11) to determine other possible causes of symptom.

Error and symptoms remain after moving chainrings as much as possible and significant error remains

34. *If rear cogs need to move in* (chainrings could not be moved out enough) to correct remaining chainline error:
 [] Amount of error recorded in *repeated* step 16 is amount of spacer thickness that needs to be transferred from left side of axle to right side of axle. Wheel needs to be re-dished and rear derailleur needs adjustment after transferring spacers.
 [] If spacers are unavailable to transfer from left side of axle to right side of axle, the amount of error in *repeated* step 16 is half of amount of spacer thickness that needs to be *added* to right side of axle set. Wheel needs to be re-dished, rear triangle *must* be realigned (not an option unless frame is steel), and rear derailleur needs adjustment after adding spacers.

35. *If rear cogs need to move out* (chainrings could not be moved in enough) to correct remaining chainline error:

[] Amount of error recorded in *repeated* step 16 is amount of spacer thickness that needs to be transferred from right side of axle set to left side of axle set. Clearance of chain to frame when chain is on outermost rear cog or shifting from outermost rear cog to the next cog should be checked. Wheel needs to be re-dished and rear derailleur needs adjustment after transferring spacers.
 [] If spacers unavailable to transfer from right side of axle to left side of axle, amount of error in *repeated* step 16 is half of amount of spacer thickness that needs to be *added* to left side of axle set. Wheel needs to be re-dished, rear triangle *must* be re-aligned (not an option unless frame is steel), and rear derailleur needs adjustment after adding spacers.

Determine if symptoms remain after correcting chainline error by moving rear cogs

Symptoms indicating chainline error may be caused by a variety of problems other than chainline error. After checking that chainline error has been eliminated, check if any symptoms remain (step #36). If symptoms remain, it is time to look toward other things as the source of the symptoms. The other things that cause symptoms similar to chainline error are covered in the INDICATIONS section (page 27-2) and the CHAINLINE TROUBLESHOOTING section (page 27-11).

36. [] Repeat steps 1–6 to determine if chainline-error symptoms remain after making complete correction of error. If they do, see INDICATIONS (page 27-2) or CHAINLINE TROUBLESHOOTING (page 27-11) to determine other possible causes of symptom.

CHAINLINE TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>When pedaling in a gear combination that has the chain on one of the outer rear cogs and the innermost chainring, the chain comes off the lower rear-derailleur pulley wheel and rides against the rear-derailleur-cage plate.</i>	
Chainrings are too far in relative to rear cogs and lateral force on chain is forcing it to derail from lower rear-derailleur pulley wheel.	Check for <i>chainrings-in</i> error and correct if significant and in the correct direction.
If lower derailleur pulley wheel or chain was changed just before symptom developed, they are incompatible, particularly if both are a low profile configuration.	Replace lower pulley wheel with brand or model that has tall teeth, or replace chain with model that has side plates protruding above rollers.
If chainline is good or error is in the opposite direction to what would normally cause this symptom, the derailleur hanger is mis-aligned.	Check and correct rear-derailleur-hanger alignment.
If chainline is not the cause, pulley-wheel/chain compatibility is not an issue, and the rear-derailleur-hanger alignment is good, then the rear-derailleur cage is bent.	Align rear-derailleur cage or replace rear derailleur.
SYMPTOM: <i>When pedaling in a gear combination that has the chain on one of the outer rear cogs and the innermost front chainring, the chain seems to rub on the next inboard rear cog.</i>	
The chainrings are too far in, relative to the rear cogs, and the angle of the chain to the innermost chainrings is more than the space between the rear cogs will allow without interference between the chain and an adjacent cog.	Check for <i>chainrings-in</i> error and correct if significant and in the correct direction.
If chainline is good or error is in wrong direction, spacers could be wrong between cogs, particularly if cogs have recently been installed.	Check and correct spacers between cogs.
If chainline is good or error is in the wrong direction, wide chain could be in use with narrow-spaced cogset, particularly if either chain or cogset has been replaced.	All seven- and eight-cog sets are narrow. A few six-cog sets are narrow. If cog set is narrow use chain that has rivet length of 7.4mm or less.
SYMPTOM: <i>When pedaling in a gear combination that has the chain on one of the outer rear cogs and the innermost front chainring, the chain seems to rub on the next chainring out.</i>	
The chainrings are too far in, relative to the rear cogs, and the angle of the chain to the outer rear cog is more than the space between the chainrings will allow without interference between the chain and the adjacent chainring.	Check for <i>chainrings-in</i> error and correct if significant and in the correct direction.
If chainline is good or error is in the wrong direction, spacers could be wrong between chainrings, particularly if chainrings have recently been installed. A most likely case causing this would be if Shimano SG/SGX/HyperDrive chainrings have been installed on a non-compatible crank arm.	Check and correct spacers between chainrings.
If chainline is good or error is in the wrong direction, wide chain could be in use with narrow-spaced chainring set, particularly if either chain or chainring set has just been replaced. A most likely case would be if Shimano SG/SGX/HyperDrive chainrings are being used with a chain that has rivets more than 7.4mm long.	Replace chain with one that has a rivet length of 7.4mm or less.

(Continued next page)

CHAINLINE TROUBLESHOOTING (Continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>When pedaling in a gear combination that has the chain on one of the inner-rear cogs and the outermost chainring, the chain comes off the lower rear-derailleur pulley wheel and rides against the rear-derailleur-cage plate.</i>	
Chainrings are too far out relative to rear cogs, and lateral force on chain is forcing it to derail from lower rear-derailleur pulley wheel.	Check for <i>chainrings-out</i> error and correct if significant and in the correct direction.
If lower rear-derailleur pulley wheel or chain was changed just before symptom developed, they are incompatible, particularly if both are a low profile configuration.	Replace lower pulley wheel with brand or model that has tall teeth, or replace chain with model that has side plates protruding above rollers.
If chainline is good or error is in opposite direction to what would normally cause this symptom, derailleur hanger is mis-aligned.	Check and correct rear-derailleur-hanger alignment.
If chainline is not the cause, pulley-wheel/chain compatibility is not an issue, and rear-derailleur-hanger alignment is good, rear-derailleur cage is bent.	Align rear-derailleur cage or replace rear derailleur.
SYMPTOM: <i>The chain seems to snap or pop onto the chainring teeth when pedaling in a gear combination that has the chain on one of the inner rear cogs and on the outermost chainring.</i>	
Chainrings are too far out relative to rear cogs, and chain side plates are hanging up on top of chainring teeth before chain drops into place.	Check for <i>chainrings-out</i> error and correct if significant and in the correct direction.
Chain is wiggly or bent.	Sight down length of chain to inspect for wiggles.
New cheap steel chainrings have sharp edges to teeth that are catching on chain side plates.	Should go away with break-in.
SYMPTOM: <i>The front derailleur cannot be adjusted to eliminate the tendency of the chain to drop past the innermost chainring when shifting to it and the chain is on one of the inner rear cogs.</i>	
The chainrings are too far out relative to the rear cogs, and the lateral force on the chain is causing it to whip past the inner chainring once it is free of the next chainring out.	Check for <i>chainrings-out</i> error and correct if significant and in the correct direction.
If chainline is good, front derailleur is out of adjustment.	Check front-derailleur height, front-derailleur rotational alignment, and inner-limit screw setting of front derailleur.
If chainline and front-derailleur adjustment are good, and bike is a road-racing model with 8 rear cogs, front-derailleur performance is <i>too good</i> .	Modify width of tail of front-derailleur cage (widen) to retard front-derailleur performance.

MEASURING CHAINLINE ERROR WITH STEIN CLC-1

The Stein CLC-1, in conjunction with a caliper, is a relatively accurate and easy-to-use tool for measuring chainline error. The tool consists of two parts: a main bar that attaches to the chainrings and extends back to the rear cogs, and a second calibrated bar that is butted against the rear cogs in order to take an error reading.

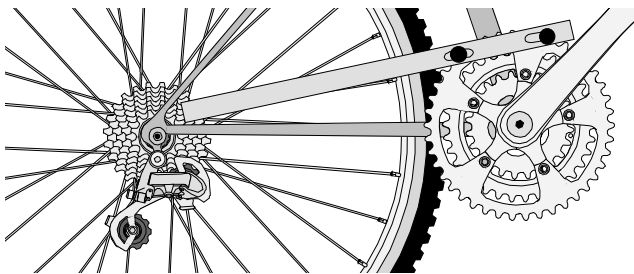
The calibrated bar over-simplifies the process. It is good for indicating whether the chainline is “good” or “not good,” but it is not very effective at indicating the amount of error. The following procedure substitutes a table of dimensions and a caliper for the calibrated bar, which makes it possible to accurately determine the amount of error.

The procedure is designed with the assumption that a digital caliper is being used, but there are extra steps at the end that make the procedure work with a non-digital caliper, as well.

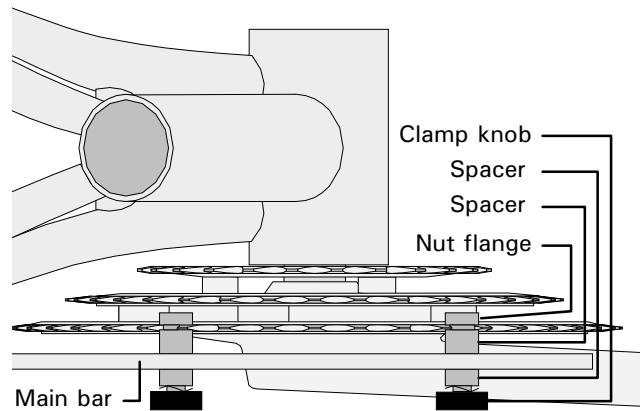
For optimal accuracy, the tool should be put in four different locations on the chainrings, and the results averaged. This neutralizes error created by out-of-true chainrings. If the chainrings have excellent true, then one reading should be sufficient. If four readings will be taken, be sure to start with one end of the tool immediately adjacent to the crank arm so that the additional readings can be taken at 90° intervals around the chainrings.

When attaching the main bar to the chainrings, note that the chainring teeth are to be sandwiched between the flange on the inner end of each clamp mechanism and the large spacer that is adjacent to the inner face of the main bar.

1. [] Place tool on outer chainring so that it is on outer face of chainring and adjacent to crank arm. Left end of tool should be at rear cogs, and not interfering with frame.



27.10 Attach the Stein CLC-1 to the outer chainring so the tool is outside the chainring and the left end of the tool is in front of the freewheel and not interfering with the frame. For the first measurement, start with the right end of the tool close to the crank arm.



27.11 Position the tool so the main bar and spacers are on the outer side of the outer chainring, and the flanges of the sleeve nuts are against the inner face of the outer chainring teeth.

NOTE: Skip step 2 if using non-digital caliper!

To use the table in step #2, simply look up the intersection of the row for the number of chainrings on the bike with the column for the number of rear cogs on the bike.

2. [] Set digital caliper to appropriate value from table below (in millimeters), then zero caliper.

Stein CLC-1 Chainline Values

Rear cogs:	5	6	7	8	9
Chainrings: 2	27.5	28.5	29.5	31.5	33.0
3	31.5	32.5	33.5	35.5	37.0

3. [] Set depth gauge against outer face of innermost rear cog, and adjust butt of caliper until it is just against face of CLC-1, then record 1st reading in step 4.
- [] Move tool to a position 8–10 teeth away from its current position, repeat measurement, then record 2nd reading in step 4.
- [] Move tool to a position 8–10 teeth away from its current position, repeat measurement, then record 3rd reading in step 4.
- [] Move tool to a position 8–10 teeth away from its current position, repeat measurement, then record 4th reading in step 4.

Step #4 calculates the actual chainline error if a digital caliper has been used. If not using a digital caliper, then use the result in step #4 as part of the calculation in steps #5–7. Regardless of whether the actual error is determined in step #4 or step #7, note that a positive error means the chainrings are positioned too far out relative to the rear cogs, and that a negative error means the chainrings are positioned too far in relative to the rear cogs.

27 – CHAINLINE

4. [] Add readings recorded below, then divide by 4 to find chainline error.

1st reading: _____ mm

2nd reading: _____ mm

3rd reading: _____ mm

4th reading: _____ mm

TOTAL _____ mm

divide by 4 $\div 4$

Chainline error: _____ mm (result)

NOTE: Steps 5-7 are only needed if a non-digital caliper was used.

5. [] Look up appropriate value in table in step 2,

and record here: _____ mm

6. [] Subtract step 4 result: – _____ mm

7. [] Chainline error is: _____ mm

28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

ABOUT THIS CHAPTER

This chapter is about stems, handlebars, handlebar extensions and clip-ons, and handlebar coverings. With regard to stems, it covers removing stems from the bike, fitting stems to the bike, installing and aligning the stem, and problems with stems. With regard to handlebars, it covers removing handlebars from the stem, fitting handlebars to the stem, installing and aligning the handlebars, and problems with handlebars. With regard to handlebar extensions and clip-ons installation, alignment and security are covered. Each of these subjects simultaneously addresses road and off-road varieties. With regard to handlebar coverings, there are instructions for installing and removing off-road handlebar grips and road-bike handlebar tape.

Supplemental information about BMX/Freestyle bars and stems and upright (touring and cruiser) styles is also included. There are no specific procedures included for these types.

One type of stem is not covered in this chapter. Bikes with a threaded fork column have a headset that threads onto the fork column and a stem inserts inside the fork column. Bikes with a threadless fork column have a headset that slides onto the fork column, and a stem that clamps onto the fork column where it extends above the headset. Because the stem in this system functions as a lock for the headset adjustment, it is covered in the **HEADSET** chapter in the section on threadless headsets (page 11-21).

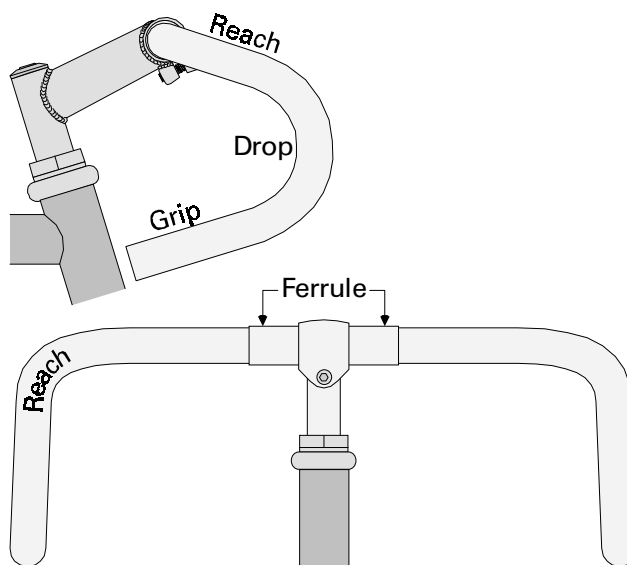
GENERAL INFORMATION

TERMINOLOGY

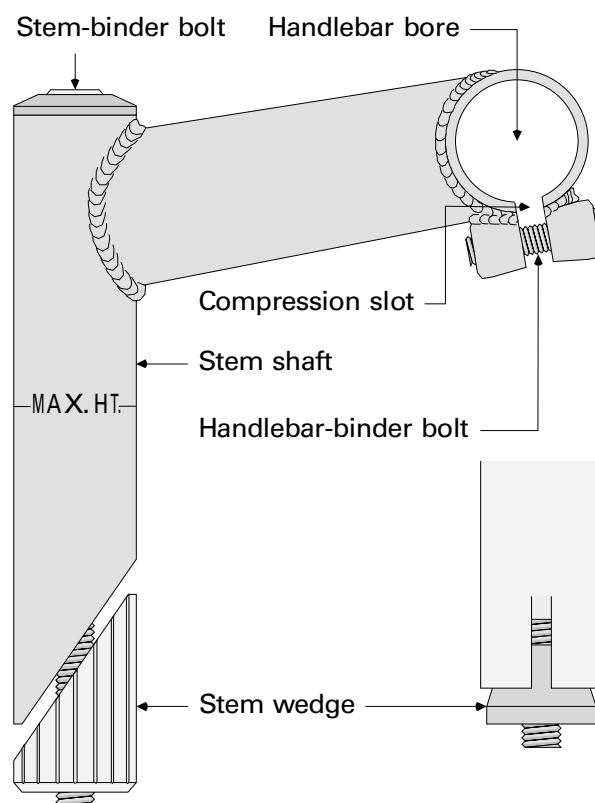
Handlebar: The tube that is gripped in the hands, and to which the brake levers and shift levers are usually mounted.

Bar: Short for *handlebar*.

Drop bar: The traditional road-bike handlebar that goes out from the stem, hooks forward, then curves down and back (the drop).



28.1 Parts of a drop bar.



28.2 Parts of a stem

28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

Bar center: The usually bulged or sleeve-reinforced center of the handlebar.

Handlebar ferrule: A reinforcing sleeve on a handlebar where the bar goes through the stem.

Stem: The component that connects the handlebar to the fork. It has also been called a “goose-neck,” or “neck.”

Stem shaft: The vertical shaft of the stem that inserts in the fork.

Stem rise: The vertical height of the stem.

Stem extension: The horizontal length of the stem.

Handlebar bore: The hole through the stem that the handlebar goes into.

Handlebar-binder bolt: The bolt that compresses the handlebar bore to secure the handlebar in the stem.

Compression slot: The slot in the handlebar bore that is compressed when the handlebar-binder bolt is tightened, causing the inside of the handlebar bore to compress on the handlebar. There is also a compression slot in the fork column bore of some stems that are used in threadless headsets (see page 11-21).

Stem-binder bolt: The vertical bolt that goes through the stem shaft that is used to secure the stem in the fork.

Stem wedge: The wedge piece below the stem shaft that secures the stem in the fork column when the stem bolt draws the wedge up. The wedge is usually a cylinder with a sloped end that slides across a corresponding slope on the bottom of the stem shaft. As the sloped wedge is drawn up, it displaces the bottom of the stem shaft laterally, causing it to bind against the inside of the fork column. Occasionally the wedge is a conical shape that slides up into a conical hole in the bottom of the stem, causing the split stem shaft to expand. (See figure 28.2, page 28-1.)

Handlebar extension: The forward extension that can be mounted on the outward end of an off-road handlebar.

Handlebar clip-on: A forward extension of the handlebar that can be mounted to a drop bar to enable the rider to ride in a more aerodynamic position.

Handlebar grips: The rubber or plastic sheaths that cover the end of an off-road bar where the bar is grasped. Also called “grips.”

PREREQUISITES

In certain instances, it is necessary to disconnect the brake-control wires and/or the shift-control wires in order to remove and replace a handlebar or stem. If this is the case, it will be necessary to adjust the derailleurs and/or brakes.

If changing stem length or bar size, it is possible that all the control cables will need to be re-sized. Once again, it will be necessary to adjust derailleurs and/or brakes.

INDICATIONS

The primary reasons to change the bar or stem is to upgrade quality or change the way the customer fits the bike. Bent MTB bars are somewhat common, as well. A stem would be also taken out to service the headset or replace a fork.

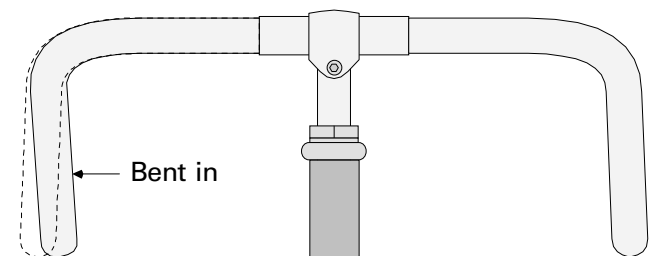
Maintenance cycles

Although stems and bars do not have moving parts, maintenance is very important. The stem runs the risk of becoming a permanent installation if the bike is exposed to a wet or humid environment, or if the customer rides a lot indoors and sweats on the stem. At least once every six months (and as often as monthly if conditions dictate it), the stem should be removed from the bike and the stem shaft, head of the stem bolt, stem-bolt threads, and stem wedge should be liberally greased. Bars need monthly inspections for fatigue bends and fatigue cracks. Handlebars should also be closely inspected for bends and cracks after every crash.

Symptoms indicating bars should be replaced

Handlebars need to be replaced when they crack. Bent handlebars are bars in the process of cracking, so all bent handlebars should be replaced immediately. Regular inspections of handlebars for cracks is very important. The most likely place for a crack to appear is on top of the bar and just outward of the stem. Other places to check for cracks on off-road bars is on either side of the brake-lever clamp and just inward of any handlebar-extension clamp.

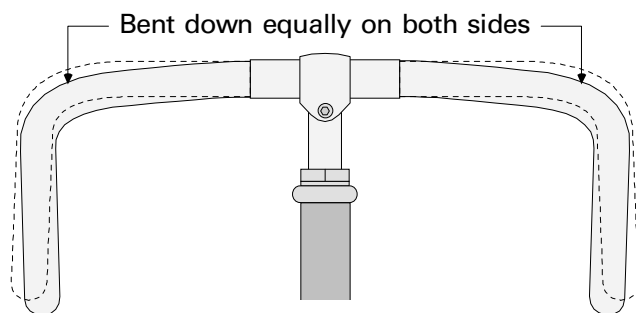
Inspect for bent handlebars after any crash. With someone holding the bike straight up and the front wheel straight, crouch down in front of the bike and look straight at the handlebars. If the two sides are not symmetrical then the bars are bent.



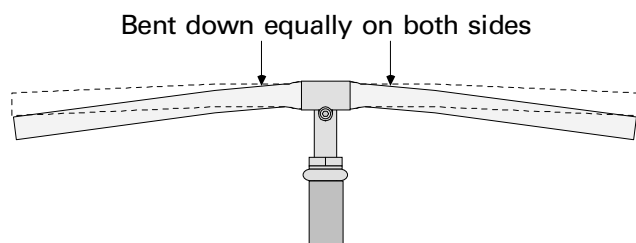
28.3 Crash-bent bars.

28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

Bars bend from fatigue as well as from crashing. This is particularly true of extra-light-weight off-road bars. When bars bend from fatigue, they will appear symmetrical, but when viewed from in front it will be apparent that they begin to drop down immediately from the point that they come out of the stem. When drop bars bend from fatigue, they exhibit this same symptom, and the drops move closer together, as well. For example, a drop bar that originally measured 40cm from center of one bar end to center of the other bar end might measure as little as 36cm.



28.4 Fatigue-bent drop bars



28.5 Fatigue-bent MTB bars.

Symptoms indicating bars should be secured

Handlebars can exhibit two symptoms when they are loose and need to be secured. They may make creaking sounds or they may slip.

Creaking sounds can be caused by other things, but nothing is more important than loose handlebars so always treat this symptom as reason to check the bar security.

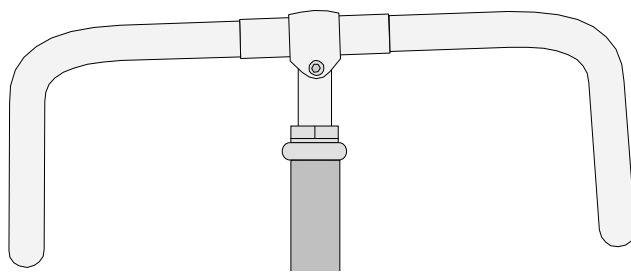
Slipping can be sudden and dramatic, in which case there will be no wondering whether the bars need to be secured, or it can be gradual and subtle. On road bikes with drop bars, it might be noticed that the brake levers seem lower, or that when riding on the drops it feels different. When installing bars, it is a good idea to note the angle of the bottom portion of the bar, and inspect after the first few rides to see if it remains the same. It is normal for the bottom of a drop bar to

point down to the back or be flat. Anytime the bottom of the drop bar is pointing up to the back, check if the handlebars are loose.

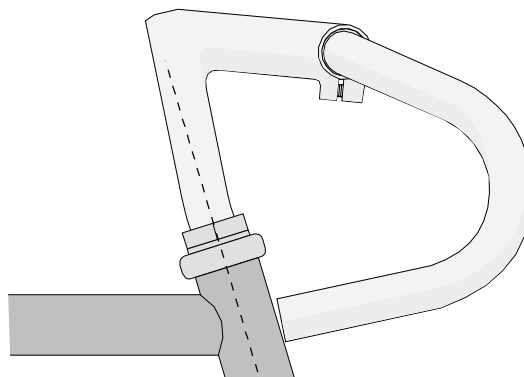
Off-road bars experience less leverage than drop bars, unless they have bar extensions or have a forward bend. Once again, note the angle of any built-in or bolt-on forward extension when the bar or extension is first installed. Check this angle after a few rides to see if it has changed. If both bolt-on extensions change the same amount, then the bar is probably slipping. If one changes more than the other, then either the bar or the extension(s) could be slipping.

Symptoms indicating stem should be replaced

Stems can bend in a crash or may bend or crack from fatigue. If they bend from a crash, the bars may also be bent and the damage to the stem may not become obvious until after replacing the bent bar. If the bars are in good condition but one side is lower than the other, then the stem is bent. Stems that bend from fatigue are rare, but what happens in these cases is that the stem shaft makes a forward bend where it comes out of the headset. Stems that crack from fatigue will have cracks in numerous locations. The cracks may appear around the handlebar-binder bolt, where the extension joins the handlebar clamp, where the stem shaft and forward extension join, or in the stem shaft in the portion below the top of the headset.



28.6 If these bars are straight, then the stem is bent from a crash.



28.7 This stem is bent forward from fatigue.

Symptoms indicating stem should be secured

The symptom indicating that the stem is loose could be creaking or slipping. Creaking is more likely. Creaking can be caused by other things, so if securing the stem does not solve the problem be sure to check handlebar security. Creaking can also be caused by the fit of headset pressed races to the head tube and by a looseness between the bar center ferrule and the bar. A loose stem will slip by rotating, not by sliding down. Rotation that happens when a crash occurs does not indicate that the stem is too loose. In fact, it is desirable that the stem rotate to prevent damage to the bars. A stem that rotates when riding is one that is too loose.

Headset overhaul and replacement

Stem removal is required for headset overhaul or replacement.

Fork replacement

Stem removal is required for fork replacement.

TOOL CHOICES

There are no special tools required for stem and bar service. There is one optional type of tool, used for cleaning out a fork after removing a stuck stem. This is either a Flex-hone BC27 (1" fork columns), BC29 (1-1/8" fork columns), or BC35 (1-1/4" fork columns). These tools are installed on a drill and spin at high speed inside the fork column to clean out rust.

TIME AND DIFFICULTY

Removing and installing a *stem and bar set* is a job of little difficulty that takes 2–4 minutes. If the stem is corroded in place, it can become a job of high difficulty.

Replacing a *stem* is a job of little difficulty in itself, but to the extent that it requires disconnection of brake or derailleur cables, it can become a job of moderate to high difficulty.

Replacing a *handlebar* is a job of little difficulty in itself, taking only 5–10 minutes, but to the extent that it requires disconnection of brake or derailleur cables, it can become a job of moderate to high difficulty. If the stem is corroded in place and must be removed to access the bars, it can become a job of high difficulty.

COMPLICATIONS

Wedge will not go down after loosening stem-binder bolt

It is normal to have to strike the top of the handlebar-binder bolt after loosening, to get the wedge to drop. When this does not work, it means that the wedge is badly corroded in place. See step #6, page 28-6.

Stem will not remove once wedge has dropped

It is natural to assume that this is caused by corrosion, but it could be as simple as binding caused by an off-center hole in a headset locknut. Try loosening the locknut before preparing to work on a corroded stem.

Stem will not install even if it is the correct size

This could be caused by corrosion, in which case the inside of the fork should be honed. It could also be caused by an under-sized or off-center headset-locknut hole. Check the installation with the locknut loosened or removed.

Handlebars slip when properly torqued

This is caused by poor bar-to-stem fit, or contamination on the mating surfaces. The complication comes when it occurs during a assembly of a bicycle that came with a fully assembled and taped bar set, which must be stripped on one half to clean the mating surfaces or measure to check fit.

Extensions slip when properly torqued

Handlebar extensions are prone to slipping due to contamination on the mating surfaces, poor fit, or painted or anodized mating surfaces. Check fit, clean mating surfaces, and sand mating surfaces to expose raw aluminum.

Control cables end up too short after installing wider bars or a longer stem

This one should be caught before the job is ever started. Nothing can be done but install new cables and adjust any brakes or derailleurs affected.

Cables will not allow stem to lift far enough to remove from fork

Sometimes a cable will interfere with removal of a stem. Cables routed under the handlebar tape to a front sidepull brake often cause this problem. It is usually easiest to remove the caliper from the fork. In all other cases, try to operate the mechanism in a way that will cause the inner wire to slacken and then slip a housing end out of any split housing stop.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is in six sections. The first is **STEM REMOVAL, REPLACEMENT, AND INSTALLATION**. It is followed by **HANDLEBAR REMOVAL, REPLACEMENT, AND INSTALLATION**. This is followed by **INSTALLING HANDLEBAR CLIP-ONS AND EXTENSIONS**. Next there is a brief section on **HANDLEBAR-COVERING REMOVAL AND INSTALLATION**. Following this is a section, **OTHER BAR SYSTEMS**, regarding BMX and upright (touring and cruiser) systems. The last part is **HANDLEBAR AND STEM TROUBLESHOOTING**. Depending on what operation is being done, use any section by itself, or it may be best to include parts (or all) of various sections to complete the task.

STEM REMOVAL, REPLACEMENT, AND INSTALLATION

STEM REMOVAL

When removing the stem from the fork, any derailleur- and/or brake-control cables can interfere with being able to pull the stem out of the fork column. Furthermore, any of these cables are more prone to damage if left attached to the bar set and they end up supporting the weight of the bar set. How these control cables can be disengaged is highly variable depending on the type of equipment. The following are guidelines that will apply often, but not always.

Mountain-bike brake levers: Usually brake cables can be released from the brake levers and reconnected in a way that will not require any adjustment. Unhook the lead-beaded end of the straddle wire from one of the caliper arms. On the brake lever, line up the slots in the cable adjusting barrel, adjusting barrel locknut, and bottom of the body of the lever. Pull the housing and end cap straight out the end of the adjusting-barrel socket and then swing the inner wire down through all the lined-up slots. If necessary, compress the lever to the grip and then slip the head of the inner wire out the back face (usually) of the lever.

Cables to front cantilever brakes when the cable is routed through the stem: Unhook the lead-beaded end of the straddle wire from one of the caliper arms. The straddle wire may be connected to the primary

brake wire by a roughly triangular device called a cable carrier. If this is the case, the straddle wire is usually resting in an open cradle in the back of the cable carrier. By deflecting the loose end of the primary wire, the straddle wire can be lifted out of the cradle. If the cable carrier is a circular disc and there is no open cradle, then unhooking the wire from the cable carrier will require full re-adjustment of the brake. It would be easier to just unmount the caliper arm (that still has the cable attached to it) from the frame by loosening the bolt that goes through the caliper arm and into the fork. Be familiar with mounting cantilever arms before deciding to remove one.

Non-aero' road-bike brake levers: If the brake cables are free loops of housing that come down into the top of the brake levers on drop bars, they can usually be released from the brake levers in a way that re-adjustment will not be required. Release any quick-release mechanisms on both brakes. Remove both wheels from the bike. Using a third-hand tool, squeeze a caliper so that the brake pads meet. Squeeze the brake lever in just enough so that the point that the cable head hooks into the anchor (inside the lever) can be seen. If there is a slot in the anchor, then push enough slack cable into the lever so that the cable head drops below the anchor, push the cable out the slot in the anchor, then pull the cable out of the lever and lever body.

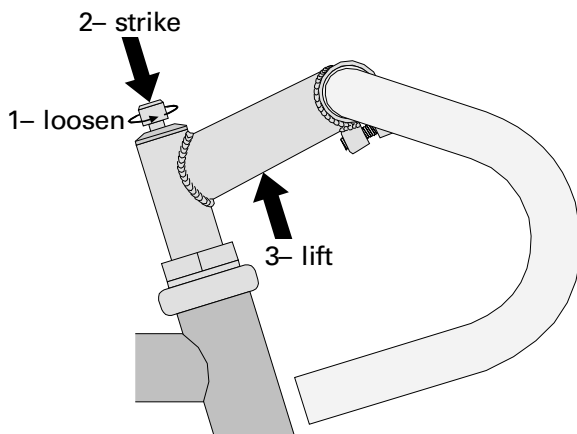
Aero' road-bike brake levers: Only the front cable can be freed without requiring re-adjustment of the brake. In many cases, this will be all that is needed to get the stem out of the fork column or to replace the stem. Simply unbolt the brake caliper from the fork. There will be a 10mm hex nut or 5mm Allen nut on the back of the fork crown for this purpose. The only brake adjustment needed will be centering the pad clearance.

Mountain-bike shift levers: All cables are attached to the shift levers in a way that the cable cannot be released from the lever without having to adjust the cable after re-installation. However, it is sometimes possible to release the lever from the handlebar without having to re-adjust the cables/derailleurs. If the shift-control mechanism is a separate unit from the brake lever and has a thin steel strap that wraps around the handlebar, then a binding bolt can be removed and the strap can be spread to allow removal of the entire lever unit from the handlebar. If the lever is a separate unit and has a thick cast aluminum body that wraps around the lever, it may be possible to remove the shifting unit from the mounting body. Look for a 5mm or 6mm Allen bolt on the backside from the lever face.

28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

Before removing the stem, confirm that the stem is conventional, and not a stem that clamps on the outside of an unthreaded fork column (AheadSet or other threadless headset). Conventional stems have an Allen bolt that goes down through the stem shaft. The only other bolt in the stem is at the handlebars to secure the bars in the stem. The other type of stem has an Allen bolt in the same location, but has one or two other bolts on the backside or just in front of the “stem shaft.” If the stem is this type, then the bike has an threadless-type headset bearing, and the stem is actually part of the headset. To perform stem removal in this case, see the **HEADSET** chapter in the section for threadless headsets (page 11-21).

1. [] **Release any cables from control levers or levers from handlebars that will facilitate bar removal.**
2. [] **Turn the Allen bolt that goes down through stem shaft 4–6 full turns counterclockwise.**
3. [] **If bolt head rises up, strike bolt head sharply with plastic mallet to force stem wedge down. (If it will not drop, then try ball peen.)**



28.8 *Loosening the stem.*

4. [] **When loosened bolt head has dropped to (or remained at) its original position, pull up with gently twisting motion to lift stem shaft out of fork column.**
5. [] **If any remaining cables resist stem's range of motion so that it will not lift clear of fork column, detach cables from brake or derailleur (derailleur or brake adjustment will be required) and then remove stem.**
6. **If stem is difficult to remove:**
 - [] **Loosen headset locknut fully and slide it up stem shaft (headset adjustment will be required later).**
 - [] **Drip light oil or penetrating oil in crack between stem shaft and fork column.**

[] **Turn bike over and flood bottom of stem (through hole in bottom of fork crown) with light oil or penetrating oil.**

[] **Pull up while twisting vigorously on stem until it has moved, then stop and wait 15 minutes.**

[] **After waiting 15 minutes for stem to cool, repeat oiling, pulling and twisting, and another waiting period.**

[] **If after stem is removed if corrosion is evident, use Flex-hone or emery cloth to clean inside of fork column and emery cloth to clean stem shaft.**

7. **If stem will not rotate in fork column or lift at all after performing step 6:**

[] **Clamp fork crown in bench vise (protecting crown with blocks of wood).**

[] **Use oiling, twisting, pulling and waiting techniques describe in step 6.**

[] **After stem is removed, if corrosion is evident use Flex-hone or emery cloth to clean inside of fork column and emery cloth to clean stem shaft.**

If the stem will not remove after trying steps #6 and #7, it must be destroyed to remove it. First, decide whether the fork must be saved. The method of removing the stem to save the fork will take at least one hour. Would it be about as cheap just to replace the fork, also?

To replace the stem and fork, simply remove the stem-binder bolt and use a hacksaw to cut the stem shaft off about 1/2" above the headset locknut. Disassemble the headset and drop the fork out of the head tube.

To save the fork, use a jab saw (special holder for a hacksaw blade) to cut three slots inside the stub of the stem shaft as deep as possible without cutting into the fork-column material. It may be necessary to force the wedge down below the stem-shaft stub. Once the stub of the stem shaft is slotted, use a punch to deflect the three sections inward. Once the stem shaft stub has been collapsed inward, it should be possible to remove it.

STEM REPLACEMENT

When replacing a stem, several factors of fit (both mechanical and biomechanical) should be considered. This book is about mechanics, not riding, so discussions about biomechanical considerations are left out except as how they may affect mechanical ones.

The first mechanical-fit consideration is the fit of the stem to the fork column. Fork columns are made in three sizes today, none of which are close enough together that there should be any confusion about fit. The three sizes are 1", 1-1/8", and 1-1/4". These numbers refer to the outside diameter of the fork column,

28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

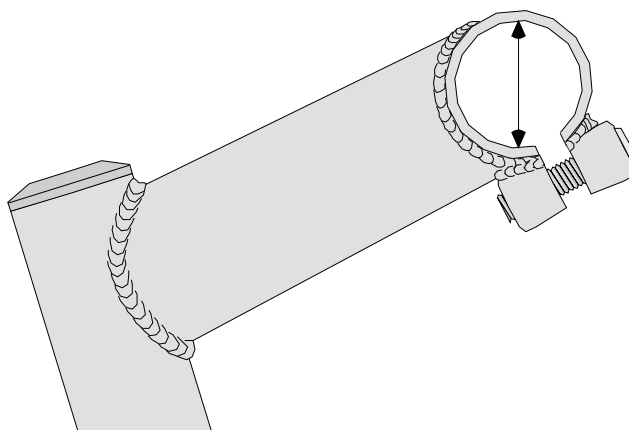
which is different from the outside diameter of the stem shaft. The stem diameter that will fit 1" forks is 22.2mm. The stem diameter that will fit 1-1/8" forks is 25.4mm. The stem diameter that will fit 1-1/4" forks is 28.6mm. The best way to determine which is needed is to measure and match the one removed. The next best way is to measure the inside diameter of the fork column, which should be .0 to .1mm larger than the stem diameter.

The second mechanical-fit consideration is the fit of the stem to the bars. In the mountain bike world this is relatively uncomplicated, with almost all handlebars currently being made holding a standard of 25.4mm. Older mountain bikes could be either 26.0mm or 22.2mm, but these are rare now. In the road-bike world, things get more complicated, with several sizes prevailing in the marketplace. These are 25.4mm, 26.0mm, and 26.4mm. The 25.4mm size is most common, with the larger sizes showing up on upscale European bars and some other high-priced brands. Cinelli, Mavic, Modolo, TTT, and Italmanubri are traditional European manufacturers that have used the 26.0mm and 26.4mm dimensions. New U.S. companies are also frequently inclined to use these larger dimensions. Ideally, the bar diameter should be within .2mm of the diameter of the handlebar bore. The difficulty is in measuring the diameter of the handlebar bore, which is not a complete circle and can easily be deformed. The best place to measure the handlebar bore is at the back edge of the compression slot to a point 180° away. Very old European bikes might have a variety of non-standard (and no longer available) bar-center dimensions.

To enhance the fit of the customer's body to the bike, it may be necessary to change the stem to get the bars closer, farther, lower, or higher. Any of these changes affect the length of cable housing for the control levers on the handlebars. If lowering the bars or shortening the stem, the loops could end up too long, which can cause more friction and poorer shift or brake response, or even kinking or failure of the control-cable housing(s). If raising the bars or lengthening the stem, the loops could end up too short, which can cause all the same problems. If making these sort of changes, check the **DERAILLEUR-CABLE SYSTEMS** chapter (page 31-4) and the **BRAKE-CABLE SYSTEMS** chapter (page 35-3) to check on sizing loops of control-cable housing.

8. [] See **HANDLEBAR REMOVAL** to remove handlebars from stem.
9. [] Measure old stem-shaft diameter and record here: _____ mm.

10. [] Measure new stem-shaft diameter and record here: _____ mm.
11. [] If measurements in steps 9 and 10 differ by < .2mm, then new stem is comparable fit.
12. [] Measure old stem handlebar-bore diameter and record here: _____ mm.
13. [] Measure new stem handlebar-bore diameter and record here: _____ mm.



28.9 Measure handlebar-bore diameter here.

14. [] If measurements in steps 12 and 13 differ by < .2mm, then new stem is comparable fit.
15. [] Lay new stem on top of old stem so that stem shafts are lined up and maximum-height marks are even and compare locations of both handlebar bores to determine whether new stem will move bars significantly up, down, forward, or back. If so, cable re-sizing may be required.
16. [] See **HANDLEBAR, REMOVAL, REPLACEMENT, AND INSTALLATION** to install bars in new stem.

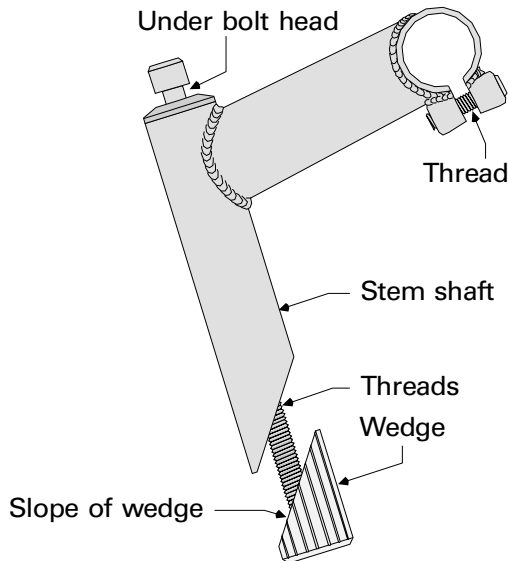
STEM INSTALLATION

Stem installation is a relatively simple procedure, but has dire consequences if done wrong. Failure to lubricate properly can turn the fork and stem into virtually a single piece of metal, requiring replacement of both. Under-tightening the stem can lead to a disastrous loss of control at the most critical time. Over-tightening the stem can lead to a hidden weakening of the fork column, which could break without warning with extremely injurious consequences. Installing the stem too high in the fork can lead to catastrophic fork-column failure.

17. [] If handlebars are not installed at this time, see **HANDLEBAR, REMOVAL, REPLACEMENT, AND INSTALLATION** (MTBs, page 28-11 or drop-bars, page 28-9) to install bars to stem.
18. [] Unthread stem-binder bolt and grease under head of bolt and bolt threads.

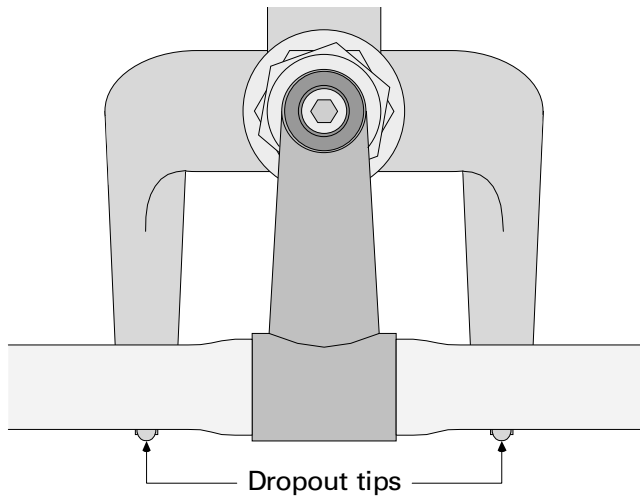
28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

- 19. [] Grease stem wedge where it contacts stem shaft and inside of fork column.
- 20. [] Grease portion of stem shaft that will be inside fork column.
- 21. [] Grease inside of fork column to depth stem shaft will be inserted.



28.10 Grease points on a stem.

- 22. [] Install any washer on stem-binder bolt and install bolt into stem shaft.
- 23. [] Engage stem-binder bolt into stem wedge.
- 24. [] Locate mark on stem shaft labeled *Maximum Height* or *Minimum Insertion* (either may be abbreviated).
- 25. [] Insert stem into fork column *at least* until Max. Ht. or Min. Insert mark is below top of headset.
- 26. *If stem is difficult to install:*
 - [] Try loosening stem-binder bolt more and insert again.
 - [] Check inside of fork column for rubber seal on inner perimeter of headset locknut getting displaced and forced into fork column with stem shaft.
 - [] Loosen headset locknut and try again (headset will need adjustment).
- 27. [] Set stem to lower height if desired.
- 28. [] Turn bars side-to-side until either bar center appears in line with fork dropouts or front axle (figure 28.11), or stem extension appears in line with front tire.



28.11 Align the handlebar center with the tips of the dropouts.

- 29. [] Check that Max. Ht./Min. Insert line is still hidden.
- 30. [] Secure steel or titanium stem-binder bolt to torque of 145–180in-lbs (24–30lbs@6" or 36–45lbs@4"), or aluminum stem-binder bolt to torque of 145–150in-lbs (24–25lbs@6" or 36–37.5lbs@4").
- 31. [] With bike on floor and facing front of bike, grasp front wheel firmly between legs and try to rotate bars side-to-side with about 30–40 pounds of pressure on one end of bars. If bars move with difficulty or don't move at all, stem-binder bolt is adequately secure.

HANDLEBAR REMOVAL, REPLACEMENT, AND INSTALLATION

NOTE: Skip to step 9 if removing off-road bars.

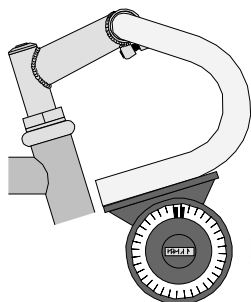
DROP-BAR-HANDLEBAR REMOVAL

Drop handlebars must be rotated wildly to snake them through the handlebar bore of the stem, and often end up interfering with another part of the bike if the stem is in the bike when the bars are being removed, so stem removal should generally be done first.

Bars may be removed to replace a stem, in which case only one side of the bars needs to be stripped, or bars may be removed in order to replace the bars, in which case both sides will need to be stripped. This section strips only one side, then in the section of the worksheet for bar replacement the other side is stripped of handlebar coverings and control levers.

28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

1. ☐ Remove handlebar tape or handlebar covering from one side of bar.
2. ☐ Unhook or detach control cables from control levers on both sides.
3. ☐ Measure angle of bars with angle finder, if customer position will be restored. Record angle here: _____



Dial protractor

28.12 Measuring drop-bar position.

4. ☐ Note position of control levers (so position can be restored if desired) and remove control levers from one side of bars (see brake and derailleur chapters).
5. ☐ Remove stem (see **STEM REMOVAL, REPLACEMENT, AND INSTALLATION**, page 28-5).
6. ☐ Loosen handlebar-binder bolt.
7. ☐ Slide stem off fat center section of bar to the side where covering and controls were removed.

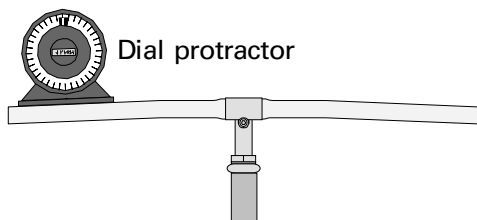
It can be tricky getting the stem past the bends in the bars. Look closely at the handlebar bore in the stem to see that at one point it is narrower than elsewhere. Keep this narrow side of the bore to the inside of each bend in the bar, then it will be unlikely the stem will jam as it is removed.

8. ☐ Rotating stem about bar to keep narrowest part of handlebar bore at inside of each bend of bar, slip stem off of bar.

Note: Skip steps 9–12 if drop bars already removed.

OFF-ROAD-HANDLEBAR REMOVAL

9. ☐ Remove grip from one end of handlebar, then measure bar angle with angle finder and record here: _____



28.13 Measuring off-road bar position.

10. ☐ Unhook or detach control cables from control levers on both sides.

NOTE: If replacing stem only, see **STEM REMOVAL, REPLACEMENT, AND INSTALLATION** to remove stem.

11. ☐ Loosen handlebar-binder bolt(s).

Now that the handlebar-binder bolt has been loosened, the bars should just slip out of the stem. In many cases, it is not this easy. In order to get the bars out of the stem, the stem bore needs to be expanded. When the bars will not slip out, first remove the handlebar-binder bolt completely. Use something like a fat screwdriver to pry open the compression slot, and then slide the bars out.

12. ☐ Slide handlebar out of stem.

HANDLEBAR REPLACEMENT

13. ☐ Remove handlebar covering and control levers from second side of bar.
14. ☐ Measure handlebar-bore diameter in stem and record here: _____ mm.
15. ☐ Measure handlebar-center diameter of new bars and record here: _____ mm.
16. If step 14 is .0 to .2mm more than step 15, bar and stem are good fit. If different by more, test for good fit. Check one of following choices.
☐ Fit is good.
☐ Need to test fit.

DROP-HANDLEBAR INSTALLATION

NOTE: If installing off-road bars, skip to step 28.

17. ☐ Remove handlebar-binder bolt(s) from stem.
18. ☐ Use caliper to measure diameter of handlebar-binder-bolt thread and record here: _____ mm.
19. ☐ Grease threads and under head of handlebar-binder bolt(s).

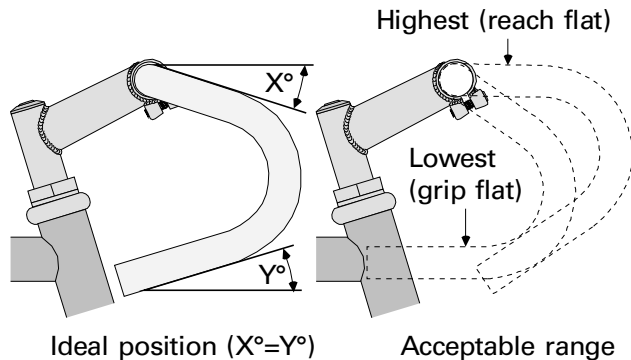
NOTE: If positioning and securing already installed drop bars, skip to step 22.

20. ☐ Use alcohol or acetone to clean inside of handlebar bore in stem and center section of handlebar.
21. ☐ Insert handlebar into stem, rotating stem around bar to keep narrowest part of handlebar bore always at inside of bar bends, and center bar in stem.
22. ☐ Install and gently snug handlebar-binder bolt(s).

The rotation of the handlebars is strictly a matter of personal preference, but it is likely that the customer has simply been living with whatever position the shop set them up at. If the customer would like to try the bars in a different position, consider these guidelines. If the top extension of the bar is parallel to the ground, it favors riding primarily on the tops of the bars, and handicaps access to the brake levers when riding in the

28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

drops. If the bottom grip of the bar is parallel to the ground, it favors riding primarily in the drops, and handicaps access to the brake levers when riding on the tops of the bars. Usually the best position is a compromise between these extremes, with the top extensions of the bars sloping slightly down toward the brake levers, and the grips sloping slightly down toward the back of the bike. This position is recommended if setting up new bikes, without a customer preference indicated. For the ideal neutral position, the angle of the reach should equal the angle of the grip.



28.14 Acceptable range of drop handlebar rotations.

23. [] Rotate bar to desired position.
24. Transfer measurement in step 18 to here (_____ mm) and torque handlebar-binder bolts to one of following torque ranges depending on handlebar-binder-bolt-thread diameter:
 - [] Torque bolts w/ thread diameter $\leq 6\text{mm}$ to 120–145in-lbs (20–24lbs@6" or 30–36lbs@4").
 - [] Torque bolts w/ thread diameter $> 6\text{mm}$ to 205–240in-lbs (34–40lbs@6" or 51–60lbs@4").
25. [] Install control levers per SHIFT-CONTROL MECHANISMS (page 30-10 or 30-15) and/or BRAKE LEVERS (page 34-6) chapter instructions.
26. If *Need to test fit* option is checked in step 16, perform following security test:
 - [] With bike on floor, stand facing bike and straddle front wheel.
 - [] Grasp brake-lever bodies in similar fashion to when riding with weight supported at brake levers, and support full weight on brake levers until feet lift off floor.
 - [] Check if bar position has changed.
 - [] If bars slip and handlebar-binder bolts are not torqued to maximum recommendation, add torque and test again.
 - [] If bars slip at maximum torque, fit is bad. Change bar or stem to improve fit.
27. [] Attach control cables to derailleur and/or brake levers and adjust derailleurs and/or brakes as per instructions in derailleur and/or brake chapters.

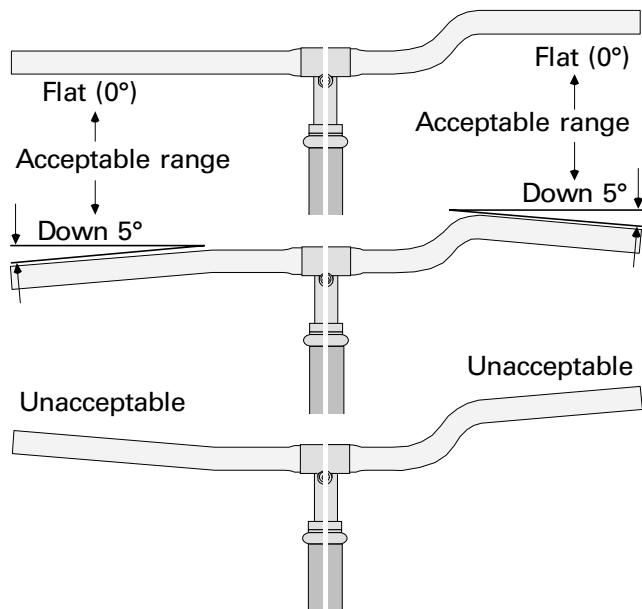
OFF-ROAD-HANDLEBAR INSTALLATION

28. [] Remove handlebar-binder bolt(s) from stem.
29. [] Use caliper to measure diameter of handlebar-binder-bolt thread and record here: _____ mm.
30. [] Grease threads and under head of handlebar-binder bolt(s).

NOTE: If positioning and securing already-installed off-road bars, skip to step 33.

31. [] Use alcohol or acetone to clean inside of handlebar bore in stem and center section of handlebar.
32. [] Insert handlebar into stem & center bar in stem.
33. [] Install and gently snug handlebar-binder bolt(s).

The rotation of the handlebars is strictly a matter of personal preference, but it is likely that the customer has simply been living with whatever position the shop set them up at. If the customer would like to try the bars in a different position, consider these guidelines. If the grips of the bars slope up to the outside, it tends to put the elbows in an inflexible position, which reduces comfort and control. If the grips are flat or slope down to the outside no more than five° (about 3/4" drop over the length of the grip), the elbows are relaxed. If the grips slope down too much, then the hand will tend to slip off the end of the grip. Somewhere between flat and 5° down is recommended if setting up new bikes, without a customer preference indicated.



28.15 Acceptable range of MTB-bar rotation.

34. [] Rotate bar to desired position.

35. Transfer measurement in step 29 to here (____ mm) and torque handlebar-binder bolts to one of following torque ranges depending on handlebar-binder-bolt thread diameter:
- ☐ Torque bolts w/ thread diameter ≤6mm to 120–145in-lbs (20–24lbs@6" or 30–36lbs@4").
 - ☐ Torque bolts w/ thread diameter >6mm to 205–240in-lbs (34–40lbs@6" or 51–60lbs@4").
36. ☐ Install control levers per SHIFT-CONTROL MECHANISMS (page 30-3 or 30-8) and/or BRAKE LEVERS (page 34-5) chapter instructions.
37. If *Need to test fit* option is checked in step 16, perform following security test if handlebar extensions are being used:
- ☐ With bike on floor, stand facing bike and straddle front wheel.
 - ☐ Grasp handlebar extensions and support full weight on extensions until feet lift off floor.
 - ☐ Check if bar position has changed, or if handlebar extensions have slipped.
 - ☐ If bars slip and handlebar-binder bolts are not torqued to maximum recommendation, add torque and test again.
 - ☐ If bars slip at maximum torque, fit is bad. Change bar or stem.
38. ☐ Attach control cables to derailleur and/or brake levers and adjust derailleurs and/or brakes as per instructions in derailleur and/or brake chapters.

the handlebar may be subjected to more rotational load than the stem clamp is designed to withstand, resulting in the bars slipping in the stem.

To reduce problems with clip-ons, follow these several rules: 1) recommend that the customer always use them as they are intended and do not rest weight out at the end of the clip-ons; 2) always clamp them directly to the bar, and not on top on any handlebar covering; 3) always clean the mating surfaces of the clamps and the bar thoroughly, including removing epoxy, paint, or anodized finishes with emery cloth; 4) lubricate bolts properly and follow torque recommendations closely; 5) inspect bars for fatigue cracks regularly where clip-on clamps engage bars.

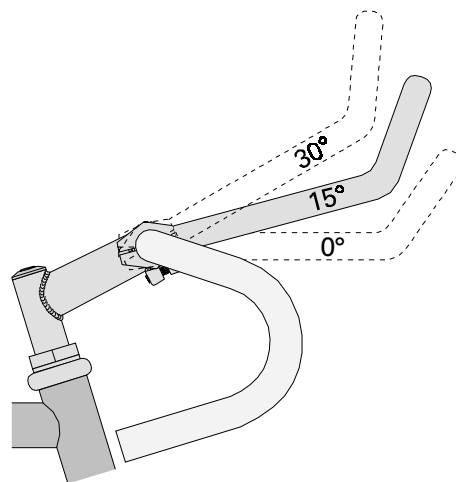
1. ☐ Remove handlebar tape or handlebar covering from portion of the bar where clamp secures.
2. ☐ Remove anodization finishes, paints, or epoxy coats from inside of clamp and outside of bar where clamps engage.
3. ☐ Clean mating surfaces with alcohol/acetone.
4. ☐ Remove clamp bolts, measure thread diameter, and record here: _____ mm.
5. ☐ Thoroughly grease bolt threads and under bolt heads.
6. ☐ Mount clip-ons, install bolts, and gently secure.
7. ☐ Position clip-ons at desired angle.

INSTALLING HANDLEBAR CLIP-ONS AND EXTENSIONS

DROP-BAR CLIP-ONS

NOTE: Skip to step 8 if installing extensions on an off-road bike.

Aerodynamic clip-on extensions for drop handlebars may be great for improved performance or comfort riding, but mechanically they are a nightmare. Manufacturers make the clamps for clip-on bars in two configurations, V-block and radius clamp. The V-block system has the advantage of fitting any diameter handlebar, but slips easily and damages bars easily if tightened enough to avoid slippage. The radius-clamp type is a more secure grip, but only if it matches the diameter of the bar closely. Either type is adequate to secure if the rider *always* rides in the intended fashion with the bulk of load on the elbow pads. In an emergency, or with poor riding habits, the load may end up at the outer end of the clip-on, which is when the clamps may slip. Even if the clamps do not slip,



28.16 Normal range of clip-on positions.

8. Torque bolts to following torque ranges depending on thread diameter:
- ☐ ≤5mm, torque to 50in-lbs (8lbs@6" or 12.5lbs@4").
 - ☐ 5.1–6mm, torque to 120–145in-lbs (20–24lbs@6" or 30–36lbs@4").
 - ☐ 7–8mm, torque to 155–205in-lbs (26–34lbs@6" or 39–51lbs@4").

OFF-ROAD-HANDLEBAR EXTENSIONS

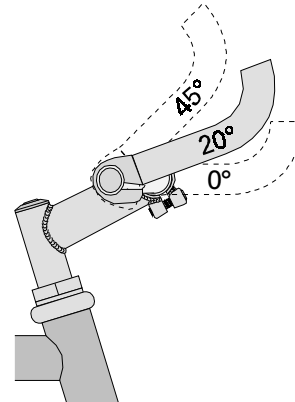
Off-road-handlebar extensions may be great for improved performance or comfort riding, but mechanically they are a nightmare. Manufacturers make the clamps for clip-on bars in two configurations, external and internal clamping. The external system has the advantage of fitting any handlebar equally well, but the clamp is bulkier and requires that the grips and controls be moved inward. The internal-clamp type doesn't require moving grips and controls, and the clamp is less bulky, but will be secure only if it matches the inside diameter of the bar closely (there are no standards for inside bar-diameter). Provided that an internal-clamp extension is a good fit, either clamp type will adequately secure the extension, if the rider *always* rides in the intended fashion, which is using extensions when climbing or high-speed cruising on smooth terrain. In an emergency, or with poor riding habits, the load may end up on the extensions when the customer hits a bump, which is when the clamps may slip. Even if the clamps do not slip, the handlebar may be subjected to more rotational load than the stem clamp is designed to withstand, resulting in the bars slipping in the stem.

Extra-light-weight bars create another problem. The external extension clamp can crush the bar due to the thin wall. Inserts are made to reinforce the bar. The insert should match the bar I.D. closely and be at least as wide as the extension clamp.

To reduce problems with handlebar extensions, follow these several rules: 1) recommend that the customer always use them as they are intended and do not rest weight on them when traveling on rough terrain; 2) always clean the mating surfaces of the clamps and the bar thoroughly, including removing epoxy, paint, or anodized finishes with emery cloth; 3) lubricate bolts properly and follow torque recommendations closely; 4) inspect bars for fatigue cracks regularly where clamps engage bars.

1. [] If installing external-clamp handlebar extension, move controls and grips inward enough to provide room for full engagement of clamp to bar.
2. [] Remove paint, epoxy coats, or anodization finishes from inside of clamps and outside of bar where clamps will engage.
3. [] Clean mating surfaces with alcohol/acetone.
4. [] Thoroughly grease bolt threads and under bolt heads.

5. [] Mount extensions, install bolts, and gently secure.
6. [] Position extensions at desired angle.



28.17 Normal range of extension positions.

7. [] Torque bolts to 120–145in-lbs (20–24lbs@6" or 30–36lbs@4").

HANDLEBAR-COVERING REMOVAL AND INSTALLATION

OFF-ROAD GRIPS

Steps #1–5 are 100% reliable and safe. Filling the bars with compressed air to remove grips works in some cases, but not if grips are torn on the end or made of certain foams. Cutting the grips off with a sharp knife always works if the grips will not be re-used, but the following procedure has no risk of self-injury.

Removal

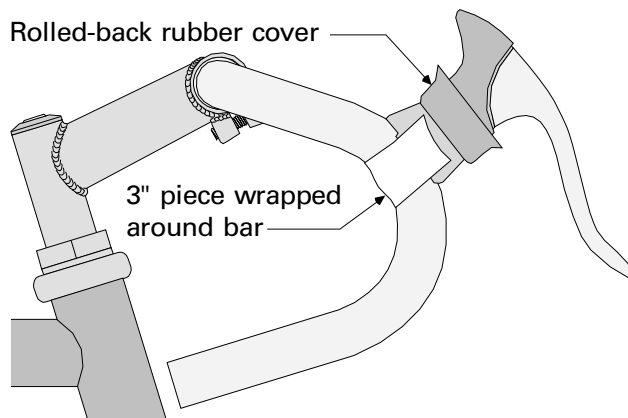
1. [] Insert long skinny screwdriver between grip and bar to create gap between grip and bar.
2. [] Spray or drip water between grip and bar then remove screwdriver.
3. [] Insert screwdriver between grip and bar at a 180° opposite original insertion.
4. [] Spray or drip water between grip and bar then remove screwdriver.
5. [] Twist grip back and forth to spread water around, then pull grip off.

Installation

1. [] Clean bar of any contamination with alcohol.
2. [] Spray inside of grip with hair spray and slip grip onto handlebar quickly.
3. [] Allow several hours for hair spray to set before riding, check grip security before riding.

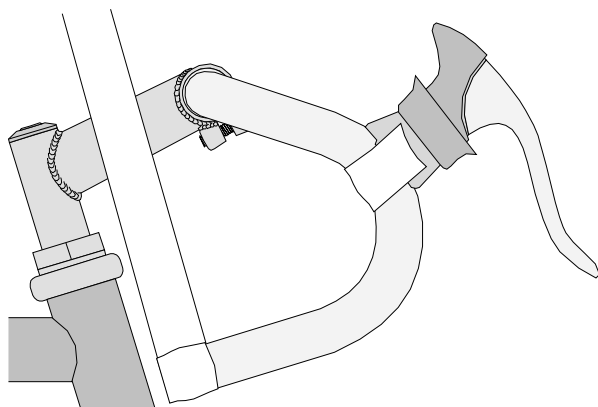
DROP-BAR TAPING

1. [] Remove old tape unless fatter bar diameter is preferred.
2. [] Roll back rubber cover on brake lever to expose base of brake-lever body.
3. [] Unless provided, cut 3" piece from end of tape and cover brake-lever mounting strap, so that both ends of piece will end up under rubber cover when rubber cover is down.



28.18 Put a 3" piece of tape over the brake lever mounting strap.

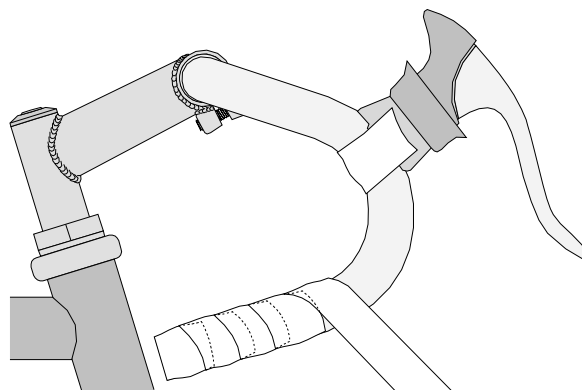
4. Check fit of handlebar plug or cap to end of bar and check one of following options:
 - [] No handlebar plug will be used, handlebar-end shifters are mounted in bars, first wrap of tape will start flush with end of bar.
 - [] Handlebar plug is snug fit to bar, first wrap of tape will start flush with end of bar.
 - [] Handlebar plug is loose in bar, first wrap of tape needs to overlap end of bar by 10–15mm.
5. [] Start tape at bottom of bar, with end of tape on top of bar and pointing in, with edge of tape flush to or overlapping bar as determined in step 4.



28.19 Start with a full wrap with no advance.

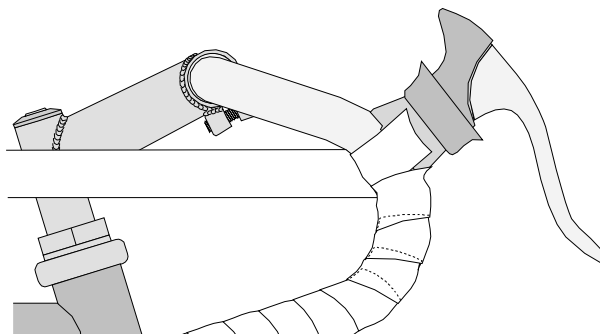
6. [] Complete one wrap of tape without advancing it so that end of tape is hidden by wrap.

7. [] Pulling with a gentle-to-firm pressure, continue wrapping around bar, advancing tape with each wrap so that each wrap overlaps the last by about 1/3 the tape width until first bend of bar is reached.



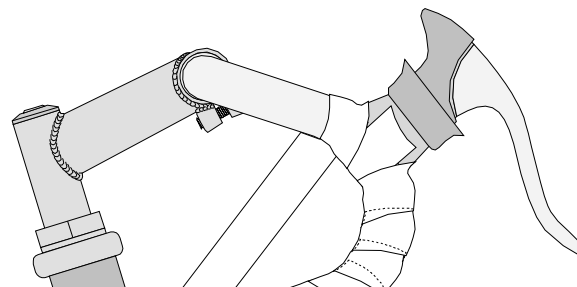
28.20 Overlap each wrap by 1/3 the width of the tape.

8. [] Continue advancing up bend of bar, maintaining 1/4 – 1/3 of tape width overlap at outside of bar bend.



28.21 Overlap each wrap by 1/4 – 1/3 the width of the tape on the outside of the bend of the bar.

9. [] Adjust amount each wrap overlaps last wrap so that when tape reaches bottom of brake lever, it overlaps bottom edge of lever body by 1/8" to 1/4".
10. [] After overlapping bottom of brake lever, advance next wrap enough to end up above brake lever at completion of wrap, and overlap top of brake lever body by 1/8" to 1/4".



28.22 Wrap around the brake lever like this.

28 – HANDLEBARS, STEMS, AND HANDLEBAR EXTENSIONS

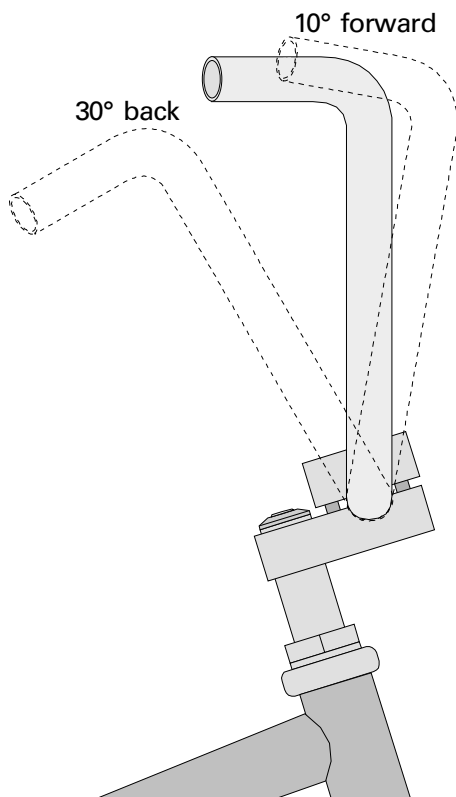
11. [] Continue wrapping around upper bend of bar, maintaining 1/4 – 1/3 of tape overlap at outside bend of bar.
12. [] Finish wrapping with tape-edge flush to edge of fat center section of bar, then cut tape so end is on bottom side of bar.
13. [] Use colored friction tape or tape supplied with handlebar tape to cover last wrap, leaving end on bottom side of bar.
14. [] If using friction tape, use soldering iron or hot knife blade to weld end of friction tape to overlap.
15. [] Tuck any excess tape into bottom end of bar and install handlebar-end plugs (if any).

OTHER BAR SYSTEMS

BMX/FREESTYLE

BMX handlebar positions

BMX and freestyle handlebars should be positioned with the rise of the bar ranging from 10° forward from straight up to 30° back. The normal position when setting up new bikes is with the rise of the bars pointing straight up.

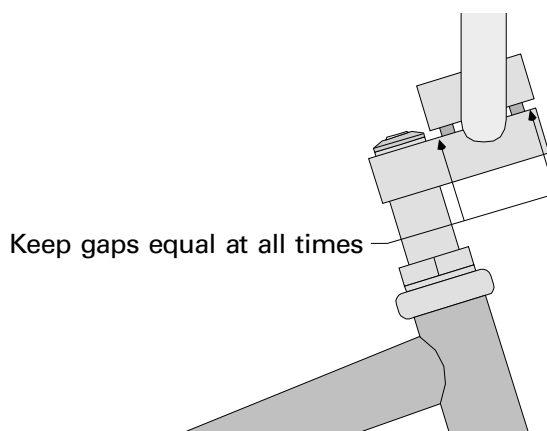


28.23 Position BMX/freestyle bars in this range.

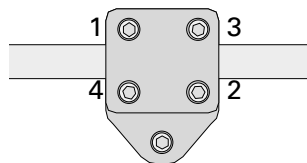
Securing BMX/freestyle stems

BMX/freestyle stems should be torqued in the fork to 170in-lbs (28lbs@6" or 42lbs@4").

Most BMX and freestyle bikes have a stem with four handlebar-binder bolts. The handlebar is sandwiched between two blocks of metal. When the binder bolts are secured, these two blocks need to remain parallel to avoid bending the bolts (see figure 28.24, below). In addition, the bolts should be tightened in a specific sequence to avoid effectively loosening one bolt while tightening another. Basically, this means always crossing over the handlebar to get to the next bolt. See figure 28.25 (below) for a tightening pattern. The bolts should be tightened in several stages, to a final torque of 240in-lbs (40lbs@6" or 60lbs@4").



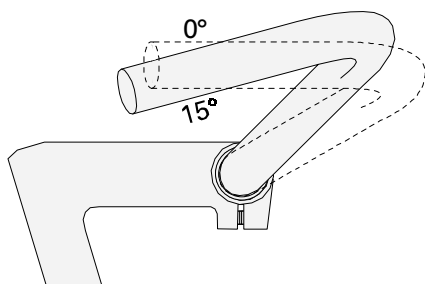
28.24 Keep an even gap at the front and back of the bar clamp at all times.



28.25 Tighten the four bolts in this pattern.

UPRIGHT BARS

See figure 28.26 for the acceptable range of handlebar positions.



28.26 This the range of acceptable positions for upright bars.

HANDLEBAR AND STEM TROUBLESHOOTING

Cause	Solution
SYMPTOM: <i>Wedge will not drop when tapping the stem-binder bolt with a ballpeen hammer.</i>	
Wedge is rusted in place.	Unthread handlebar-binder bolt, remove stem without wedge, drive wedge out with punch.
SYMPTOM: <i>Stem will not remove after the wedge has dropped.</i>	
Off-center hole in locknut is cutting into stem shaft.	Loosen headset locknut before removing stem.
Stem is corroded in place.	See procedure for removing difficult stems (page 28-6, steps 6 and 7).
SYMPTOM: <i>After loosening handlebar-binder bolt, bars will not slip easily through stem.</i>	
Handlebar bore had to be spread for installation, so in relaxed state it is still exerting pressure.	Insert something in compression slot to expand handlebar bore.
SYMPTOM: <i>Stem jams in bend of drop bar when installing or removing the stem from the bars.</i>	
Stem with wide bar clamp for MTB-type bars is being used on drop bars.	Do not use this combination if installing. Spread compression slot as much as necessary if removing the bars from the stem.
SYMPTOM: <i>Bar center is difficult to fit in stem.</i>	
Bar center is wrong dimension for handlebar bore in stem.	Measure both diameters. The bar should be no more than .2mm larger than the handlebar bore I.D. in the stem.
Stem is good fit, but handlebar-bore diameter is slightly collapsed or undersized.	Expand compression slot in stem after verifying stem and bar are compatible.
SYMPTOM: <i>Stem is difficult to install in fork column.</i>	
Stem is over-sized for fork column.	Measure stem O.D. and fork column I.D. Stem cannot be larger than fork column by any amount.
Headset-locknut seal is displaced.	Check seal and insert correctly if displaced.
Headset locknut has off-center hole.	Loosen locknut and install stem to test. Replace locknut to fix.
Corrosion in fork column or on stem shaft.	Clean stem shaft with emery cloth and hone inside of fork column.

(Continued next page)

HANDLEBAR AND STEM TROUBLESHOOTING (continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Stem will not secure.</i>	
Stem was installed with stem-binder bolt too loose, and slope-style wedge has rotated 180° out of position.	Remove stem and install with stem-binder bolt no looser than necessary to get stem into fork column.
Stem-binder-bolt head, stem-binder-bolt threads, and wedge surface are not greased.	Grease all appropriate points.
SYMPTOM: <i>Handlebars slip when properly torqued.</i>	
Handlebar-binder bolt(s) need grease on threads and under head.	Grease handlebar-binder bolt.
Bars are undersized to handlebar bore in stem.	Measure both and make sure bar diameter is not more than .2mm less than bore diameter.
Bar center has collapsed or is worn out from previous slipping.	Remove bars and check condition of mating surface to stem.
Mating surfaces are contaminated.	Remove bars from stem and clean mating surfaces with alcohol or acetone.
Reinforcing sleeve has separated from handlebar.	Check if bar center sleeve is staying stationary when bar slips. If so, replace handlebar.
SYMPTOM: <i>After installing new handlebars, one side is lower than the other.</i>	
Stem was bent in a crash.	Replace stem.
SYMPTOM: <i>Handlebar extension or clip-on will not secure when bolts properly torqued.</i>	
Bolt heads and threads not greased.	Grease bolts.
Mating surfaces are contaminated.	Remove and clean mating surfaces.
Mating surfaces coated with paint or anodization.	Clean to raw aluminum with emery cloth.
Internal extension clamp, or radiused clip-on clamp diameter is wrong diameter for bar.	Change bar, or clip-on, or extension, for better fitting item.
SYMPTOM: <i>Handlebar-binder bolt breaks when torqued.</i>	
Torque was excessive for bolt diameter.	Check thread diameter and use appropriate torque.
If torque was correct, bar diameter is too small for stem, causing bolt to bend before bar is secured.	Check fit and replace one item to improve fit.
SYMPTOM: <i>Stem-binder bolt breaks when torqued.</i>	
Torque for steel bolts is being used on aluminum bolt.	Check material and use correct torque.
SYMPTOM: <i>Handlebars creak when riding.</i>	
Handlebar-binder bolt is loose.	Check torque.
Stem-binder bolt is loose.	Check torque.
Stem shaft is creaking inside fork column due to lack of grease.	Remove and grease stem shaft.
Headset is creaking.	Check headset for marginally-loose pressed races and loose headset locknut.
Reinforcement sleeve is creaking.	Can only be identified by eliminating all other choices. Try dripping penetrating Loctite into end of sleeve. If this fails, live with noise or replace handlebar.

29 – SEATS AND SEATPOSTS

ABOUT THIS CHAPTER

This chapter is about removing and installing seats and seatposts.

GENERAL INFORMATION

TERMINOLOGY

Seat: The platform on which the rider sits. It may also be called a “saddle.”

Seatpost: The shaft that the seat is mounted too that inserts into the seat tube of the frame.

Seat clamp: The mechanism that clamps the seat to the seatpost.

Integral seat clamp: A seat clamp that is built into the seatpost.

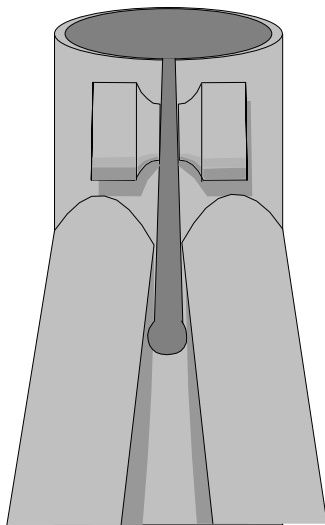
Non-integral seat clamp: A seat clamp that is separate from the seatpost.

Seat rails or rails: The rods or wires that are underneath the seat to which the seat clamp attaches.

Seatpost binder: The mechanism that secures the seatpost to the frame.

Seat lug: The portion of the frame where the seatpost inserts.

Compression slot: The slot in the seat lug that is compressed by the seatpost binder to secure the seatpost.



29.1 The compression slot in the back of the seat tube.

PREREQUISITES

There are no prerequisites for removing and installing seatposts and seats.

INDICATIONS

Seatposts

There are three reasons seatposts need to be removed and installed; 1) because they are bent; 2) because they are undersized and will not secure; 3) or because they are being upgraded.

Seatposts can corrode and stick inside the seat tube so it is good preventive maintenance to remove them and grease them periodically.

Seats

Seats need to be removed and installed for the following reasons: 1) because the seatpost is being changed; 2) the seat rails are bent; 3) the seat is torn or worn out; 4) or because the seat is being upgraded.

TOOL CHOICES

There are no special tools required for servicing seatposts and seats, but Odyssey MS-200 sizing rods are extremely convenient for determining the correct seatpost size.

TIME AND DIFFICULTY RATING

Seatpost removal is a 1 minute job of little difficulty, unless it is stuck.

Seat removal and installation is a 1–3 minute job of little difficulty.

COMPLICATIONS

Difficult seatpost removal

Seatposts can easily get stuck in the frame. They may even get permanently stuck. There is a section of this chapter about dealing with stuck seatposts.

Sizing seatposts

Because the seat lug may be deformed, it can be difficult to determine the correct size of seatpost. Because the hole may not be round, measuring with a caliper can give misinformation.

Difficult seatpost insertion

Corrosion and seat-tube distortion can make seatpost insertion difficult, even with the proper-size seatpost. Difficult insertion should *never* be used as proof of poor fit. See the **SEAT-TUBE MILLING** chapter (page 7-2), when a correctly-fit seatpost is difficult to insert.

Slipping seatposts

Slipping seatposts are almost always undersized. An undersized post has been installed usually because the correct-fit post was difficult to install.

Adjusting seat angle

Some seat clamps make it difficult to change the seat angle. Either the seat changes angle while the clamp is being tightened, or the clamp does not allow for fine adjustment of the seat angle. Always check the seat angle after securing the clamp, and if the correct angle is between two available settings, choose the setting with that leaves the nose of the seat higher.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into two sections. These are **SEATPOSTS** and **SEATS**.

SEATPOSTS

REMOVAL

1. [] Mark seatpost with tape or marking pen if height needs to be restored.
2. [] Loosen seatpost-binder bolt.
3. [] Remove seatpost with a gentle twisting and pulling motion.
4. [] Inspect inserted portion of seatpost for scratches that indicate seat tube should be honed and/or reamed.
5. [] Inspect inserted portion of seatpost for corrosion that indicates need for honing of seat tube and better greasing in future.

DIFFICULT REMOVAL

If the seatpost will not remove easily in the previous step #3, extra measures will be required. These measures may be as simple as the application of penetrating oil and a little patience, or they may mean that the seat and clamp need to be removed so that the seatpost can be grasped in a vise (usually destroying the seatpost). In the worst-case scenario, it may

mean that the seatpost will have to be deliberately destroyed to get it out. Follow this procedure only as far as necessary to get the post out.

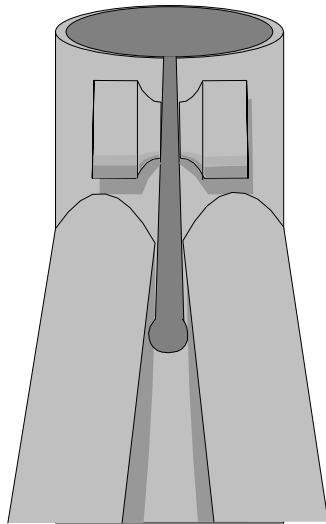
1. [] Remove seatpost-binder bolt completely.
2. [] Use lever to spread compression slot so that it is slightly wider at the top than at the bottom.
3. [] Drip penetrating oil between seatpost and seat tube and allow 5 minutes for it to penetrate.
4. [] With the bike on the floor and one foot in crotch of seat tube and down tube (being careful to not damage derailleurs or chainrings), twist seat back-and-forth, while pulling up forcefully, for no more than 30–45 seconds.
5. [] Add more penetrating oil and allow the seatpost and frame to cool off for 15 minutes.
6. [] Repeat steps 4–5 as many times as necessary, unless progress is not being made.
7. [] If steps 1–6 are inadequate, disassemble seat clamp and remove seat.
8. [] With bike upside down in stand, strike bottom of integral clamp (if any) repeatedly with plastic mallet.
9. [] If previous step is not possible, or fails, take bike out of stand and clamp end of seatpost firmly in vise. Two people can pull and twist on frame to pull it off of seatpost.
10. [] If everything to this point has failed, use hacksaw to cut seat post off approximately 1" above seat lug.
11. [] Use jabsaw (special hacksaw holder), to cut 3–4 slots down inside of seatpost stub as deeply as possible without cutting into seat-tube material.
12. [] Crush protruding section of seatpost in vise and use twist and pull procedure to pull frame off of seat post.

SIZING

The best way to measure a seat tube for the correct size of seatpost is to use an Odyssey MS-200 sizing rod. If this is not available, then a caliper can be used, but several measurements should be taken and averaged.

Because the seat lug may be deformed or contaminated, force may be required to install the MS-200 to the largest possible diameter that will fit. As long as the force is by hand (no impact), it is not possible to insert the tool to a larger dimension than will be correct. When inserting the tool, align the flatted side with the compression slot.

1. [] Spread or compress compression slot to uniform width at top and bottom.



29.2 *The compression slot is narrow at the top due to previous installation of an undersized seatpost. Use stacks of feeler gauges to compare the slot width from top to bottom.*

2. ☐ Insert MS-200 sizing rod as far as it will go and read dimension off of largest segment that inserted.

INSTALLATION

1. ☐ If old seatpost was scratched or corroded, hone and ream seat tube as necessary. (See SEAT-TUBE MILLING, page 7-2.)
2. ☐ If re-installing old scratched or corroded seatpost, clean it thoroughly with emery cloth.
3. ☐ Grease inserted portion of seatpost thoroughly.
4. ☐ Grease inside of seat tube thoroughly.
5. ☐ Grease seatpost-binder-mechanism threads.
6. ☐ Oil quick-release pivot (if any).

Seatposts have a mark for minimum insertion. It must never be left above the seat lug, even on a used seatpost that was being ridden that way before. If no mark can be found, insert the seatpost to a depth of at least 2.5".

7. ☐ Insert seatpost at least to *Minimum insert or Maximum height* mark, or to previous mark if restoring customer setting.
8. ☐ Gently secure post at desired height.
9. ☐ Install seat, if not already installed (see INSTALLATION, page 29-5).
10. ☐ Align nose of seat directly above center of top tube of frame.

There is not a recommend torque in the following step for seatpost-binder mechanisms for several reasons. Variations in thread pitch, bolt size, and seat-lug design make it too difficult to establish a narrow range that is always acceptable. Quick-release mecha-

nisms cannot be torqued at all. Quick-release mechanisms also require a wide variety of setups in order to secure them properly.

It is not required that a seatpost-binder mechanism make the seatpost immobile. It is likely that the seat lug will be damaged if immobilization is attempted. Step #122 requires putting a lateral load on the nose of the seat. The binder should be tightened until the post resists slipping at 50 pounds of force at the nose of the seat.

11. ☐ **Bolt-type seatpost-binder mechanisms:** Secure bolt to 60in-lb minimum.

Quick-release mechanisms: Adjust quick release so that force occurs through 45° of motion while closing lever to parallel-to-frame position.

12. ☐ Test seatpost security. It should withstand at least 50lbs applied to side of seat nose without seatpost rotating.

13. If seatpost fails step 12 test:

☐ **Bolt-type seatpost-binder mechanisms:** Increase torque by 5in-lb increments, until test is passed.

☐ **Quick-release mechanisms:** Adjust quick release so that clamping force begins earlier by 15° increments, until test is passed.

SEATS

REMOVAL

Before removing any customer's seat that will be re-installed, measurements of its angle and fore-and-aft position should be taken.

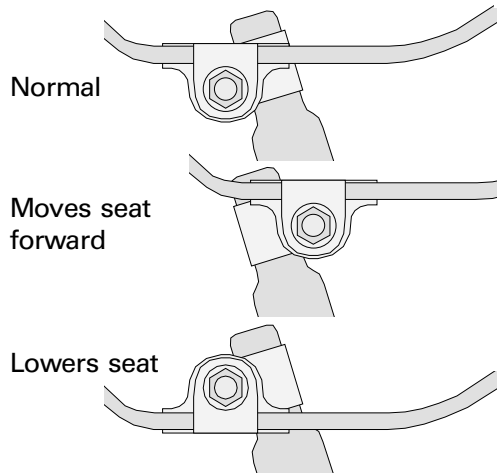
If the seat is being removed because a bent seatpost is being replaced, then it would do little good just to measure the seat angle. Instead, measure the difference between the seat angle and the seatpost angle. A dial protractor can be used for both of these angle measurements. To measure the seat angle accurately, place a long straight edge from seat nose to tail and place the protractor on top of it.

To measure fore-and-aft, just record the distance from the backside of the stem shaft to the seat nose.

1. ☐ Measure and record seatpost angle: _____°
2. ☐ Measure and record seat angle: _____°
3. ☐ Subtract to get angle difference: _____°
4. ☐ Measure seat nose distance from back of stem shaft and record here: _____mm
5. ☐ Loosen clamp bolt and remove seat.

NON-INTEGRAL CLAMPS

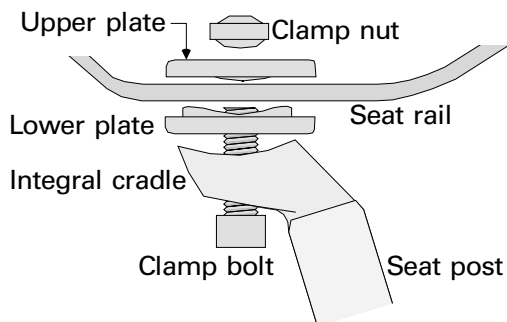
Non-integral clamps are the most primitive type and offer the least angle adjustment. Make sure the serrations on the facing plates are engaged before tightening the nut(s). If there are nuts on both sides, be sure to tighten them equally. Normal torque on nuts (threads greased) is 130–170in-lbs (11–14lbs@6"). See the following illustrations for clamp orientations.



29.3 Normal and optional clamp orientations.

SINGLE-BOLT INTEGRAL CLAMPS

Single-bolt integral clamps have a single bolt, usually accessed from below the clamp and behind the seatpost. The threads should be greased and the bolt should be torqued to 120–145in-lbs (20–24lbs@6"). Angle is adjusted by moving the seat when the clamp bolt is loose. Some models have a tendency for the angle to change while the clamp bolt is secured. Check the angle after securing the bolt.

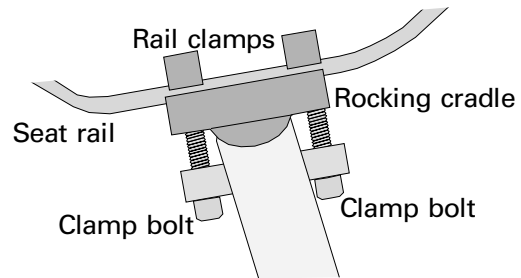


29.4 Single-bolt integral seat clamp.

DOUBLE-BOLT INTEGRAL CLAMPS

Double-bolt integral clamps have two clamp bolts that work in opposition. When one is loosened and the other is tightened, the seat angle will change. The two bolts are generally identical and are on opposite sides of the center of the cradle, with neither bolt going through the center of the cradle.

Grease threads, and alternate tightening whichever bolt is needed to change the seat angle to desired position. When angle is correct, alternate tightening both bolts equally until both have reached a torque of 85–95in-lbs (18–24lbs@4").

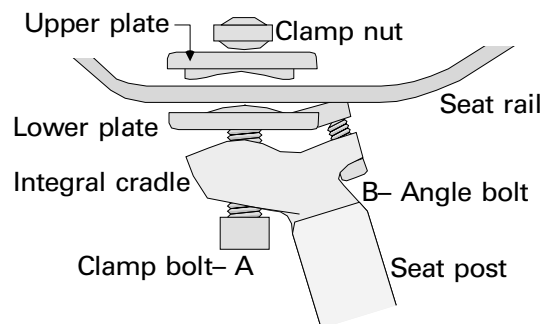


29.5 Double-bolt integral seat clamp.

CLAMPS WITH ANGLE-ADJUSTMENT SCREWS

Clamps with an angle-adjustment screw are variations of a single-bolt integral clamp. Like the single-bolt integral clamp, there is a large bolt that goes through the center of the cradle. There is a second bolt or screw (generally smaller), that is towards the front or back of the cradle. This is the angle-adjustment screw.

With the main clamp bolt loose, adjust the angle-adjustment screw to the desired location, then tighten the main clamp bolt to 120–145in-lbs (20–24lbs@6").



29.6 Single-bolt integral seat clamp with an angle-adjustment screw. To set angle, loosen A, then tighten or loosen B. To secure, tighten A.

INSTALLATION

The customer's existing seat position should be maintained as closely as possible if the seat is removed and re-installed or replaced, no matter how unorthodox the position is. There's certainly no harm in bringing their unorthodox seat position up when they return for the bike, but don't be surprised if there adamant that its comfortable just the way it is.

When setting up bikes for sale, the seat should be set at a neutral position. This means that the fore-and-aft adjustment should be in the middle of the range, and that the angle should be as close to flat as possible. If serrations in the seat clamp do not allow a flat angle, set the nose at the first click *up*.

6. [] **Install seat in seat clamp, but do not secure.**
7. [] **Adjust seat to match original position, or to shop's angle and fore/aft standards.**
8. [] **Secure clamp to recommended torque.**

Non-integral clamps:

130–170in-lbs (11–14lbs@6")

Single-bolt integral clamps:

120–145in-lbs (20–24lbs@6")

Double-bolt integral clamps:

85–95in-lbs (18–24lbs@4")

Single-bolt integral clamps with angle-adjustment screws (main bolt only):

120–145in-lbs (20–24lbs@6")

Testing seat security

It is not sufficient to simply torque the seat clamp to the recommended torque and forget it. A seat that tips when the rider is on it can dump the rider on the top tube or rear tire with catastrophic results. *To test seat security, exert a downward pressure of at least 75 pounds on the nose of the seat. It should not slip at all.*

9. [] **Apply 75lb load down on nose of seat to check for slip.**

30 – SHIFT-CONTROL MECHANISMS

ABOUT THIS CHAPTER

This chapter is about shift levers and twist-grip shifters. There are separate chapters about the setup of control cables that attach to the shift-control mechanisms (**DERAILLEUR-CABLE SYSTEMS**, page 31-1), but this chapter includes information about installing the inner wire into the shift-control mechanism. There is a separate **REAR DERAILLEURS** chapter (page 32-1) and **FRONT DERAILLEURS** chapter (page 33-1).

GENERAL INFORMATION

TERMINOLOGY

Shift-control mechanism: A lever or twist grip that the rider uses to control the derailleur operations.

Shift lever: A lever that is rotated about a pivot to move the inner wire that operates the derailleur.

Shifter drum: A cylinder that the cable wraps around when the shifter is rotated.

Twist grip: A cylinder that is part of the hand grip on the handlebar that is rotated around the handlebar to move the inner wire that operates the derailleur.

Grip Shift: See *twist grip*.

Down-tube levers: Shift-control mechanisms that are mounted on the down tube of the frame.

Stem shifters: Shift-control mechanisms that are mounted on the vertical shaft of the stem.

Bar-end shifters: Shift-control mechanisms that are mounted in the ends of drop-style handlebars.

Bar cons: See *bar-end shifters*.

Top-mount shifters: Shift-control mechanisms that are mounted on top of MTB-style handlebars.

Thumb shifters: See *top mount shifters*.

Below-bar shifters: Shift-control mechanisms that are mounted so that they are reached by using the thumb below the bar on MTB-style handlebars.

Integral shift/brake levers: Shift-control mechanisms found on road bikes with which the shift levers are integrated into the brake levers.

Inner wire: The wire portions of the shift-control cable.

Housing: The outer sheath of the shift-control cable.

Shift-control cable: The inner wire and housing that work as a unit to transfer a change at the shift-control mechanism to the derailleur.

Adjusting barrel: A hollow bolt that the inner wire passes through, with a socket head that the housing inserts into. The adjusting barrel is screwed in and out of the shift-control mechanism to adjust the relative length of the inner wire.

Indexed (shifting): A shifting system in which the shift-control mechanism stops at prescribed increments, rather than anywhere within a prescribed range. When an indexed shift-control mechanism is moved to one of the prescribed positions, the shift is completed automatically.

Friction (shifting): A shifting system in which the shift-control mechanism moves to an infinite number of positions within a prescribed range. The shift-control mechanism is moved to wherever the operator chooses to complete the shift. It is not automatic.

Front derailleur: The mechanism that moves the chain between gear choices on the crankset.

Rear derailleur: The mechanism that moves the chain between gear choices on the rear hub.

PREREQUISITES

If installing a new shift-control mechanism or replacing an existing one, cable installation and derailleur indexing adjustment will be required. There are no other prerequisites.

INDICATIONS

Maintenance

Most of the time, the only maintenance needed by a shift-control mechanism is lubrication. Sometimes they need partial disassembling and cleaning.

Derailleur replacement

Derailleurs and shift-control mechanisms must be compatible. Sometimes changing a derailleur means that a new shift-control mechanism is needed.

Rear cogset replacement

Sometimes a cogset will be changed to have more gears. The derailleur may be able to handle the increase, but an indexing shift-control mechanism is almost always set for a specific number of gears.

Symptoms indicating need for cleaning

Any shifting system is complex, and a symptom may be caused by any of several parts of the system. An indexing lever in need of cleaning will create a symptom of the indexing adjustment being too tight and too loose at the same time. This can also be caused by control-cable problems, dirty or worn-out chain or derailleur, or compatibility problems with the shift-control mechanism, derailleur, chain, and cogset.

Symptoms indicating need for replacement

The symptom indicating need for replacement is the same as the symptom indicating need for cleaning, except when all the other causes have been eliminated and cleaning has been done, the symptom persists.

Indexing shift-control mechanisms have delicate internal parts that sometimes break. The symptom will be either a lever that will not move, or it moves but the control cable cannot. The same symptom can also be caused by the inner wire being installed wrong. If the inner wire is in correctly, the shift-control mechanism needs to be replaced.

TOOL CHOICES

Installing and removing a shift-control mechanism requires no special tools. As a consequence of installing a shift-control mechanism, a derailleur will need adjustment, but any special tools for this are covered in the **REAR DERAILLEURS** chapter (page 32-5) and **FRONT DERAILLEURS** chapter (page 33-3).

Shimano STI levers (road-bike shift levers that are integrated into the brake levers) require a couple of special tools called the TL-ST01 and TL-ST02 for disassembling the lever.

TIME AND DIFFICULTY

In most cases, installing a shift-control mechanism is a 2–5 minute job of little difficulty. Adjustment of the derailleur is additional. If installing bar-end shifters, taping the bars is additional. If changing between a lever system that is integrated with the brake levers and one that is not, brake-lever installation and brake adjustment would take additional time. For the time and difficulty rating of all these additional factors, see the chapters that pertain to them.

COMPLICATIONS

Compatibility with derailleur

Shift-control mechanisms must be compatible with the derailleurs they are used with. An indexing shifter moves a fixed amount of cable for each click of the control. This amount of cable motion must be the correct amount to move the derailleur precisely from one gear to the next.

Any table of compatibility is doomed to becoming outdated rapidly. Manufacturer's technical support and literature will always be a better source of information. As a general guideline, different brands of shifters and derailleurs can rarely be matched (except Grip Shift brand, which are made specifically for other brands of derailleurs). Even models within a brand may be incompatible; for example, Shimano Dura-Ace components can't be mixed with other Shimano components.

When in doubt, it is possible to test for whether two components are compatible. In the **REAR DERAILLEURS** chapter is a section called **FUNCTIONAL RANGE OF ADJUSTMENT** (page 32-21) that describes a test that measures shifting performance. If mismatched equipment performs well in this test, it is compatible.

Compatibility with inner wire

Shape and size of the inner-wire head is important. Some modern shifters have plastic sockets that the inner-wire head seats in. If it is not a good fit, it can jam in place and be very difficult to ever get out. Before using a wire, insert its head backwards into the shifter socket and make sure it slips all the way in and out easily.

Inner-wire diameter is important with indexing shifters. The amount of cable pulled with each click of the shifter is a function of the diameter of the cylinder (shifter drum) that the cable is wrapping around and the inner-wire diameter. Until 1995, all indexing levers used a 1.2mm inner wire except Shimano Dura-Ace (1.6mm). Shimano switched to a 1.1mm wire in 1995, and back to 1.2mm in 1996.

Integration with brake levers

Certain shifters on MTBs share a mount with the brake lever. The configuration of the mount is specific to the model of shifter. When one of these older shifters needs replacement, it is possible that the brake levers and shifters will both need replacement.

Symptom caused by multiple items

When indexing shift performance is poor, the nature of the symptom will not necessarily point to one specific cause. A shifter, cable, derailleur, chain, or rear cogset could all cause the same symptom.

Patience to investigate all the possible causes of the symptom is required to narrow it down to, or to exclude, the shifter as the cause.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into seven sections for each type of shift-control mechanism. Each section is divided into an installation sub-section and a service sub-section. Some sections are divided further, when different brands or models within a category require different procedures. The seven sections are:

BELOW-BAR SHIFTERS
TOP-MOUNT SHIFTERS
TWIST-GRIP SHIFTERS
INTEGRAL SHIFT/BRAKE LEVERS
DOWN-TUBE LEVERS
BAR-END SHIFTERS
STEM SHIFTERS

BELOW-BAR SHIFTERS

Types

Many below-bar shifters are integrated with the brake lever. They can be removed from the brake lever for cleaning or replacement, but to install and align them, the brake lever must be installed and aligned.

Another type of below-bar shifter is not integrated with the brake lever. This type needs to be positioned relative to the brake lever after correctly positioning the brake lever.

Terminology

Up-shift lever: The lever that is pushed to move the derailleur from a smaller diameter gear (fewer teeth) to a larger diameter gear (more teeth).

Release lever: The lever that is pushed to release the derailleur to a smaller diameter gear (fewer teeth) from a larger diameter gear (more teeth).

Shifter pod: The complete shift-control mechanism that is part of an integrated shift/brake lever.

Pod-mounting plate: The flat plate that is part of the brake-lever body.

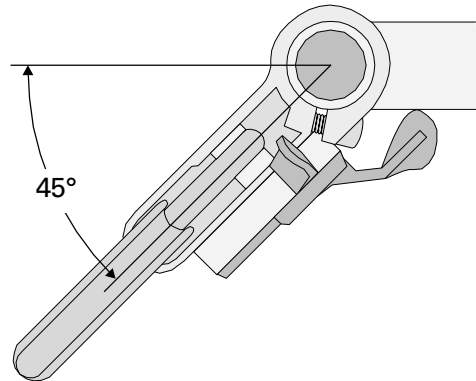
Brake-lever binder bolt: The bolt that secures the brake-lever clamp to the handlebar.

Pod-mounting bolt: The bolt that secures the shifter pod to the pod-mounting plate.

INSTALLATION

Integrated shift/brake levers

1. [] Remove grip if necessary.
2. [] Slide shift/brake lever over end of bar.
3. [] Install grip to final position.
4. [] Slide shift/brake lever outward until clamp is against inside edge of grip.
5. [] Remove and lubricate brake-lever binder bolt.
6. [] Install brake-lever binder bolt and gently snug.
7. [] With bike in on-ground position, use dial protractor to rotate lever so that brake lever body is 45° from horizontal.

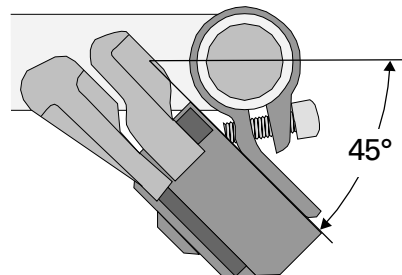


30.1 Rotate the brake lever 45° down from horizontal.

8. [] Tighten brake-lever binder bolt to: 35–50in-lbs (9–12lbs@4").

Non-integrated below-bar shifters

1. [] Remove binder bolt from shifter-mounting strap or clamp.
2. [] Lubricate binder-bolt threads.
3. [] Install shifter, brake lever, then grip onto handlebar. Correctly position brake lever (adjacent to grip and rotated down 45° from flat), then secure brake lever.
4. [] Install shifter binder bolt and gently snug.
5. [] Slide shifter outward against brake lever, until release lever is just far enough outward to not touch brake lever when shifter is operated.
6. [] Rotate shifter so that shifters will operate in a plane 45° down from horizontal.



30.2 Rotate the shifter 45° down from horizontal.

30 – SHIFT-CONTROL MECHANISMS

8. [] Tighten shifter-clamp binder bolt to:
25–30in-lbs (6–8lbs@4").

SunTour X-Press shifters

The correct rotational alignment for these shifters is 60° down from horizontal (starting with shifters at horizontal *in front* of handlebars).

INNER-WIRE INSTALLATION

Shimano Rapidfire and Rapidfire Plus inner-wire installation

Shimano Rapidfire levers (both levers pushed with the thumb) have a cover plate retained by a Phillips screw that has to be removed to access the inside of the shifter for inner-wire installation. Some Rapidfire Plus levers have a plug in the access hole for the inner wire. Rapidfire SL levers (described after the next heading), have a completely different cable-installation process.

Shimano Rapidfire and Rapidfire Plus (release lever operated by index finger) shifters need to be fully released in order to correctly install the inner wire. The wire can be installed without fully releasing the shifter, but the lever will not operate correctly.

1. [] Remove access cover plate if any.
2. [] Operate release lever at least 7 times to insure lever is fully released.

Earlier Shimano levers were difficult to install inner wires in, because once the inner wire was installed through the hole in the shifter drum it would not pass easily through the adjusting barrel. Sometimes it is necessary to remove the adjusting barrel from the shifter to complete the inner-wire installation.

3. [] Insert end of wire through access hole into inner-wire head socket and out adjusting barrel.
4. [] Pull inner wire through until head seats into socket in the shifter drum.
5. [] Pulling firmly on inner wire, push up-shift lever and then release lever to make sure wire moves to and away from shifter as levers are operated. (If not, inner wire is in wrong and should be removed.)

Shimano Rapidfire SL inner-wire installation

Shimano Rapidfire SL shift mechanisms are distinguished in appearance by the fact that there is a slot in the derailleur-cable adjusting barrel for quick-releasing the cable out of the shift mechanism. On less expensive models, there is a cover that swings out of place to expose the anchor for the inner-wire head. More expensive models have a similar cover, but instead of

swinging out of place, two tiny Phillips screws hold it in place. In both cases, the cover is accessed from the back face of the lever unit, just below the handlebar; where the inner-wire slot ends in the mount for the adjusting barrel, the cover begins. Underneath the cover is a pivoting cable anchor, just like the one in the brake lever that the brake inner wire attaches to.

1. [] Press release lever 7 times to make sure shift mechanism is in fully-released condition.
2. [] Remove cable-anchor cover by pivoting it up towards handlebar, or by removing small Phillips screws and lifting cover off lever (depending on model).
3. [] Line up slot in adjusting barrel with slot in adjusting-barrel mount.
4. [] Swing cable anchor up towards handlebar.
5. [] Hook inner-wire head into cable anchor.
6. [] Swing inner wire into slot in adjusting-barrel mount and into slot in adjusting barrel.
7. [] Rotate adjusting barrel 1/2 turn so inner wire will not accidentally come out.
8. [] Replace cable-anchor access cover.

SunTour X-Press inner-wire installation

1. [] Unscrew shifter cover screw at center of shifter cover and remove cover.
2. [] Feed inner wire out adjusting barrel.
3. [] Hook inner-wire head into socket in shifter plate inside shifter.
4. [] Replace shifter cover.

SERVICE

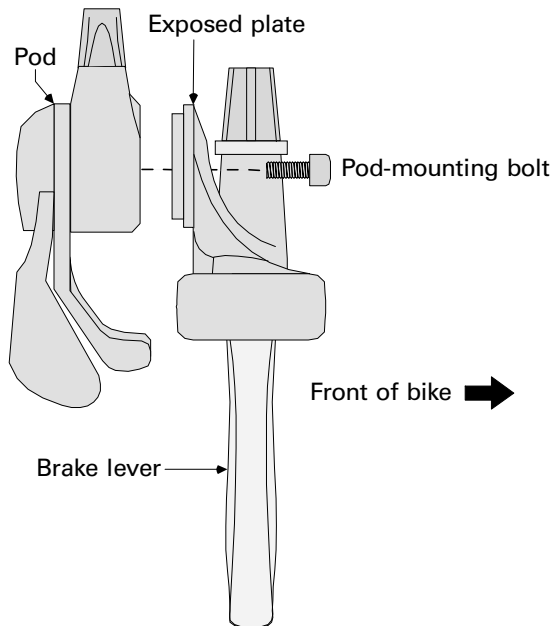
Shifter pods can be replaced or cleaned, but they are never disassembled to replace individual parts because the individual parts are not sold.

Shimano shifter-pod replacement

Shifter pods are attached one of three ways at this time. First, a little orientation. The front of the shift/brake-control unit is the side that can be seen when standing in front of the bike and facing it. The back face is the side that would face toward the rider's knees. Some models have the shifter pod mounted on a plate that is visible from the front. There is a bolt head in the center of the shifter pod on the back face of the assembly. These will be called **exposed-plate models** (see figure 30.3, page 30-5). Some models have the shifter pod mounted on a plate that is enclosed between the shifter pod and the gear-indicator unit. There is a bolt head in the center of the shifter pod on the back face of the assembly. These will be called **enclosed-plate models** (see figure 30.4, page 30-5). Shimano Rapidfire SL models have an exposed plate, but there is no bolt head in the

center of the shifter pod (see figure 30.5, below, right). Rapidfire SL levers can also be identified by the unique fact that they have a slot in the derailleur-cable adjusting barrel that is used for moving the inner wire in and out of the adjusting barrel. This last type will be called Rapidfire SL models.

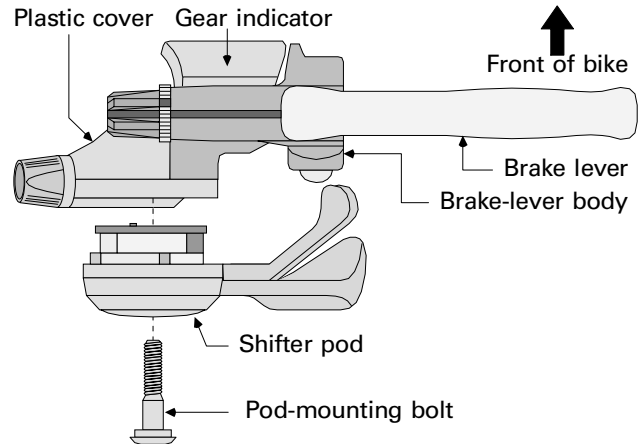
Exposed-plate models: To remove the shifter, loosen the bolt that is visible on the front face of the mounting plate. Note the rotational orientation of the shifter because it may have multiple mounting positions. When the bolt is fully removed, the shifter pod will pull off the back side of the plate. When reinstalling, make sure that the positioning pegs go into the desired positioning holes in the mounting plate. Use Loctite #222 on the mounting-bolt threads and torque the bolt(s) to 25in-lbs (6lbs@4").



30.3 Removing the pod from the exposed plate.

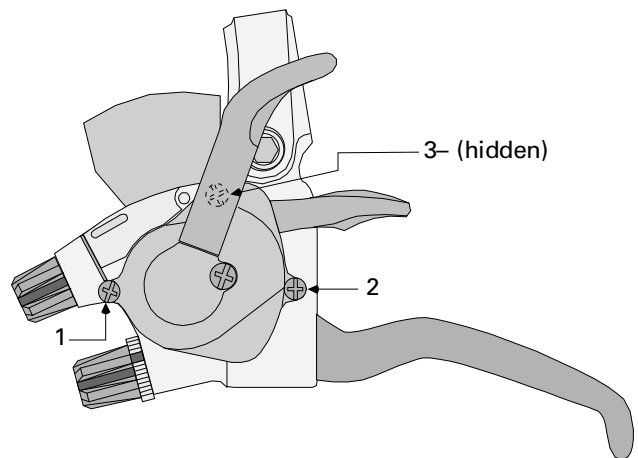
Enclosed-plate models: The shifter-pod mounting bolt goes through the center of the pod and is accessed from the back face of the pod. It is often secured with a heavy-duty Loctite and may be difficult to break loose. The bolt is threaded into a sleeve nut with a flatted flange that is hidden behind the gear-indicator unit. The flatted flange tends to pop out of its recess and just spin, so pull out on the shifter pod firmly while loosening or tightening the mounting bolt. If the sleeve nut spins uncontrollably, it will be necessary to remove the gear-indicator unit. When installing the pod, make sure the lever is fully released so that the post on the colorful plastic plate that activates the gear indicator goes in the hole that is sup-

posed to engage it. Use Loctite #222 on the mounting-bolt threads and torque to 25in-lbs (6lbs@4"). On some models, the pod cannot be removed unless the gear-indicator unit is also removed. This includes STX and Alivio Models with "MC" in the model number, which are visually distinguished by having an enclosed mounting plate and an under-the-bar indicator unit.



30.4 Removing the pod from an enclosed-plate unit.

Rapidfire SL models: Remove the gear indicator and the derailleur inner wire first. The shifter pod on these models is held in place by three Phillips screws. All the screws are on the back face of the pod. One is close to the derailleur-cable adjusting barrel. Another is just clockwise of the release lever. The third one is just counterclockwise of the release lever. One of the screws near the release lever will be hidden by the up-shift lever. When these three screws are removed, the shifter pod pulls easily of its mount. (See figure 30.5, below.)

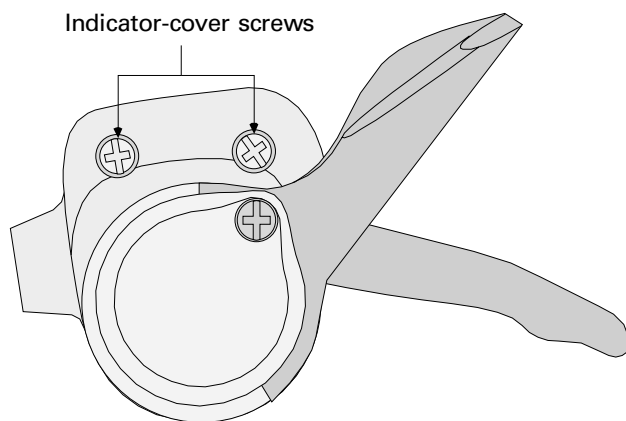


30.5 To remove the pod from a Rapidfire SL model, remove screws 1, 2, and 3.

Shimano Rapidfire and Rapidfire Plus gear-indicator-unit replacement

The following information covers gear-indicator removal and replacement for earlier Shimano Rapidfire and Rapidfire Plus models. There is another section following this one for Rapidfire SL models (distinguished by slot in derailleur-cable adjusting barrel). There are several ways that the gear indicator is mounted to the shift/brake control. When the pod is mounted to an *exposed-plate model*, the indicator unit comes off with the pod. These will be called **integrated type** (figure 30.6). Other types on *enclosed-plate models* may be over-the-bar or under-the-bar indicator units. All of these are not integrated with the shifter pod and come off separately. The under-the-bar type will be called **non-integrated under-the-bar type** (figure 30.7). The over-the-bar types come in *three* variations at the time of this writing! These will be called **hidden-screw over-the-bar type** (figure 30.8), **visible-screw over-the-bar type** (figure 30.9), and **Rapidfire SL type** (described under separate heading).

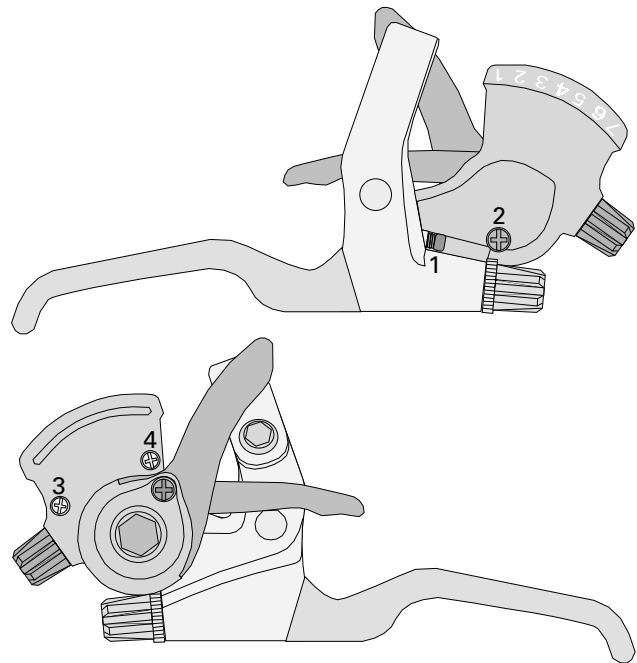
Integrated type: This is found on 700CX and 400CX models. After removing the pod from the mount, unthread two Phillips screws on the back side of the pod that are just below the indicator window. The indicator unit cover will lift off of the pod. The indicator itself is a thin sliding plastic strip that cannot be removed correctly without fully disassembling the pod unit, which *should not be done*. If the strip is damaged and jamming, it can be ripped out with a pair of pliers after removing the cover.



30.6 Shifting pod with an integrated gear indicator.

Non-integrated under-the-bar type: Remove two Phillips screws that are on the backside of the pod and just outside the perimeter of the pod cover, which rotates when the up-shift lever is operated. Remove the brake-lever reach-adjustment screw.

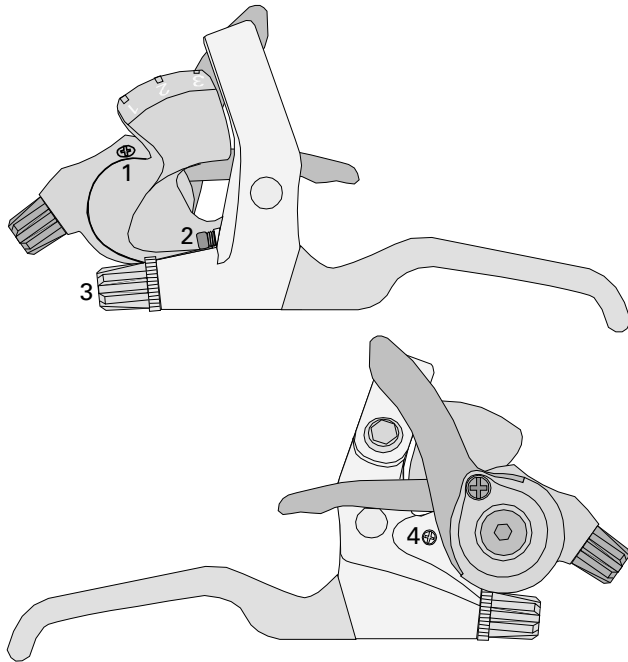
On the front side of the indicator unit, remove the Phillips screw that is adjacent to the brake-cable adjusting-barrel locknut. Lift off the indicator-unit cover. The orange indicator arm (spring loaded, be careful) just lifts out of the cover plate. When reinstalling the indicator arm, the spring must be set up to force the arm fully counterclockwise. The plastic actuator lifts out of the shifter-pod mounting plate to expose the flanged sleeve nut that the pod-mounting bolt screws into. When reinstalling, the pod unit needs to be shifted to the fully-released condition so that the long pin on the actuator will line up properly with the hole it inserts in.



30.7 To remove an indicator unit from a non-integrated under-the-bar type, remove screws 1, 2, 3, and 4.

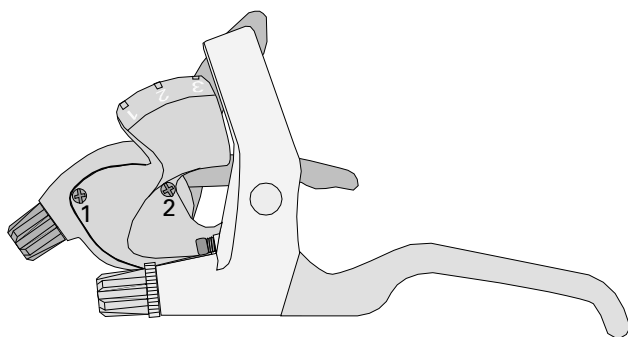
Hidden-screw over-the-bar type: When this type is on the handlebar, no screws can be seen in the indicator unit when viewed from the front. The whole shift/brake control must be removed from the handlebar to remove the indicator. Once the whole assembly is off the bar, one screw will become visible that was hidden by the handlebar. The other screw is on the back face of the casting just below the bottom of the shifter pod. Remove both these screws. *Do not remove the two screws in the indicator unit that are close to the window!* Remove the brake-cable adjusting barrel. On the front face of the control unit, the brake-lever reach-adjustment

screw must be removed so that the indicator unit can be lifted off. Pull on the indicator unit to remove it from the lever body.



30.8 To remove the indicator unit from a hidden-screw over-the-bar type, remove screws 1 and 2, adjusting barrel (3) and screw 4.

Visible-screw over-the-bar type: This type can be removed without removing the whole shift/brake control unit from the lever. Viewed from the front, small screws at the base of the indicator-unit tower and close to the brake-cable adjusting barrel will be seen. Remove these with a #0 Phillips screwdriver, and the indicator unit lifts right off. *Do not disassemble the unit!* The plastic actuator lifts up, and the mount cover snaps off.



30.9 To remove the indicator unit from a visible-screw over-the-bar type, remove screws 1 and 2.

Shimano Rapidfire SL gear-indicator-unit removal and installation

Rapidfire SL models are distinguished by a slot in the derailleur-cable adjusting barrel. The gear indicator is on the front face of the plate on which the shifter pod mounts. Removing two small Phillips screws enables the gear-indicator unit to be lifted off the mounting plate. An asymmetrical hexagonal plastic stud in the back face of the gear indicator engages an asymmetrical hexagonal socket that is in a hole in the mounting plate; if the shifter pod is in the fully-released mode when installing the gear indicator unit, the asymmetrical stud and socket will line up automatically. When installing the gear-indicator unit, the brake-lever reach-adjusting bolt may need to be removed in order to line the gear-indicator unit up properly.

Shimano shifter-pod cleaning and lubrication

Before replacing a shifter pod that is not functioning, consider cleaning and re-lubing it. To clean it, the pod must be removed from the mount and the cover must be removed from the pod. On pods with *integrated indicators*, the indicator cover should also be removed.

The technique for removing pod covers is different for different models. On *exposed-mount* types only, there may be a single large Phillips screw at the center of the pod cover on the back side. Some *exposed mount* types have an additional small Phillips screw at the perimeter of the pod cover that must also be removed. Some *exposed mount* types have only a small Phillips screw at the perimeter of the pod cover. All *enclosed mount* types have only a small Phillips screw at the perimeter of the pod cover.

The Rapidfire SL models have a small Phillips screw at the base of the up-shift lever that must be removed in order to remove the pod cover.

After removing the pod and cover(s), soak the pod in solvent. After it has soaked, agitate it in the solvent and repeatedly operate the levers while it is submerged. Blow it dry *thoroughly* and generously lube it with a heavy-weight spray lube.

TOP-MOUNT SHIFTERS

INSTALLATION

Top-mount shifters are installed inward of the brake levers. The shifter is above and in front of the handlebar.

The end of the lever extends to the grip, and if the lever is positioned too far outward the lever can interfere with use of the grip. Some models have cast clamps and must be slid on the bar from the end before installing the brake lever or grip. Some models have strap clamps that can be spread open and slipped over the bar while the brake lever and grip are in place.

1. [] **With brake lever and grip in final positions, mount shifter loosely, inward of brake lever.**
2. [] **Lubricate mounting-bolt threads and snug bolt gently so that shifter can easily be moved, but will stay in place by itself.**
3. [] **Operate shift lever so that lever is parallel to handlebar.**
4. [] **Move lever unit laterally so that end of lever is even with *and not overlapping* inward end of grip.**
5. [] **Rotate lever unit around handlebar until lever swings in a plane that is parallel to ground.**

Lever rotation is acceptable in a range from parallel to the ground, to rotated 45° forward. A position of 25–30° forward is recommended.

6. [] **Rotate lever forward to desired angle (25–30° recommended).**
7. [] **Secure mounting bolt to 20–25in-lbs (5–6lbs@4").**

INNER-WIRE INSTALLATION

When installing the inner wire, thread it fully through the socket on the shifter drum so that the head ends up in the socket, *then* put the end of the wire through the housing stop or adjusting barrel and draw the wire fully through. Putting the wire partially through the hole in the shifter drum and then through the housing stop, before pulling the wire all the way through the hole in the shifter drum, will result in the inner wire developing a corkscrew bend.

SERVICE

Look for a shifter-mounting bolt on the bottom side to remove the shifter from the mount. If there is a screw in the shifter cover, remove it. Soak and agitate the shifter in solvent, then blow dry and lubricate thoroughly. There is no point to disassembling the mechanism because there are no parts available.

TWIST-GRIP SHIFTERS

GRIP SHIFT

Models

The following instructions are suitable for models SRT 100/150, SRT 400i/300i/200i, SRT 500R, Quickshift, MRX-100, and SRT 400/600/800/900 (X-ray). These models were current in 1995 at the time of this writing. Models after this time may be similar or completely different.

Installation

1. [] **Loosen brake lever.**
2. [] **Slide Grip Shift shifting unit onto handlebar.**
The washer installed in the next step is very important because it keeps the shifter from binding against the grip.
3. [] **Slide 7/8" thin plastic washer onto handlebar.**
4. [] **Install grip fully onto handlebar.**
5. [] **Slide Grip Shift shifter outward so that it is against inward end of grip.**
6. [] **Secure brake lever at final rotational and lateral positions.**

For securing the Grip Shift to the handlebar, there is either a binder bolt or set screw with an Allen head. Either is located at the inward end of the unit, at a location that will be toward the back side and bottom, when the unit is on the handlebar with the adjusting barrel positioned just below the brake lever.

7. [] **Remove and lube mounting-binder bolt or set screw.**

Depending on the set-up of the frame and handlebars, the conventional positioning of the adjusting barrels below the brake levers might create an awkward cable routing. If this is the case, do not hesitate to try positioning the Grip Shift adjusting barrels above the brake-lever bodies.

8. [] **Rotate Grip Shift shifter until its adjusting barrel is just below brake-lever body, then install and gently secure binder-bolt/set-screw.**
9. [] **Operate brake lever to make sure Grip Shift does not interfere with operation and reposition shifter as necessary.**
10. [] **Secure set screw (2.5mm Allen) to 20in-lbs (7lbs@3"), or binder bolt (3mm Allen) to 17in-lbs (6lbs@3").**

Detaching cable

1. [] **Rotate shifter forward to fully release inner wire and disconnect inner wire from derailleur.**

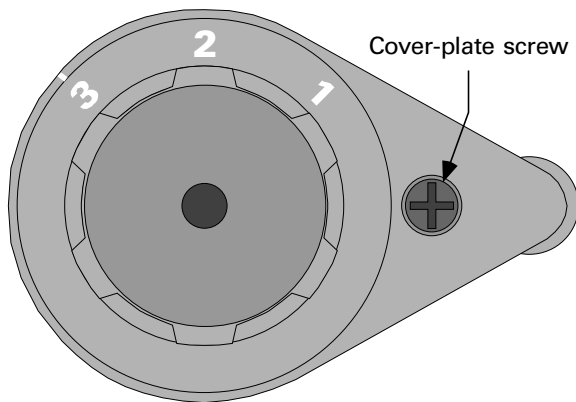
Cover-plate removal

Most Grip Shift mechanisms have a cover plate that must be removed for dissassembly, but some do not.

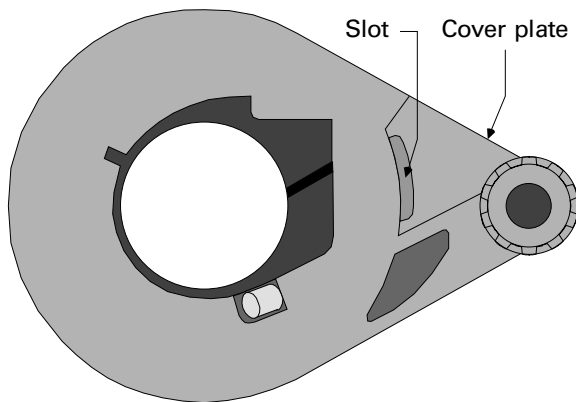
If the inner wire is exposed in a groove around the bend at the base of the adjusting barrel, there is no cover plate.

If there is no exposed wire, look for a Phillips screw in the outward face of the base that goes out to the adjusting barrel (see figure 30.1). When the screw is removed, the plate comes right off.

If there is no exposed wire or Phillips screw, look for a shallow slot that just fits a 3/16" screwdriver blade on the inward face of the base that goes out to the adjusting barrel (figure 30.11). Insert a screwdriver in this slot and twist or pry to pop the cover plate off.



30.10 This outward-end view shows the Phillips screw that holds on the cover plate on some models.



30.11 This inward-end view shows the slot used to pry off the cover plate on some models.

2. [] Remove cover plate on base that goes out to adjusting barrel.

Removing twist unit and cable

3. [] Remove the grip and washer just outward of shifter.

If a cover plate was removed, the twist unit will pull out of the housing effortlessly. If the model had no cover plate, it must be rotated fully back (pulling the cable as far as possible) before pulling it off with some effort.

4. [] Pull twist unit out of housing. Models with no cover plate must be rotated **fully** back before pulling.

5. [] Push inner wire into adjusting barrel until end is through and out of adjusting barrel.

Some shifters have the inner-wire head inserted in a socket that is in the inward face of the shifter housing. Some shifters have the inner-wire head inserted in the large cylinder surface of the twist unit.

6. [] Push inner wire out of twist unit or out of shifter housing.

Cleaning and lubrication

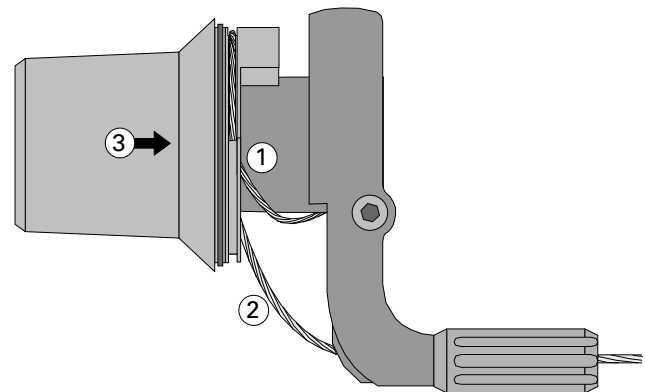
7. [] Parts should only be cleaned with a mild soap. Solvents may degrade plastic parts.
8. [] Lubricate shifter-housing barrel, spring, spring cavity, cable groove on way to adjusting barrel, and détentes in twist unit with Grip Shift Jonnisnot grease or petroleum jelly **only**.

NOTE: If inner-wire head is in twist unit, skip to step 12.

Inserting inner wire in shifter with wire-head socket in shifter housing

NOTE: If wire is already installed, skip to step 14.

9. [] Feed wire end into socket on inward face of shifter housing and seat head fully.
10. [] Wrap wire one time around shifter-housing barrel and then into adjusting barrel, pulling so that loop ends up slightly smaller than diameter of enclosure.
11. [] Slide shifter onto barrel of housing and place loop of housing up feed ramp and into groove around inward end of twist unit, then go to step 14.



30.12 To install the inner wire: 1) wrap the wire once around the shifter-housing barrel, 2) feed the wire onto the ramp and into the groove around the twist unit, 3) then push the twist unit into the shifter housing.

Inserting inner wire in shifter with wire-head socket in twist unit

12. [] Insert wire into socket in twist unit, and seat head fully.
13. [] Slide twist unit onto barrel of shifter housing, and insert wire through adjusting barrel.

Assembling shifter

14. [] Line up twist unit so that any part of gear-indicator range on twist unit lines up with gear-indicator mark on shifter housing.
15. [] Pull firmly on inner wire while pressing in twist unit with firm pressure. Rotate twist unit back-and-forth to get spring to line up with détente, until parts seat together fully.
16. [] Install cover plate, if any.
17. [] Pull on inner wire while operating twist unit back-and-forth to check that cable moves and twist unit clicks in détentes.

SACHS POWER GRIP AND POWER GRIP PRO

Installation

1. [] Install brake lever on handlebar loosely.
2. [] Slide shifter onto handlebar and leave loose.
3. [] If shifter has separate grip, slide both 7/8" I.D. washers onto handlebar and install stationary grip fully on, then slide shifter out gently against washers.
4. [] If shifter includes full grip, slide shifter fully on bar.
5. [] Position and secure brake lever.
6. [] Rotate shifter until adjusting barrel is just below brake-lever body.
7. [] Secure shifter bolts on bottom side of housing to 35in-lbs (12lbs@3").

Inner-wire replacement and service

Before performing the following procedure, confirm that the model being dealt with is one this procedure covers. The most current models do not require any disassembly for wire removal. Simply detach the inner wire from the derailleur and attempt to push it out of the shifter.

If this works, do not use the following procedure for inner-wire replacement.

1. [] Leave shifter on handlebar during disassembly.
2. [] Shift to release all cable tension and detach inner wire from derailleur and remove all cable housings.
3. [] ***Pull*** cable-adjusting barrel out of shift-mechanism cover.
4. [] Remove both bolts in bottom of shift-mechanism cover.

5. [] While holding bottom cover up against handlebar, pull cover off top of shift mechanism.
6. [] Pull lock button up out of back side of lower cover.
7. [] Pull J-ring off of top of inward end of twister.
8. [] Pull inner-wire guide out of front side of lower cover.
9. [] Drop lower cover off of handlebar and slide cover off end of inner wire.
10. [] If cleaning parts, remove grip and twister from handlebar.
11. [] Clean all parts, if desired.
12. [] Grease inside of twister & both sides of J-ring.
13. [] Install twister and grip on bar, if previously removed.
14. [] Insert inner wire into hole on twister.
15. [] Insert inner wire into back side of adjusting-barrel hole in lower cover.
16. [] Slide lower cover up inner wire and put lower cover on bottom side of handlebar so that lip on inner edge engages groove in bottom side of twister.
17. [] Holding lower cover up against bottom of handlebar, place lock button in back face of lower cover with tab going down into cover.
18. [] Place J-ring over inward end of twister so that pawl on inside surface of J-ring engages top-most détente in twister.
19. [] Rotating twister and deflecting end of J-ring as necessary, seat end of J-ring in slot in lower cover.
20. [] Install inner-wire guide in lower cover so that small end goes in back side of adjusting barrel hole and top end catches under shoulder on twister where inner wire first appears.
21. [] Place upper cover over mechanism.
22. [] Insert bolts in lower cover and gently snug.
23. [] Slide adjusting-barrel assembly over cable and insert nut on adjusting barrel into hole in lower cover.
24. [] Position and secure shifter as described in previous section, *Installation*.

INTEGRAL SHIFT/BRAKE LEVERS

INSTALLATION

1. [] Pull out on rubber cover on outward side of shift/brake lever to reveal head of lever-mounting bolt and loosen bolt until almost out of nut in mounting strap.

2. [] Lubricate threads of nut in mounting strap.
3. [] Slide lever onto bottom of handlebar. If lever is correct for this side of bike, housing stop will point inward.
4. [] Snug mounting bolt so that lever can just be moved up and down.
5. [] Move lever up or down so that bottom tip of lever is .5" above or below line extended forward from bottom of bar.
6. [] Rotate lever so that it points straight forward.
7. [] Secure lever-mounting bolt to 70–85in-lbs (17–21lbs@4").

SHIMANO STI SERVICE

Terminology

Shifter unit: The entire lever assembly that pulls back to the handlebar to operate the brake, or pushes to the center of the bike to operate the gears.

Brake/shift lever: The primary lever, that is pulled back for braking and pushed inward to pull the derailleur inner wire.

Release lever: The secondary lever that is pushed inward to release the derailleur inner wire.

Housing-stop/front-cover: The cover in front of the head of the brake/shift lever. The housing-stop portion is the protrusion that points inward that has a socket in it for the cable housing to insert in.

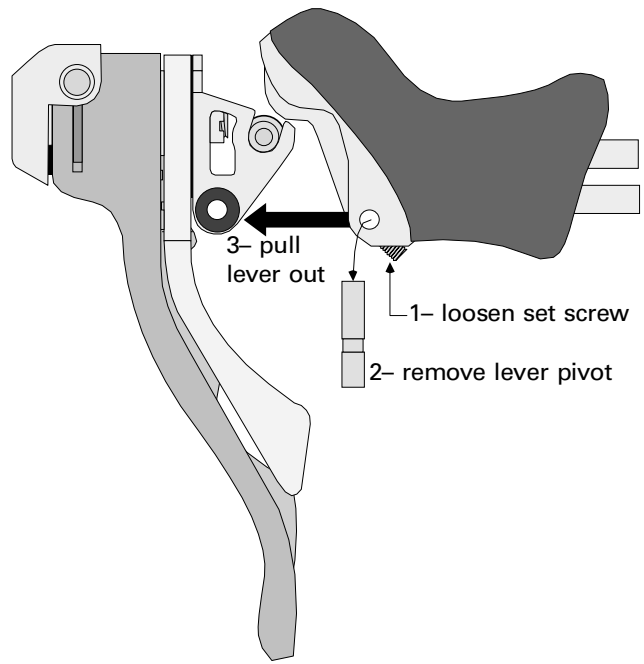
Lever-pivot stud: A small axle that the shifter unit pivots on when pulling the brake/shift lever backward to operate the brake.

Brake-lever housing: The stationary body of the lever that attaches to the handlebar.

Chrome adapter: A large piece of chromed metal that connects the shifter unit to the brake-lever housing.

Shifter-unit removal

1. [] While pedaling, operate release lever until chain reaches last gear, then detach inner wire from derailleur.
2. [] Remove cable housings and pull inner wire from all guides on frame.
3. [] Compress brake lever to handlebar to reveal cable head in socket in outward side of head of brake/shift lever.
4. [] Push inner wire into housing stop on inward side of lever and pull inner-wire head out outward side.
5. [] Remove entire brake lever from handlebar.
6. [] Loosen brake-lever-stud fixing screw using 2mm Allen key, one complete turn.



30.13 To remove the shifter unit: 1) loosen the set screw, 2) push out the lever pivot, 3) then pull the shifter unit out of the lever body.

7. [] Operate brake lever to relieve pressure from brake-lever return spring and push brake-lever pivot stud inward using 4mm Allen or similar tool. (Note orientation of stud. Recessed portion of stud is on end to inward side of lever.)
8. [] Carefully remove lever assembly from lever housing. (Watch for lever bushings and lever-return spring that may fall out.)

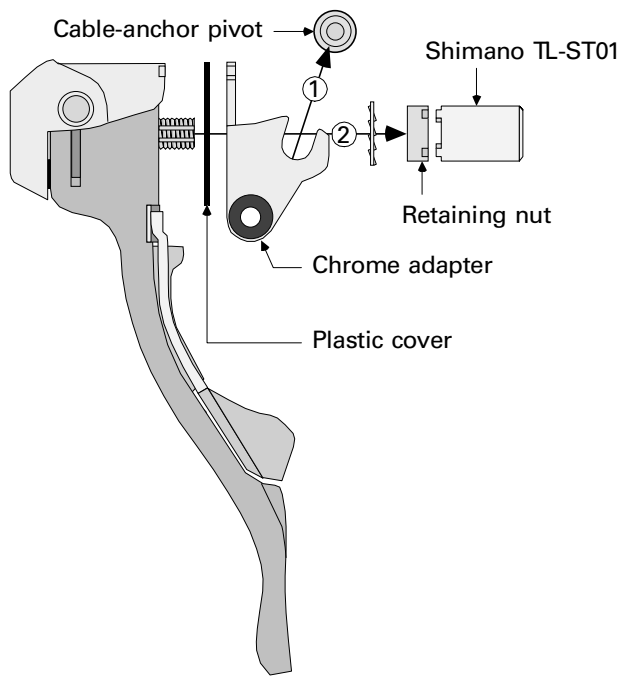
Dura-Ace models: lever-unit service

See figure 30.14 (page 30-12) for an illustration of steps #1–5.

NOTE: Perform shifter-unit removal before this procedure.

1. [] Gently pry cable-anchor pivot upward using small tipped screwdriver. (Note orientation of bushings and place on bundle.)
2. [] Remove retaining nut at back of shift lever by turning TL-ST01 with 5mm Allen wrench. (Hold tool square to nut and apply force toward nut while turning counterclockwise.)
3. [] Remove lock washer that was behind nut.
4. [] Remove chrome adapter and plastic dust cover together from lever assembly. (Note the spring is engaged on dust cover. Leave spring on cover.)
5. [] Remove small metal washer from splined stud.
6. [] Noting engagement of release lever to release plate, remove release plate from splined stud.

30 – SHIFT-CONTROL MECHANISMS



30.14 To disassemble Dura-Ace shifter unit: 1) remove cable-anchor pivot; 2) remove retaining nut with Shimano TL-ST01 tool; then pull lock washer, chrome adapter, and plastic cover off of brake/shift unit.

7. [] Carefully clean and flush unit in solvent, taking care not to disturb internal parts.
8. [] Using care, dry with compressed air.
9. [] Lubricate pivot points with oil or light grease.
10. [] Install release plate (flat side out) onto splined stud, engaging tab on release lever to notch in release plate.
11. [] Install small metal washer over splined stud.
12. [] Install chrome adapter (includes plastic dust cover and spring) over splined stud.
13. [] Install lock washer over splined stud.
14. [] Apply Loctite 242 inside nut, install and secure nut to 50in-lbs (17lbs@3").
15. [] Lubricate and install bushings onto cable-anchor pivot.
16. [] Press cable-anchor pivot downward into slots in chrome adapter.

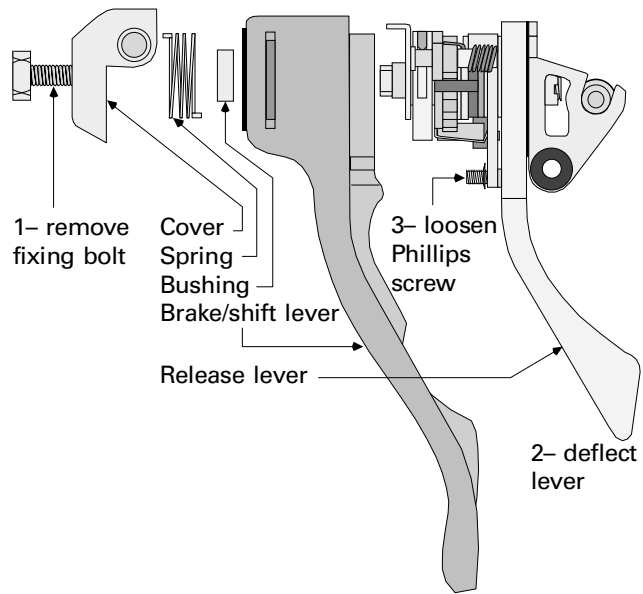
Non-Dura-Ace models: lever-unit service

See figure 30.15 for steps #2–5.

NOTE: Perform shifter-unit removal before this procedure.

1. [] Ultegra models only, pry name plate off front of lever.
2. [] Remove fixing bolt and lock washer from front of lever.
3. [] Pull housing-stop/front-lever-cover off. (Note orientation of seal and spring behind cover.)
4. [] Looking at back side of lever assembly, move return lever to side to expose release-lever fixing screw and remove screw with #2 Phillips.

5. [] Separate release lever and brake/shift lever to expose internal mechanisms.
6. [] Carefully clean and flush unit in solvent, taking care not to disturb internal parts.
7. [] Using care, dry with compressed air.
8. [] Lubricate pivot points with oil or light grease.
9. [] Apply Loctite 222 to thread of shift-unit fixing screw.
10. [] Place cleaned and lubricated mechanism (or new mechanism) back inside brake/shift lever. Make sure mechanism is fully seated inside.
11. [] Move release lever to expose Phillips screw, and secure screw to 12–18in-lbs.
12. [] Apply Loctite 242 or 222 to threads of fixing bolt that holds on housing stop/front lever cover.
13. [] Seat seal ring in groove in face of brake/shift lever.
14. [] Engage end of large coil spring into slot in back face of housing stop/front cover. (Only one end of spring may allow spring to fit easily into recess.)
15. [] Place housing-stop/front-cover over brake/shift lever so that end of spring in cover inserts into small hole in face of brake/shift lever.
16. [] Rotate cover approximately 90° in direction that housing stop points to, until square hole in cover lines up with flats on stud, then press cover onto stud.
17. [] Treat cover-fixing-bolt threads with Loctite 222 and install lock washer and bolt to 50in-lbs (17lbs@3").
18. [] Ultegra models, affix name plate to lever front with adhesive.



30.15 To disassemble non-Dura-Ace lever-unit: 1) remove fixing bolt, 2) deflect release lever to side, 3) loosen the Phillips screw until the release lever and brake/shift lever will separate..

Shifter-unit installation

1. [] Lubricate brake-lever bushings and install in chrome adapter. (Long bushing installs in outward side of chrome adapter, opposite housing stop.)
2. [] Place spring over longer bushing, with 90°-bend end engaged into small hole in chrome adapter.
3. [] Hold shift unit horizontally, with housing stop facing up.
4. [] Place TL-ST02 (or 3/32" tension/roll pin) over long end of spring.
5. [] Guide brake-lever housing onto shift unit and align lever-pivot-stud holes. This process may be awkward.
6. [] Insert lever-pivot stud from above, with end containing recess pointing up. (Recess must end up lined up with lever-pivot-stud set screw.)
7. [] Secure set screw.
8. [] Pull TL-ST02 off of spring.

Inner-wire installation

1. [] Press release lever numerous times to make sure lever is fully released.
2. [] Compress brake lever so that head of lever moves out of brake lever housing.
3. [] Insert inner wire into socket on outward side of head of lever unit, then pull inner wire through housing stop until inner-wire head seats in socket.

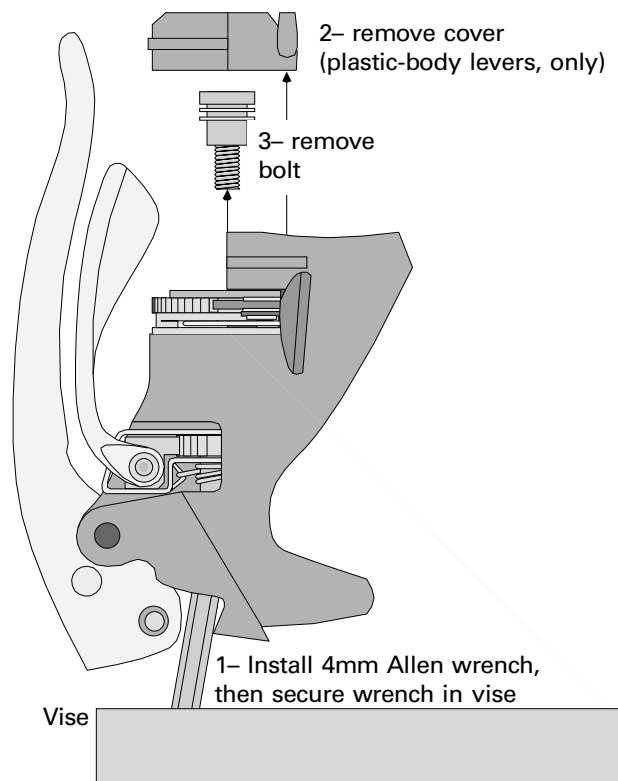
CAMPAGNOLO/SACHS BRAKE/SHIFT-LEVER SERVICE

Inner-wire and brake-lever removal

1. [] Operate release lever to shift derailleur into most released position, and disconnect inner wire from derailleur.
2. [] Disconnect brake inner wire from brake caliper.
3. [] Un-tape handlebars and remove all cable housings from inner wires.
4. [] Remove rubber cover from lever.
5. [] Compress brake lever, push brake inner-wire head out of brake lever, and pull brake inner-wire fully out.
6. [] Push derailleur inner-wire so head comes out bottom of brake-lever body and pull derailleur inner-wire fully out.
7. [] Loosen Allen nut on outward side of top of lever body, then pull whole lever off of handlebar.

Disassembling and cleaning the shift mechanism

1. [] Push release lever (the smaller inward lever) repeatedly to make sure mechanism is fully relaxed. (Do not operate lever again until work is completed!)
2. [] Levers with plastic bodies only, remove cover on bottom of lever body to expose shift mechanism.
3. [] Pull on brake lever to open and insert a 4mm L-shaped Allen wrench inside the front of brake lever into the 4mm-Allen fitting deep inside of lever body.
4. [] Secure this Allen wrench in soft jaws in vice.
5. [] Insert another 4mm Allen wrench into bolt in base side of brake-lever body. For right-hand lever, unthread bolt by turning clockwise. For left-hand lever, unthread bolt counterclockwise. Pulling up (from vise) on release lever will tip it so it does not apply side-load to bolt while bolt is being turned.

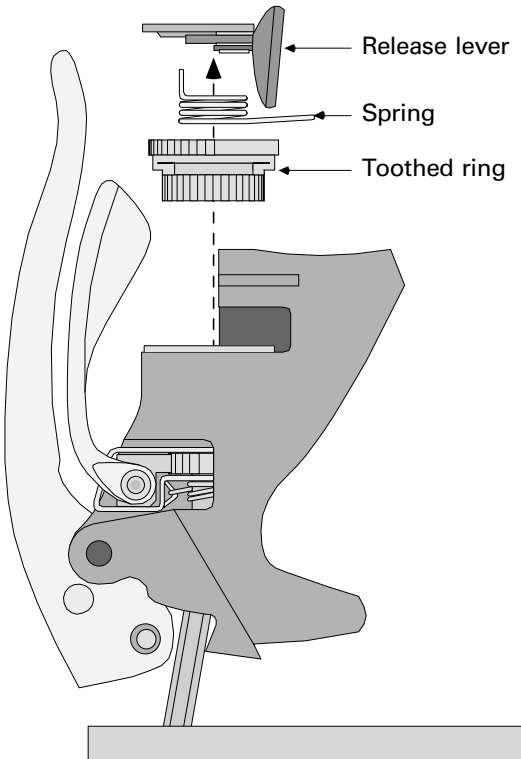


30.16 To remove the release-lever retaining bolt: 1) install 4mm Allen into bolt head in brake-lever body, 2) remove plastic cover (plastic-body levers only), 3) remove bolt.

6. [] Pull up on release lever and use needle nose pliers to remove bolt.
7. [] Remove any shims under head of bolt. Note number of shims and bundle them together.

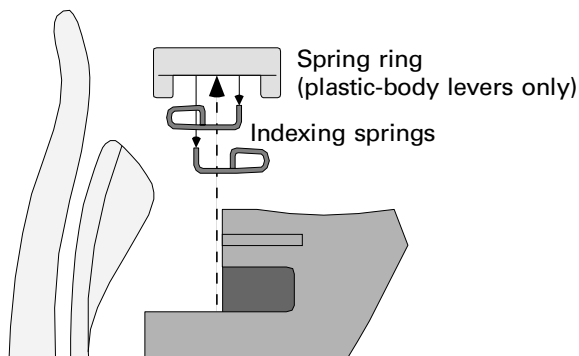
30 – SHIFT-CONTROL MECHANISMS

8. [] Tip release lever to disengage from spring, then rotate release lever approximately 90° to pull it out of brake-lever body.
9. [] Lift up toothed ring and pull partially out of brake-lever body until long end of spring clears spring hole in brake-lever body.
10. [] Rotate toothed ring approximately 180° and tip to pull out of lever body.



30.17 Remove release lever, spring, then toothed ring.

11. [] Note any washers under toothed ring and remove.
12. [] Lift prong on coil spring and gently pull spring out of toothed ring.
13. [] Use needle-nose pliers to remove two odd-shaped (indexing) springs down inside lever body that were exposed by removal of toothed ring.



30.18 Removing the indexing springs.

14. [] Use small screwdriver or seal pick to gently encourage ring (in which indexing springs were mounted) out of lever body.
15. [] Further disassembly is possible, but not usually required. Cleaning of unit possible while still assembled. (To disassemble further, remove brake lever to better access internal parts. Remove snap ring from back of body to fully disassemble.)
16. [] Using care not to displace any internal parts, clean parts using mild solvents.
17. [] Carefully dry with compressed air.

Assembling the shift mechanism

1. [] Grease new indexing springs, grease inside indexing-spring mounting ring, as well as ring seat in lever body.
2. [] With flatter side of indexing-spring mounting ring facing down, install indexing springs into small holes so that curve of springs matches curve of mounting ring.
3. [] Install indexing-spring mounting ring into body, seating it on two studs.
5. [] Front levers have a split washer under toothed ring. Grease washer, and place on top of spring-mounting ring. (Align split with hole in lever body for release-lever spring.)
6. [] Grease outside and inside of toothed ring. Grease the return spring.
7. [] Place release-lever spring into toothed ring so that long end of spring sticks out of slot in toothed ring.
8. [] Aluminum body levers only, align toothed ring so that vertical-spring end enters big slot in lever body first, then slide toothed ring into lever body.
9. [] Rotate toothed ring so that horizontal end of spring points at spring hole in lever body.
10. [] Use tip of small screwdriver to deflect horizontal end of spring to line up with hole, then push toothed ring in all the way. (Indexing spring can displace below toothed ring and interfere. If this is difficult, removed toothed ring and make sure indexing spring is against wall of mounting ring.)
11. [] Rotate toothed ring so that flats in hole line up with flats on stud below, then drop toothed ring onto stud below.
18. [] With recess in release-lever disc facing up and end of lever pointing toward brake lever, insert release lever over toothed ring and engage release-lever spring into hole in release lever.

As an alternative to the previous step, put the release lever in place *without* engaging the spring, with the big hole in the disc lined up with the hole in the

toothed ring, and the release lever positioned where it stops against the lever body. Modify a very small slotted screwdriver by putting a notch in its tip and use this to guide the vertical end of the spring into the small hole in the disc of the release lever.

19. [] **Pivot release lever around end of spring until hole in release lever is centered over hole in toothed ring. (Expect this to be awkward since the spring will provide resistance.)**
20. [] **Reinstall any shims on retaining bolt. Apply Loctite 242 to threads of bolts.**
21. [] **Maintaining upward pressure on the end of the release lever to keep the spring down in the toothed ring, install and secure retaining bolt to 50in-lbs (17lbs@3"). Right-hand lever secures by turning bolt counterclockwise. Left-hand lever hand secures clockwise.**

DOWN-TUBE LEVERS

INSTALLATION

Clamp-mounted shifters

Clamp-mounted shifters have a strap that wraps around the down tube, with a binder bolt that pulls the ends of the strap together, located on the bottom side of the down tube. There is usually a small tab brazed to the top side or bottom side of the down tube that locates the shifters. The strap should be up the tube from the tab, but touching it. In case there is no tab, locate the shifters so that the ends of the levers come within 1–1.5" of the back side of the head tube. Secure the binder bolt to 24–30in-lbs (8–10lbs@3").

Braze-on mounted shifters

Braze-on mounted shifters mount to brazed-on fittings mounted on both sides of the down tube. They sometimes have a unitized construction and go on all at once, and they sometimes are several parts that are placed on the braze-on one at a time.

If they are a single unit, simply slip them onto the braze-on and tighten the screw or bolt that goes through the center of the lever drum. The screw threads should be treated with Loctite 222, and the torque should be 10–15in-lbs (3–5lbs@3").

If they are friction (non-indexing) levers, they will usually consist of several parts. The first part is usually a plate that fixes to the large square at the base of the braze-on. This plate usually has a stop that stops the forward motion of the lever. If the plate is on wrong, the lever will not stop parallel to the down tube when pushed all

the way forward. The next part is usually a thick washer with a round hole in the middle. This is followed by the lever itself. After the lever is another washer that usually has a flatted hole that engages the flats on the end of the braze-on. A cover plate typically follows this, and the last part is the mounting/tension screw that holds everything on and adjusts the amount of friction. This screw should be oiled, not treated with Loctite.

If the lever has too much friction and will not operate smoothly without loosening the tension screw to the point that it will not resist the derailleur return spring, try lubricating both faces of the lever where it is sandwiched between the washers.

SERVICE

If the lever comes off as a unit, then the only service is to soak it in solvent, dry with compressed air, and inject oil. If this does not solve the problem, the lever must be replaced.

Levers that come off in parts when the central screw is undone can be cleaned thoroughly, dried, then lubricated and installed. In rare cases, the washers that sandwich the lever can be replaced (if worn out).

BAR-END SHIFTERS

REMOVAL

The shift mechanism usually must be removed from the mount to access a bolt that secures the mount inside the handlebar. Turn the bolt *clockwise* to loosen the mount. If the bolt will not turn clockwise without stripping the Allen socket, turn the mount counterclockwise.

INSTALLATION

The shift unit must be removed from the mount to install the mount in the end of the handlebar. When installing, be sure to grease the mounting-bolt threads *and* the inside and outside surfaces of the expander that fits inside the handlebar. Align so that shifter will point straight down and torque bolt (counterclockwise) to 50in-lbs (12lbs@3").

SERVICE

Bar-end shifters usually have a unitized construction. The only service is to soak in solvent, dry, and oil. If problems continue, replace the shifters.

STEM SHIFTERS

INSTALLATION

Stem shifters are installed on the vertical shaft of the stem. They should be mounted as close to the headset locknut as possible, unless this position causes the

cable housings to deflect awkwardly around the headset. Lubricate bolt threads and torque bolt to 50in-lbs (12lbs@3").

SERVICE

Stem shifters can be disassembled, cleaned and oiled. There are no individual parts available, so non-functional levers should be replaced as a unit.

SHIFT-CONTROL-MECHANISM TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SPECIAL NOTE: <i>All shifting problems can easily be caused by other parts of the drive train. Always check derailleur, shifter, cable, chain, and gear compatibility before assuming the problem is with the shift-control mechanism. Check for cable-friction problems, derailleur wear, and chain wear, also.</i>	
SYMPTOM: <i>Shimano Rapidfire lever will not operate.</i>	
Inner wire was installed when lever was not fully released.	Remove inner wire and install when lever is fully released. Remove pod cover if necessary.
Internal mechanisms are dirty.	Remove pod and pod cover, soak in solvent, dry, and oil.
Parts have failed internally.	Replace pod after checking for first two causes.
SYMPTOM: <i>Grip Shift does not allow derailleur to align with cog after completing shift.</i>	
Inside of Grip Shift needs lubrication.	Disassemble Grip Shift, clean, and lubricate.
Grip Shift is worn out internally.	After eliminating other possible causes, replace shifter.
SYMPTOM: <i>Shimano rear derailleur operated by Grip Shift will not shift to outermost cog without hesitation when derailleur adjustments, shifter lubrication, and cable setup are all good.</i>	
Some models of Shimano derailleurs had too light a return spring to pull the cable through the Grip Shift even when everything was set up correctly.	An additional spring can be installed on the derailleur (see page 32-??), or a Grip Shift Bassworm can be added to the cable system.
SYMPTOM: <i>Shimano STI integrated shift/brake levers on road bike will not stay in a gear after shifting inward.</i>	
Internal part in shifter has failed.	Contact Shimano for warranty.
SYMPTOM: <i>Friction-type shift lever will not hold its position after completing the shift.</i>	
Tension/mounting screw needs to be tightened.	Tighten tension/mounting screw.
SYMPTOM: <i>Friction-type shift lever is sticky at loosest tension setting that will hold against derailleur return spring.</i>	
Friction washers need lubrication.	Drip oil in crevasses on both faces of lever drum, or disassemble shifter and lubricate faces directly.

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Friction-type shift lever will not hold its position after completing the shift, no matter how much the tension screw is tightened.</i>	
Friction washers that sandwich lever are worn out.	Replace washers, if parts available.
Slick-plastic friction washers that do not need lubrication have been oiled.	Disassemble lever, clean washers with alcohol, and re-install.
Tension/mounting screw is not screwing fully into braze-on because of interference in hole.	Put washers under head of tension/mounting screw.
SYMPTOM: <i>Braze-on-mounted down-tube friction lever keeps loosening up after proper friction tension has been achieved.</i>	
Flats in hole in outer friction washer are a loose fit to flats on braze-on stud.	Replace outer friction washer.
If washer is fresh, braze-on flats are under-sized or worn.	Deform washer to create tighter fit, or find shim stock to jam between washer and braze-on flats.
SYMPTOM: <i>Mounting screw will not start threading into braze-on when installing down-tube shifter on braze-on.</i>	
5 × .8mm mounting screw is being installed in braze-on with more rare 4.5mm thread type.	Replace screw with correct size, or install shifter that comes with correct screw.
Threads in braze-on are damaged.	Chase thread with correct tap (usually 5 × .8mm)
SYMPTOM: <i>Campagnolo/Sachs integrated brake/shift levers are difficult to operate when pressing on the release lever.</i>	
Levers are new and need to break in.	Make sure lever is clean and lubricated, and if so, allow adequate time for break-in.
Levers are dirty internally.	Disassemble, clean, and lubricate.

31 – DERAILLEUR-CABLE SYSTEMS

ABOUT THIS CHAPTER

This chapter is about setting up and servicing the cables that operate the derailleurs. It covers selection of the inner wire and housing, and the sizing and preparation of the housings. Attaching the inner wire to the shifter is covered in the **SHIFT-CONTROL MECHANISMS** chapter (page 30-1). Attaching the inner wires to the derailleurs and adjusting the tension on the inner wires is covered in the **REAR DERAILLEURS** (page 32-1) and **FRONT DERAILLEURS** (page 33-1) chapters.

GENERAL INFORMATION

TERMINOLOGY

Indexing-compatible: This term signifies that a component is suitable for use with an indexing derailleur system. Most modern derailleurs are indexing. This means that the shifter moves in distinct increments. When the shifter is moved from one position to the next, it is supposed to be just the right amount to move the derailleur from one gear to the next. The thickness of an inner wire determines how much inner wire will move as it wraps around the shifter drum. The friction and compression in the cable system have to be low and consistent for the indexing to work.

Cable: The term cable will be used to refer to the complete cable system, including the inner wire, housings, and fittings. The term *cable* is often used to refer to the inner wire as well. To avoid confusion, this book will always use *cable* to describe the whole system, and *inner wire* to describe the wire portion of the cable system.

Housing: The outer sheath that covers part of the inner wire. It is used to guide the inner wire around bends and to connect two points that move in relation to each other.

Compressionless housing: This housing type has stiff wires embedded in it, running along the housing length, that reduce compression. To identify this housing, look at the cut end. Many wire-ends will be seen.

Housing liner: A plastic sheath inside the housing that is used to reduce friction. These days, it is almost always fixed permanently in place.

Wound housing: This type of housing, more typically used on brakes, consists of a single coil wound from one end of the housing to the other. It is usually covered in a plastic sheath and usually has a liner inside. To identify it, look at the cut end. It will look like the end of a coil spring. If not sure after looking at the end, strip off the plastic sheath for a few millimeters at the end. Whether it is a single coil (wound), or multi-strand (compressionless), will become completely clear. Wound housing is not considered suitable for use on indexing derailleur systems.

Ferrule: The cap that fits on the end of the housing to improve fit to the housing stop.

Inner wire: The wire that is attached to the shifter, passes through housing on the way to the derailleur, and attaches to the derailleur. At times, it may just be called the *wire*.

Drawn wire: A type of inner wire that has been drawn through a die to change its shape. The process flattens the individual strands of the inner wire so that the surface of the inner wire is smoother.

Inner-wire head: The drum- or disc-shaped bead at the end of the inner wire. It fits in a socket in the shifter.

Housing stop: The socket-like fitting on the frame, shifter, or derailleur that is the point where the housing stops and the inner wire continues.

Adjusting barrel: An adjustable housing-stop that is threaded into the derailleur and/or shifter. An adjusting barrel is a screw with a socket on the end that the housing fits into. There is a small hole all the way through that the inner wire passes through.

Cable guide: An *inner-wire guide*, but the conventional term will be used here to avoid confusion. It is usually a plate of plastic with a groove or tunnel that guides a bare inner wire around a bend, such as the bottom of the bottom-bracket shell.

PREREQUISITES

Whenever cables are serviced or installed, derailleur adjustments must be done.

INDICATIONS

Maintenance

Cables just wear out. There may be no overt symptoms, but a cable can operate sluggishly just because it is old. Cables are relatively inexpensive and are vital to derailleur performance. It is not an extravagance to automatically replace the cable system annually, particularly if adjusting a derailleur.

Indexing malfunctions

Problems with the cable can cause an indexing derailleur to malfunction. The usual scenario is that a system has stopped working that formerly worked. When the cable tension is adjusted so that it does not seem too tight for the release shifts, it is not tight enough for the opposite shifts. Then if it is adjusted to be tight enough for the shifts when the inner wire is being pulled, it becomes too tight when the cable is being released. This problem can be caused by chain wear and component-compatibility problems, as well.

Difficult shifter operation

Particularly on friction-shifting systems, when the lever becomes difficult to operate, and lubing and adjusting the friction tension on the shifter does not solve the problem, it is likely there is a cable problem.

Rusty or damaged inner wire

Inner wires fail because they get rusty, fray, become kinked, or because the wire sheath tears on a Gore-Tex cable. Replace all wires with these problems, even when the damage does not seem to be in a critical location.

Damaged and dirty housings

Housings fail because they get kinked or bent, and because the plastic outer sheath cracks. Dirt can also get inside a housing and substantially increase the friction.

Housings get kinked or bent because of impact and overextension, but they also get damaged in the same way because they are mis-sized. It is very common that the loop of housing at the rear derailleur is too short, resulting in a bend in the housing where it comes out of the rear-derailleur adjusting barrel. Kinked and bent housings should be replaced, unless the housing is too long and the damage is confined to an area that will be cut off.

Dirt gets inside housings and increases friction. There is no good way to inspect for dirt and there is no good way to clean it out. It could be abrasive particles embedded in the inner liner. This hidden dirt is the likely reason that a used cable system that looks fine does not shift as well as it did when new. This hidden dirt is a good reason to just routinely replace cable systems when adjusting derailleurs.

Handlebar and stem changes

When the shifters are mounted on the handlebars, and the handlebar width or stem height and length are changed, the loops of housings at the shifters need to be re-sized. If the shifters are moving further away because of wider bars or a longer stem, cable replacement is often required.

TOOL CHOICES

The only tools required for installation of cables are appropriate tools for cutting inner wire and housing. Preferred tools are in **bold**. Tools are preferred because a balance between versatility, quality, and economy.

CABLE TOOLS (table 31-1)

Tool	Fits and considerations
Park CN-2	Cuts inner wires only
SunTour TA110	Cuts inner wires only
Hozan C214	Cuts inner wires only
Hozan C215	Cuts inner wires and compressionless housing
Shimano TL-CT10	Cuts inner wires and compressionless housing
VAR 990	Cuts inner wires and compressionless housing
Felco C7 Deluxe	Cuts inner wires and compressionless housing
7-8" diagonal side cutter, any brand	Cuts wound housing

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into several sections. The first section is about **CABLE TYPES AND COMPATIBILITY**, which covers the different types of inner wires and housings used for derailleur systems and compatibility of the different types with different shifting systems. The next section is **SIZING HOUSING LOOPS**, which covers the determination of the optimum length of housing loops from stops on the frame to shifters mounted on the bar or stem. The final section is **PREPARATION AND INSTALLATION OF THE CABLE SYSTEM**, which covers housing-end finishing, cable-system lubrication, and routing considerations.

Unlike other chapters in this book, there is no section on troubleshooting. This is because cable problems are covered in the respective derailleur chapters.

CABLE TYPES AND COMPATIBILITY

INNER WIRES

Inner wires differ by diameter, type of surface, and type of construction.

Inner-wire diameter

Wire diameter is important in regard to indexing performance and fit in the housing. The typical wire diameters are 1.2mm and 1.5mm. There have been some less common sizes, as well. For 1995 only, Shimano used a 1.1mm diameter. Older Campagnolo equipment came with a 1.6mm diameter wire.

All index systems, with the exception of down-tube Shimano Dura-Ace levers, require 1.2mm diameter wire. The compressionless housing used for index systems will not fit anything larger than 1.2mm wire. The 1.1mm Shimano wire was used in a smaller housing that would not fit the 1.2mm wire. To prevent problems when replacing a 1.1mm inner wire, always replace the housing as well. When Shimano Dura-Ace indexing down-tube levers are used, the wire diameter must be 1.5mm.

Non-indexing systems have no requirements for wire diameter, other than it fit through the housing being used.

Inner-wire surface

Indexing systems require wires with a smooth surface to reduce cable-system friction. One way to insure that the wire is smooth enough is to use nothing but original equipment for replacement inner wires. Another alternative is to use *drawn inner wires*, which have the smoothest surface. Most drawn inner wires will be marketed as such; however, their appearance should identify them clearly. Drawn inner wires have a more reflective surface, and the individual strands are much less obvious. When looking at drawn inner wire, instead of seeing individual strands it just looks like there are tiny grooves spiraling around the inner wire. Drawn inner wire also feels much smoother when pulled between two fingertips.

Non-indexing systems have no requirements for the wire surface, but whatever makes a wire smoother will improve the feel of any shifting system.

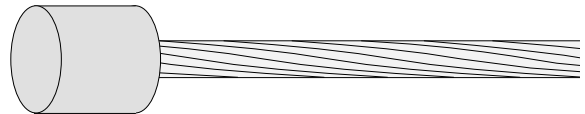
Inner-wire construction

Most inner wires today are a simple twisted wire. Several strands are laid parallel and then twisted together all at once. There is another construction which might be called *braided*. It is not actually braided, but has that appearance. It is made by making several very small twisted-wire cables, and then twisting these together to make a larger cable. This *braided* or *double-twisted* inner wire is more supple than the same thickness of a simple twist. The 1.5mm wire required for use with Shimano Dura-Ace down tube indexing shifters should be the *braided* or *double-twisted* type.

INNER-WIRE HEADS

Barrel heads

The barrel-headed inner wire has always been the most common, and today is almost universal. This type has a cylinder-shaped head that is usually slightly longer than its diameter. The wire goes into the end of the cylinder.



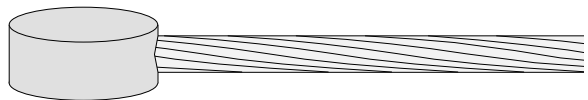
31.1 A barrel-head on a derailleur inner wire.

The most common barrel diameter is approximately 4.5mm. Old Simplex and all Campagnolo shifters require something closer to 4.0mm. It is possible to grind or file the wire head to improve fit.

Even some barrel heads that are the correct diameter can be a fit problem. Flashing material left over from fabrication and out-of-roundness can cause the barrel to jam in the socket in the shifter. Always test fit the barrel before setting up the cable system all the way.

Disc heads

Some old Schwinn and Huret shifters required a disc-shaped cable head. This type was also used briefly by SunTour in the X-Press levers. The disc type has the inner wire enter the head at the perimeter of the disc. Disc-types are uniform in size. Inner wires that are sold as *universal* or *double-ended* usually have a barrel at one end and a disc at the other end.



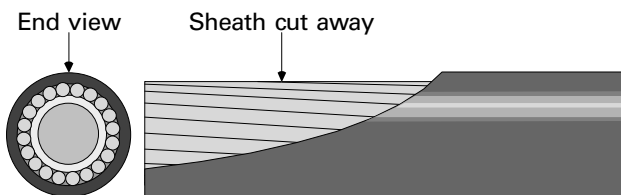
31.2 A disc-head on a derailleur inner wire.

HOUSINGS

Housing for derailleur systems may be the compressionless variety, or the wound variety.

Compressionless housing

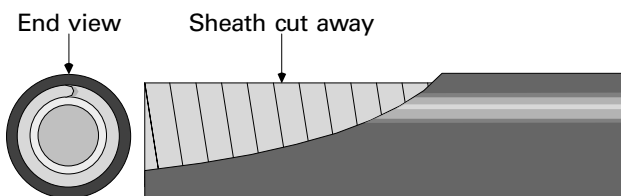
Compressionless housings are required for indexing systems, but are optional for friction systems. However, they improve performance of a friction system. Housing is compatible with a particular inner wire as long as the wire inserts comfortably into the housing. In 1995, Shimano made compressionless housing that was specifically for use with a 1.1mm inner wire. The 1.2mm wires are a tight fit in this housing. To use a 1.2mm inner wire on a bike with this housing, just replace the housing. All compressionless housing has a plastic liner inside.



31.3 *Compressionless housing.*

Wound housing

Wound housings have a metal strip that is wound like a coil spring. These coils compress under load, which translates into lost motion at the shifter. Lost motion occurs when the shifter moves, but the derailleur does not respond. Most wound housing has a plastic liner inside to reduce friction, but some cheap varieties are exposed metal inside. The ones without a liner are not recommended for use with any derailleur system, indexing or friction.



31.4 *Wound housing.*

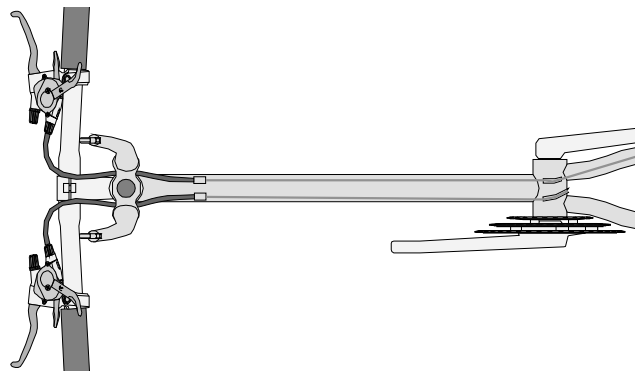
The Shimano Dura-Ace indexing down-tube levers that use a 1.5mm inner wire require high-quality wound and lined housing for the loop at the rear derailleur.

SIZING HOUSING LOOPS

MTB-SHIFTER LOOPS

Normal routing

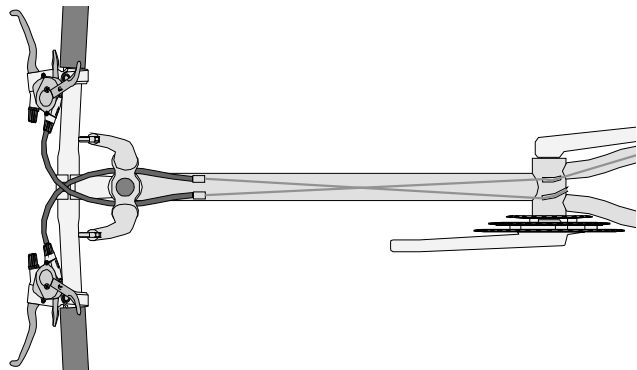
In normal routing, the loop from the right shifter goes by the right side of the head-tube/stem to a housing stop on the right side of the frame, and then the inner wire stays on the right side of the bike all the way to the rear derailleur. The left side is the same, except everything is on the left. On bikes with narrow handlebars (and particularly if the stem is short also) the normal routing may cause the housing to have a dramatic double-bend on its way from the shifter to the housing stop on the frame. If this is the case, consider crisscrossed routing.



31.5 *Normal routing, but crisscross routing would be more suitable on this bike.*

Crisscrossed routing

Crisscrossed routing is used only when normal routing is a problem. Crisscrossed routing cannot be used on all frames, even when the normal routing is a problem. Any time using crisscrossed routing causes an inner wire to drag on a frame tube on its way from the housing stop to the cable guide, it is unacceptable.

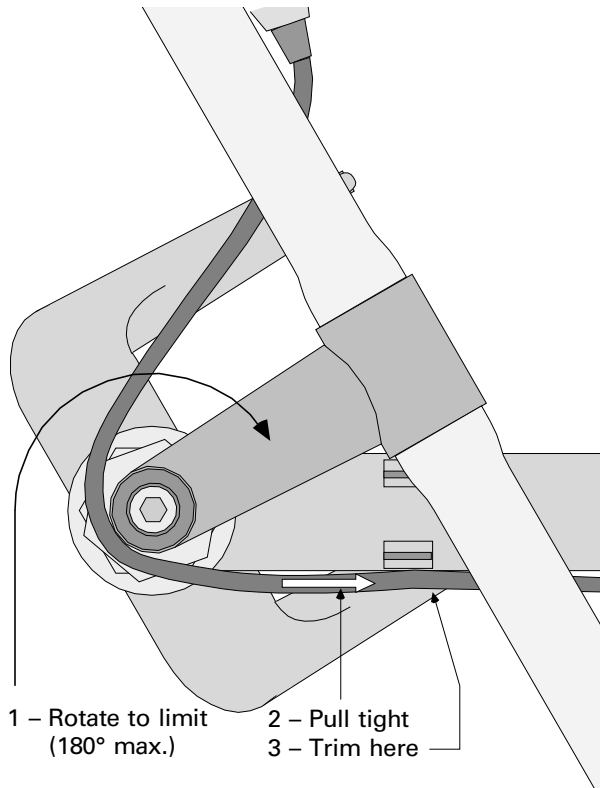


31.6 *Crisscrossed routing.*

Crisscrossed routing is done by routing the housing loop from the right shifter around the *left* side of the head-tube/stem to the housing stop on the *left* side of the frame. The inner wire is then routed back to the right side of the cable guide at the bottom-bracket shell. The left side is the reverse. The inner wires end up crossing each other between the top of the down tube and the bottom-bracket shell.

Sizing procedure

1. [] Slide piece of housing onto inner wire that comes out of shift-control mechanism.
2. [] Route housing to the housing stop on frame that will be used, making sure that loop does not have to deflect around any existing brake cables.
3. [] Rotate handlebars to limit (180° max.) to side that is opposite housing stop on frame that loop is being routed to.
4. [] Pull housing as it will go past the housing stop on the frame (without damaging housing), making sure housing remains inserted in housing stop on shift-control mechanism.



31.7 *Sizing the housing loop from a bar-mounted shift control mechanism.*

5. [] Mark housing at point that is even with closed end of housing stop on frame.
6. [] Remove housing from inner wire and cut housing at mark.

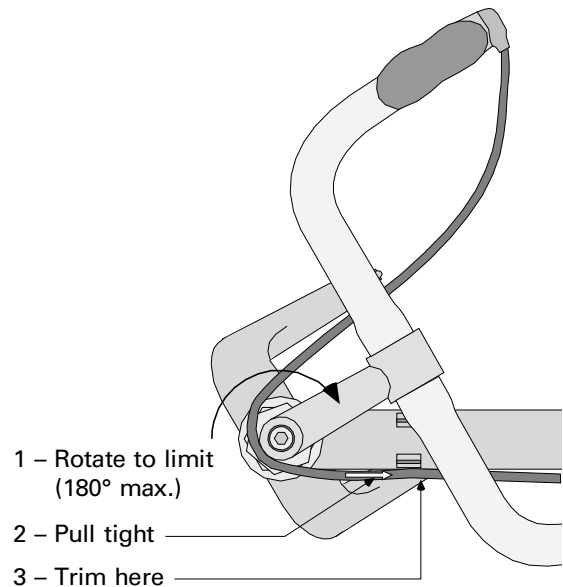
INTEGRAL SHIFT/BRAKE-LEVER LOOPS

Normal routing

In normal routing, the loop from the right shifter goes by the right side of the head-tube/stem to a housing stop on the right side of the frame, and then the inner wire stays on the right side of the bike all the way to the rear derailleur. The left side is the same, except everything is on the left.

Sizing procedure

1. [] Slide piece of housing onto inner wire that comes out of shift-control mechanism.
2. [] Route housing to housing stop on frame that will be used, making sure that loop does not have to deflect around any existing brake cables.
3. [] Rotate handlebars to limit (90° max.) to side that is opposite housing stop on frame that loop is being routed to.
4. [] Pull housing as it will go past the housing stop on the frame (without damaging housing), making sure housing remains inserted in housing stop on shift-control mechanism.



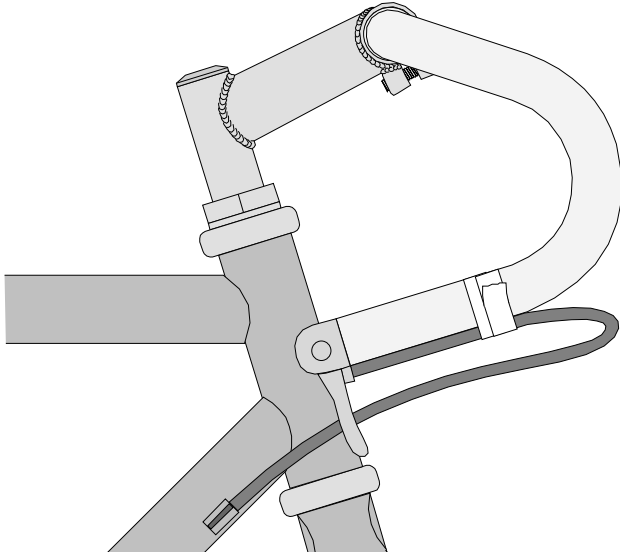
31.8 *Sizing the housing loop from an integral shift/brake lever.*

5. [] Mark housing at point that is even with closed end of housing stop on frame.
6. [] Remove housing from inner wire and cut housing at mark.

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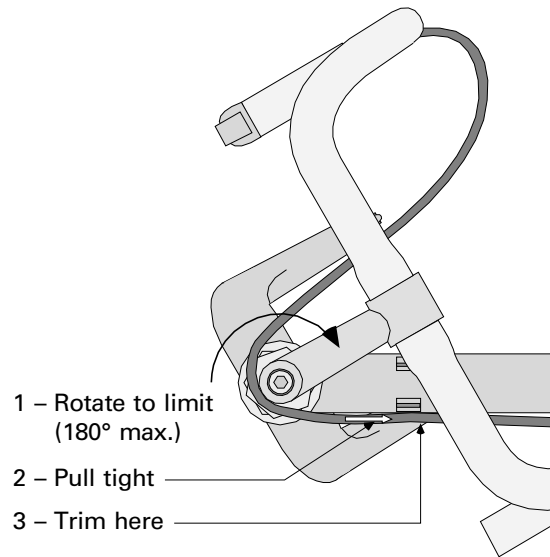
BAR-END-CONTROL LOOPS

Housing loops from bar-end controls on drop-style handlebars are run under the handlebar tape where the housing leaves the shifter. The housing comes out of the handlebar tape where the curve of the bar starts up toward the brake lever.



31.9 *Routing of the housing loop from a bar-end control.*

1. [] Slide piece of housing onto inner wire that comes out of shift-control mechanism.
2. [] Temporarily retain housing to handlebar only to point bar begins to curve upward, with adhesive tape or ties.
3. [] Route housing to housing stop on frame that will be used, making sure that loop does not have to deflect around any existing brake cables.
4. [] Rotate handlebars to limit (180° max.) to side that is opposite housing stop on frame that loop is being routed to.
5. [] Pull housing as it will go past the housing stop on the frame (without damaging housing), making sure housing remains inserted in housing stop on shift-control mechanism and does not pull out of tape or tie on handlebar.



31.10 *Sizing the housing loop from the handlebar to the frame.*

6. [] Mark housing at point that is even with closed end of housing stop on frame.
7. [] Remove housing from inner wire and cut housing at mark.

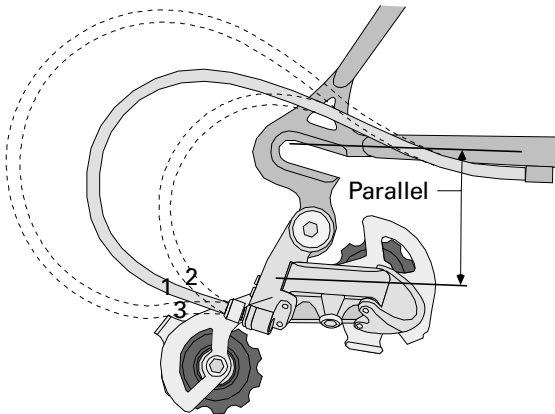
STEM-SHIFTER LOOPS

1. [] Slide piece of housing onto inner wire that comes out of shift-control mechanism.
2. [] Route housing to the housing stop on the frame that will be used, making sure that loop does not have to deflect around any existing brake cables.
3. [] Rotate handlebars to limit (180° max.) to side that is opposite housing stop on frame that loop is being routed to.
4. [] Pull housing as it will go past the housing stop on the frame (without damaging housing), making sure housing remains inserted in housing stop on shift-control mechanism.
5. [] Mark housing at point that is even with closed end of housing stop on frame.
6. [] Remove housing from inner wire and cut housing at mark.

REAR-DERAILLEUR LOOP

Sizing the cable-housing loop for the rear derailleur is a somewhat subjective process. Consistently factories set this loop up too short, resulting in frequent kinking of the housing or housing ferrule where it comes out of the adjusting barrel. This factory setup leads to mechanics getting used to seeing *too short* as normal. Consequently, when setting the loop length up by the following rules, it is likely to look too long to an experienced mechanic.

The key to setting the length of the loop to the rear derailleur is to just focus on the entry of the housing into the cable-adjusting barrel. As the housing loop gets longer and shorter, the end of the housing in the adjusting barrel will twist up and down, and not come straight out of the adjusting barrel. When it is not twisted up or down, the length is correct.



31.11 Sizing the housing loop at the rear derailleur.

1. [] Install inner wire into housing piece, but do not route inner wire through housing stop on frame.
2. [] Install a ferrule on one end of housing piece, then insert that end into cable-adjusting barrel, with inner wire going into adjusting barrel, as well.
3. [] Hold other end of housing piece adjacent to housing stop on frame.
4. [] Position derailleur so parallelogram body is roughly parallel to line from axle to center of bottom bracket, or pointing *slightly* down.
5. [] Move housing back and forth at housing stop at frame and stop at point housing ferrule in adjusting barrel is not twisted up or down in adjusting-barrel socket.
6. [] Mark housing at point that is even with closed end of housing stop on frame.
7. [] Remove housing from inner wire and cut housing at mark.

FRONT-DERAILLEUR LOOP

Most front derailleurs do not have housing going to the front derailleur. When they do, try to make the loop a simple curve without any abrupt bends or double bends at the points the housing enters a housing stop.

PREPARATION AND INSTALLATION OF THE CABLE SYSTEM

HOUSING-END FINISH

Compressionless housing

Compressionless housing should be cut with an *enclosing* style of cable cutter, such as the Shimano TL-CT10. Careful alignment and stabilization of the tool and housing will insure a relatively square cut. If cutting the housing makes it out-of-round, a gentle squeeze between the handles of the tool or pliers will make it round again.

The inner liner often gets closed when the housing is cut. A push pin or similar sharp object can be used to open up the liner again.

Unlike wound housing, *compressionless housing should never be filed or ground flat on the end!*

Wound housing

Wound housing is used much more on brake systems than it is on derailleurs. Discussion of the proper finishing of wound housings is covered in the **BRAKE CABLE SYSTEMS** chapter (page 35-9).

INSTALLING FERRULES

It is critical to use ferrules *anytime they will fit*. Fit a ferrule onto the housing and check if the ferrule will install into the housing stop or adjusting barrel. If it fits without jamming, it must be used.

Ferrules for compressionless housing

There are ferrules made for wound housing that will fit onto compressionless housing, but are not suitable. Compressionless-housing ferrules are specially reinforced at the closed end to resist corruption from the ends of the wires that are part of the compressionless housing. If the wrong ferrule is used, the housing wires will force themselves through the hole in the ferrule where the inner wire comes

31 – DERAILLEUR-CABLE SYSTEMS

out. Pre-sized pieces of compressionless housing come with appropriate ferrules installed. Most packages of bulk compressionless-housing come with a supply of suitable ferrules. When purchasing separate ferrules that are suitable for use with compressionless housing, they are more likely to be described as fitting *Shimano SIS housing* than as fitting compressionless housing. In any case, to identify a compressionless-housing-compatible ferrule, look at the hole at the end where the inner wire comes out. If the material is obviously more than .5mm thick, the ferrule is compressionless-housing compatible.

Reusing ferrules

Factory ferrules that are on compressionless housing can be reused when installing new housing if there are no new compatible ferrules available.

1. [] **Put old housing in vise about 1/2" from end of jaws, with end of ferrule sticking up above vise about 3/4".**
2. [] **Gently grasp housing with needle-nose pliers just below ferrule.**
3. [] **Lever pliers down against vise to lift ferrule off end of housing.**
4. [] **Place ferrule(s) on new housing.**
5. [] **Insert old derailleur inner wire through a ferrule until inner-wire head is against ferrule.**
6. [] **Use cable fourth-hand tool to draw inner wire through housing, simultaneously pressing both ferrules onto housing.**

Crimping ferrules onto housing

Ferrules come from the factory crimped onto the housing so that they won't get lost in transit. Once a cable is installed on a bike, there is no advantage to having the ferrules crimped on. Crimping is a waste of time, and it complicates reusing ferrules. Crimping on ferrules is not recommended.

LUBRICATION

Any housing used for derailleur systems should be lined with a plastic sheath. Performance will always be improved by dripping or spraying oil into the housing before installing the cable system. Oil will reduce the friction caused by dirt that gets into the housing, and will reduce the tendency for the inner wire to rust. Grease should not be used because it can congeal when it gets cold or old, which will lower the performance of the cable system.

32 – REAR DERAILLEURS

ABOUT THIS CHAPTER

This chapter is about installing, adjusting, and servicing rear derailleurs. The procedures for installation and adjustment make references to installing the wheel, chain, shift-control mechanism, and cable. These items are fully covered separately in preceding chapters. This chapter also covers repair of derailleur-hanger threads.

The procedure assumes that the front derailleur is installed. The front derailleur need not be precisely adjusted, but must be capable of moving the chain to the innermost and outermost chainrings. It may seem like a good idea to install and adjust the front derailleur first, because of this. However, the front-derailleur procedure requires that the rear derailleur be able to shift the chain to the innermost and outermost positions, as well. Whichever is done first, to complete one derailleur adjustment it may be necessary to do some preliminary work on the other derailleur, as well.

There is some confusing and contradictory terminology used in regard to derailleurs, so be sure to become acquainted with the following terminology section to become clear on the terms used in *this* book.

GENERAL INFORMATION

TERMINOLOGY

High gear: With regard to rear derailleurs, high gear typically means the rear cog with the fewest number of teeth. It is called high gear because it results in the highest number when calculating gear ratios. It is confusing because the cog with the greatest number of teeth sticks up higher, and more teeth may seem to some to be “higher.” For this reason, this book will always use the more wordy alternative, *outermost gear*, or a letter code that is described in the following section **NAMING COGS AND GEAR COMBINATIONS** (page 32-3).

Top gear: Same as *high gear*.

First gear (or first position): Called *first gear* because it is the first one counted when counting cogs on the freewheel/freehub, this term is avoided because the innermost cog provides the lowest gear ratio, which might also be called *first gear*.

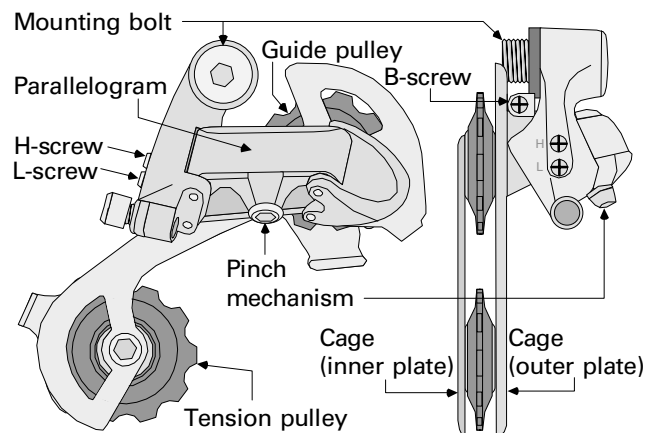
Outermost gear: The cog on the rear wheel that has the fewest teeth and is closest to the dropout. This term will be used instead of *high gear*, *top gear*, or *first gear*, or a letter code (described in the following section **NAMING COGS AND GEAR COMBINATIONS**, page 32-3) will be used.

Low gear: With regard to rear derailleurs, low gear typically means the rear cog with the greatest number of teeth. It is called low gear because it results in the lowest number when calculating gear ratios. It is confusing because the cog with the fewest number of teeth sticks up the least, and fewer teeth may seem to some to be “lower.” For this reason, this book will always use the more wordy alternative, *innermost gear*, or a letter code (described in the following section **NAMING COGS AND GEAR COMBINATIONS**, page 32-3) will be used.

Bottom gear: Same as *low gear*.

Last gear (or last position): A gear is called *last gear* because it is the last one counted when counting cogs on the freewheel/freehub, this term is avoided because the outermost cog provides the highest gear ratio, which might also be called *last gear*.

Innermost gear: The cog on the rear wheel that has the most teeth and is closest to the spokes. This term will be used instead of *low gear*, *bottom gear*, or *last gear*, or a letter code (described in the section **NAMING COGS AND GEAR COMBINATIONS**, page 32-3) will be used.



32.1 This side view and back view show the major parts of the rear derailleur.

32 – REAR DERAILLEURS

Limit screw: Adjustable stops that are used to stop the inward and outward motion of the derailleur at points that enable the chain to shift to the innermost and outermost cogs without going too far.

H-screw: A limit screw for stopping the derailleur from shifting the chain out past the outermost cog.

L-Screw: A limit screw for stopping the derailleur from shifting the chain in past the innermost cog.

B-Screw: A screw used to adjust the spring tension on the mounting pivot, which affects the distance between the cogs and the guide pulley.

Pulley wheel: A toothed wheel in the derailleur cage that the chain runs on.

Jockey wheel: An alternate name for a pulley wheel, generally the upper one. Guide pulley will be used instead.

Guide pulley: The upper pulley wheel in the derailleur cage that guides the chain from one cog to the next.

Tension pulley: The lower pulley wheel in the derailleur cage that pulls back on the lower section of chain to keep it under tension.

Derailleur cage: The assembly at the bottom of the derailleur that encloses the chain, consisting of two plates and two toothed wheels called pulley wheels.

Outer plate: The plate in the derailleur cage that is outward of the pulley wheels.

Inner plate: The plate in the derailleur cage that is inward of the pulley wheels.

Parallelogram: With regard to the rear derailleur, this is the part of the body between the mounting pivot and the cage pivot (consisting of two arms on four pivots) that actuates to move the derailleur cage inward and outward.

Adjusting barrel: A hollow screw in the derailleur that the inner wire passes through and the housing stops against. As the adjusting barrel is screwed in and out, the relative length or tension of the cable system is changed.

Pinch mechanism: The mechanism that attaches the inner wire to the derailleur. The inner wire is usually routed through a groove in a plate on the derailleur, and a bolt or nut presses a washer or plate on top of the inner wire to trap and compress it in the groove. The groove in the plate is often hidden by the pressure washer/plate.

Indexing: This describes a type of shifting in which the shift mechanism moves in distinct increments. These increments are designed to be just the right amount to get the chain to move precisely from one gear to the next. Indexing has virtually replaced friction shifting. In friction shifting, the lever moves

smoothly over its full range of motion without any incremented stops. It is up to the operator to decide what the correct amount of lever motion is to get from one gear to the next.

Derailleur hanger: The plate that the derailleur attaches to. Sometimes it is integral to the right rear dropout. Sometimes the right rear dropout is a two-piece construction so that the hanger can be replaced. On the most inexpensive bikes, the derailleur hanger is the plate that mounts between the dropout and the wheel-retention mechanism.

Stop tab: The tab near the bottom of the derailleur hanger that stops the forward rotation of the derailleur.

Mounting bolt: The bolt through the topmost part of the derailleur that attaches the derailleur to the derailleur hanger.

Mounting pivot: The derailleur pivots around the mounting bolt at the mounting pivot. This pivoting allows the derailleur to change position to accommodate changes in gear size as the derailleur moves in and out. This pivot also allows the derailleur to be rotated back to allow rear-wheel removal.

Return spring: When the tension on the inner wire is released, this spring inside the parallelogram causes the derailleur to move out as far as the outer-limit screw will allow.

Cage pivot: The pivot that the derailleur cage rotates about. The cage rotates so that the tension pulley can move forward or backward. This keeps the chain taught when its effective length changes as it is moved to gears of different sizes.

Cage stop screw (or pin): A screw (or pin) in the outer cage plate that bumps into the cage pivot housing to keep the cage pivot spring from completely unwinding when the chain is not in the derailleur.

Over-shift: When the chain moves too far, and does not align with the intended cog.

Under-shift: When the chain does not move far enough, and does not align with the intended cog.

In-shift: Any shift to a cog that is more inward than the one that the chain is currently on.

Out-shift: Any shift to a cog that is more outward than the one that the chain is currently on.

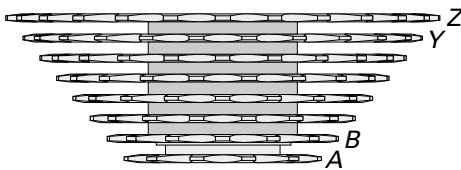
Up-shift: This term will not be used because there are two opposite ways that it could be understood. On a rear cogset, an up-shift could be an in-shift because the chain is moving up onto a cog of larger diameter. An out-shift could also be called an up-shift because the chain is being moved to a cog that will create a higher gear ratio. The terms in-shift and out-shift will be used to avoid this confusion.

Down-shift: This term will not be used because there are two opposite ways that it could be understood. On a rear cogset, a down-shift could be an out-shift because the chain is moving down onto a cog of smaller diameter. An in-shift could also be called an down-shift because the chain is being moved to a cog that will create a lower gear ratio. The terms in-shift and out-shift will be used to avoid this confusion.

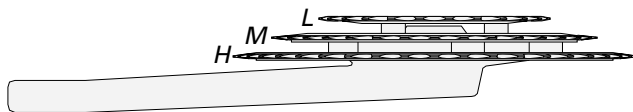
NAMING COGS AND GEAR COMBINATIONS

To perform certain adjustments, the chain needs to be in certain gear combinations. Numbering the gears to identify them does not work because rear cogsets have from 5 to 8 gears (so the innermost could be called 5, 6, 7, or 8), and cranksets have from 1 to 3 chain rings (so the innermost might be called 1, 2, or 3).

To avoid confusion, gears will be assigned codes as shown in figures 32.2 and 32.3 below.



32.2 “A” is always the outermost cog. “B” is always the next-to-outermost cog. “Y” is always the next-to-innermost cog. “Z” is always the innermost cog.



32.3 “H” is always the outermost chainring. “M” is always the middle chainring of a triple. “L” is always the innermost chainring.

Using the above diagrams, it should be easy to conclude that putting the chain in a gear combination of A/M would place the chain in the outermost position in the rear, and the middle position of a triple crank. Y/L would mean the chain was in the next-to-innermost position in the rear and the innermost in the front.

PREREQUISITES

Rear wheel installation

Part of a complete derailleur set-up is to align the derailleur hanger. The wheel must be installed in precise alignment to perform the derailleur-hanger alignment.

Shifter and cable installation

To adjust the rear derailleur, the shift-control mechanism and the cable system must be installed.

Chain sizing

Rear-derailleur performance is influenced by chain length. It is necessary to size the chain to optimized shift performance and to prevent derailleur damage.

INDICATIONS

Maintenance

Dirt accumulation and wear both affect derailleur performance.

The obvious dirt on the pulley wheels is a factor, but dirt hidden inside the mounting pivot and cage pivot can drastically influence shift performance. For this reason, normal maintenance of a rear derailleur should include disassembling and cleaning the entire derailleur.

Wear is a factor in the parallelogram pivots, the mounting pivot, and the cage pivot, but the most critical wear factor is a worn-out guide pulley. A normal part of derailleur service would be to replace the guide pulley. When the pivots are worn out, the derailleur must be replaced.

Changing freewheel/freehub cogset

Any time a freewheel or freehub cogset is replaced with anything other than an identical replacement, it is necessary to adjust the rear derailleur.

Replacing rear wheel

Any time a rear wheel is replaced with anything other than an identical replacement, it is necessary to adjust the rear derailleur.

Aligning rear dropouts

After aligning the rear dropouts, the derailleur-hanger alignment may have changed, which affects derailleur position and adjustment. Check and align the rear-derailleur hanger and adjust the derailleur.

Bent derailleur hanger

When bikes fall over on the right side, or when the derailleur is shifted past the Z cog and into the spokes, the derailleur hanger is likely to be significantly bent. This requires hanger alignment and derailleur adjustment.

Changing chain

Whenever a chain is changed, even if replacing a worn chain with an identical replacement, shift performance is affected. Fresh chains have less lateral flexibility than worn chains. Different chains

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have different performance characteristics. After replacing a chain, the derailleur adjustments should be checked.

Symptoms indicating adjustment is needed

There are a number of symptoms indicating a probable need for derailleur adjustment.

If the derailleur under-shifts or over-shifts when shifting to the *A* cog, or the chain makes excessive noise while on the *A* cog, the rear-derailleur H-screw may need adjustment.

If the derailleur under-shifts or over-shifts when shifting to the *Z* cog, or the chain makes excessive noise while on the *Z* cog, the rear-derailleur L-screw may need adjustment.

If any in-shift or out-shift to any cog between *A* and *Z* is hesitant, or results in excessive chain noise after the shift is completed, it indicates that the indexing needs adjustment.

If the shift performance is poor in several outer cogs but good in all the inner cogs, it may indicate that the B-screw or chain length need adjustment.

Symptoms indicating derailleur service is needed

There are several symptoms indicating that the derailleur should be cleaned or the guide pulley should be replaced.

Any time normal adjustments do not create acceptable shifting and all the components are known to be compatible, assume that disassembling and cleaning is needed and the guide pulley may need replacement.

When the derailleur body remains cocked back when shifting from the innermost cog out to the outermost cog, it is a good indication that the mounting pivot and cage pivot are fouled with dirt.

When the derailleur is obviously congested with dirt and gummed up, it should be disassembled and cleaned.

Symptoms indicating derailleur replacement is needed

The primary reason that derailleurs must be replaced is because they get bent. Other than adjusting barrels, pinch mechanisms, and pulley wheels, most parts are either unavailable or too costly to replace.

The most likely part of a rear derailleur to get bent is the cage. The symptom of a bent cage is that the two pulley wheels no longer share a common plane. When

sighting through the central plane of one pulley wheel towards the other, the further wheel should be hidden by the closer wheel. If not, the cage is probably bent. Although it is possible to improve this condition, it is difficult to eliminate it.

It is also possible that the parallelogram arms might be bent. It may be possible to see a twist along the length of the arm, or it may appear that the plate on the back of the mounting pivot is not parallel with the portion of the outer cage plate where it mounts to the cage pivot.

After a catastrophic shift of the derailleur into the spokes or spoke guard, it is possible that either the plate on the backside of the mounting pivot, or a tab on the mounting-pivot housing may be damaged. If the plate is bent, it can often be bent back. If the tab on the mounting-pivot housing is sheared off, the derailleur needs to be replaced.

The mounting pivot, cage pivot, and parallelogram pivots may all wear out to the point that shift performance is compromised. There is no way to quantify this wear, or point to a specific symptom that proves any of these pivots are significantly worn. When everything else is fine, but shift performance remains poor, consider these points for wear. Check the wear by jerking the bottom of the derailleur cage in and out and noting the amount of free play that is evident. Compare this to a new derailleur of similar brand and quality. If there is an obvious difference, then pivot wear may be the factor that is affecting shift performance.

TOOL CHOICES

Table 32-1 (page 32-5) shows most of the tools available for rear-derailleur adjustment. Preferred choices are shown in **bold** type. Choices are preferred because of a combination among: ease of use, versatility, durability, and economy. If more than one choice of a particular tool type is **bold**, it indicates that either different tools are needed to work on equipment with different configurations, or that several tools are equally preferred.

TIME AND DIFFICULTY

Rear-derailleur adjustment, including hanger alignment and cable-system setup, is a 12–16 minute job of moderate difficulty. Rear-derailleur removal, disassembling, cleaning, installation, and adjustment is a 30–35 minute job of moderate difficulty.

COMPLICATIONS

Component compatibility problems

See the following section, **COMPONENT COMPATIBILITY**, for the numerous complications that exist.

Damaged derailleur

Bent derailleurs are somewhat common, but not always obvious. It is not unusual to spend time adjusting the derailleur, only to find that it will never work well due to damage.

Damaged hanger

Derailleur-hanger damage can be very minor, or severe. Minor damage consists of slight bends or damaged threads. Slight bends can be aligned and damaged threads can be repaired or replaced. Major bends may require replacement of the dropout by a frame builder.

The recommended procedure starts all derailleur adjustments with a derailleur-hanger check. This eliminates the problem of getting most of the way through an adjustment procedure, only to find the hanger needs alignment and the adjustments will need to be redone.

Worn components other than derailleur

Worn chains, rear cogs, cables, and shift controls can all affect derailleur adjustment. It is usually not until the attempt to adjust the derailleur fails that these other factors will get considered, resulting in duplication of effort to adjust the derailleur.

Derailleur wear

Derailleur wear can be difficult to detect. The guide pulley is the most likely part to wear out, but removal is required to tell if the bearing is worn. The derailleur-mounting pivot, cage pivot, and parallelogram pivot can all be worn out without any clear evidence, but with a significant effect on the performance of the rear derailleur.

Dirty drive train

Dirt in the derailleur cage, pulley wheels, chain, cable system, shift-control mechanism, and rear cogs can affect shift performance. Adjusting a derailleur (particularly an indexing one) without cleaning all the related components has very limited potential for success.

COMPONENT COMPATIBILITY

As a rule, it is always best to follow manufacturer's recommendations when selecting components. If not following the manufacturer's recommendations, when non-compatible components are used together, it should show up as a shifting problem. Not all prob-

REAR-DERAILLEUR TOOLS (table 32-1)

Tool	Fits and considerations
HANGER ALIGNMENT	
Campagnolo R	Sloppy pivot, not compatible with many wheel sizes
Park DAG-1	Low-play pivot, easy to use and to measure errors, fits all wheel sizes
Shimano TL-RD10	Expensive, complicated, sloppy pivot, allows hanger alignment without wheel in place in very limited circumstances
VAR 139	Even easier to use than Park DAG-1, but lacks Park's precision pivot
Wheels Mfg. GHT	Sloppy pivot, not compatible with many wheel sizes
FOURTH-HAND (CABLE-TENSION) TOOLS (These tools are same as used for front derailleurs and brakes.)	
Dia-Compe 556	Tends to let inner wire jam in tool
Hozan C356	Tends to let inner wire jam in tool
Lifu 0100	Consumer tool
Park BT-2	Least tendency for inner wire to jam in tool
VAR 233	Tends to let inner wire jam in tool

lems are immediately obvious. If using non-matched components, do not assume that there are no compatibility problems until the indexing performance has been tested. There is a section in this chapter following the derailleur adjustment section about testing indexing performance (page 32-21).

Derailleur and hanger

These days, most derailleur hangers are of a relatively-uniform design. The variations that exist are in the thread type, the hanger length, and the angle of the stop tab on the hanger.

Almost all derailleur hangers have a 10 × 1mm thread, except Campagnolo dropouts, which have a 10mm × 26tpi thread. Fortunately, these two threads are a class B (acceptable) fit, in most cases. The problem comes if installing an aluminum mounting bolt into an aluminum hanger. The best solution is to always run a 10 × 1mm tap through the hanger before installing a derailleur or hanger-alignment tool. This will clean the threads if they already match, or convert a 10mm × 26tpi thread to the more common type.

Derailleur hangers differ in how far below the axle they position the mounting bolt of the derailleur. This affects two things: 1) The maximum-cog-size capacity of the derailleur (how large a rear cog can be accommodated). If the hanger is longer than normal, the derailleur may work with a larger cog size than it is rated for. If the hanger is shorter than normal, the derailleur may not work with the largest cog size that it is rated for. 2) The other problem created by hanger length is how it affects shift performance when it is longer than normal. An extra-long hanger will move the guide pulley further from the cogs (particularly outer ones). This means greater lateral motion of the derailleur is required for shifting, and can mean that an indexing derailleur will not perform adequately. A normal range of hanger length is approximately 24–30mm (axle-center to mounting-hole-center). Deviations from this norm are most often found on frames with aluminum dropouts.

Also, deviations in the angle of the hanger stop tab affect the distance from the guide pulley to the cogs. On many derailleurs, there is a body-angle-adjustment screw (B-screw) that compensates for these deviations. On some unorthodox dropouts, the angle of the stop tab may be beyond the capacity of the B-screw to compensate for. A normal range for this angle (measured from the vertical line through the center of the mounting hole) is 25°–35°, with larger values good for shorter hanger lengths, and smaller values good

for longer hanger lengths. Filing the stop tab can compensate for angles above 35°. Use of a longer B-screw may compensate for angles below 25°.

Derailleur and shift-control mechanism

With indexing systems, compatibility between the shift-control mechanism and derailleur is critical. This is because an indexing shifter will pull a specific amount of cable for each click. The derailleur must move in or out the right amount to line up with the next cog. If the amount of cable that is moved is wrong, then the derailleur will move the wrong amount.

The shift-control mechanism and derailleur should be brand-matched whenever possible. At the time of this writing, the only exceptions to this are a few aftermarket shift-control mechanisms that are made specifically for a different brand of derailleur, such as Grip Shift or Sachs controls made for Shimano derailleurs.

Even with brand-matching, there may be problems. Shimano Dura-Ace shift controls and derailleurs are not compatible with other models of Shimano equipment. A customer's 7-speed system may not be upgraded to 8-speed just by changing the shifter and the cogs. An 8-speed-compatible derailleur may be needed, as well.

Derailleur and cogset

In addition to being compatible with the shifter, the derailleur must be compatible with the cogset. For proper index performance, ideally the cogset should be a brand match with the derailleur. In addition, the derailleur needs to be suitable to the number of cogs in the cogset. In particular, 8-speed cogsets require derailleurs that have 8-speed capacity.

Inner wire and shift-control mechanism

The inner wire must be compatible with the shift-control mechanism because it is the combination of the shifter-drum diameter *and* the inner-wire thickness that determines how much cable is moved for a given amount of lever motion. See the **SHIFT-CONTROL MECHANISMS** chapter (page 30-2) for more information of shifter and inner-wire compatibility.

Maximum cog size

Every derailleur is rated for a maximum cog size. This number reflects the largest size cog that the derailleur can shift onto without jamming. The manufacturer's rating is based on an assumed derailleur-hanger length. If the actual hanger is longer than the assumed length, the derailleur may work on a cog that is a few teeth larger than the rating. If the actual hanger length is shorter than the assumed length, then the derailleur may not even work on a cog that is equal to the maximum-rated cog size.

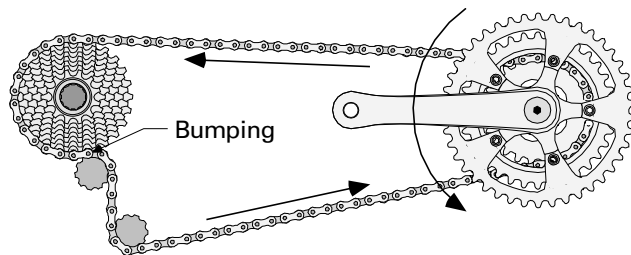
Ratings for derailleurs can be determined in several ways.

Manufacturer's literature: There is often an instruction sheet that comes with a new derailleur. This instruction sheet normally includes the ratings for the derailleur. In addition, some manufacturers can supply literature on request.

Sutherland's Handbook for Bicycle Mechanics: This book includes ratings for a wide variety of derailleur models, but is up-to-date for only a brief time after the date of publication. It is particularly useful if trying to figure out the capacity of an older-model derailleur that is currently on a bike.

Bike'alog: This computerized source reference for bicycle parts has capacity information for currently-available derailleur models.

Test method: To test if a derailleur's maximum-cog-size capacity is being exceeded, follow this procedure: Install the derailleur and size the chain normally. Shift the chain to the *L* chainring, then the *Z* cog. If the chain will not shift to *Z* (and the limit screw is loose enough), then maximum cog size has been exceeded. If the shift is completed, then tighten the B-screw (if any) all the way in. Backpedal and push up on the cage pivot housing. If the guide pulley moves closer to the *Z* cog, maximum cog size has not been exceeded.



32.4 If the chain length is correct and the B-screw is as tight as possible, this symptom indicates the maximum freewheel size of the derailleur has been exceeded.

Maximum total capacity

Every derailleur is rated for maximum total capacity. This number shows the derailleur's capacity to pull up slack chain when in the *A/L* position. The number (36T, for example) indicates the maximum sum for the rear-cog tooth differential added to the front-gear tooth differential. For example, a 12–30 cogset has a differen-

tial of 18 teeth. If the chainring set was 26–36–46, its differential would be 20 teeth. The sum of these differentials would be 38T. A derailleur rated 36T would not be able to pull up all the chain slack if used on a bike with these gears.

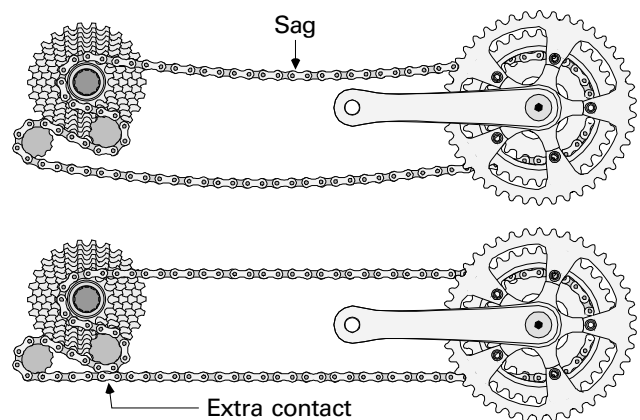
Ratings for derailleurs can be determined in several ways.

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Bike'alog: This computerized source reference for bicycle parts has capacity information for currently-available derailleur models.

Test method: To test if a derailleur's maximum total capacity is being exceeded, follow this procedure: Install the derailleur and size the chain at the shortest length that will allow the chain to keep a double bend through the derailleur cage when the chain is in the *Z/H* position. Shift the chain to the *A/L* position. Check if the chain hangs slack at the bottom or touches itself or the derailleur cage an extra time on its way from the tension pulley to the chainring.



32.5 These symptoms indicate the maximum capacity has been exceeded if the chain is not too long.

32 – REAR DERAILLEURS

Derailleur and first-cog position

The surface that the derailleur mounts to must be in a specified range of distance from the face of the *A* cog. If not, then indexing problems will be experienced. This relationship is a function of the thickness of the dropout/hanger and the right-side axle spacing. It can be adjusted by adding or subtracting spacers from the right side of the axle. In general, the shorter this dimension is, the better. The only limit is when the chain interferes with the frame or dropout when on the *A* cog, or when shifting between the *A* cog and the *B* cog. A typical distance from the face of the derailleur hanger to the face of the *A* cog is 11–14mm.

Derailleur and chain

Indexed derailleurs moved in fixed amounts. The chain must respond as expected for the shift to be completed. If the chain has more lateral flexibility than expected, then when the derailleur moves its fixed amount, the chain will not respond enough to complete the shift. Chains vary in lateral flexibility because of brand differences and wear. If manufacturer's recommendations are not adhered to, shift performance may be compromised.

Chain and cogs

The width of a chain must be suitable to the free-wheel/freehub cogset or it may rub against adjacent cogs. See the **CHAINS** chapter (page 26-2).

The shaping of the side plates of the chain affects the chain's ability to engage the cog teeth. When not using the manufacturer's recommended chain, shift performance may be compromised.

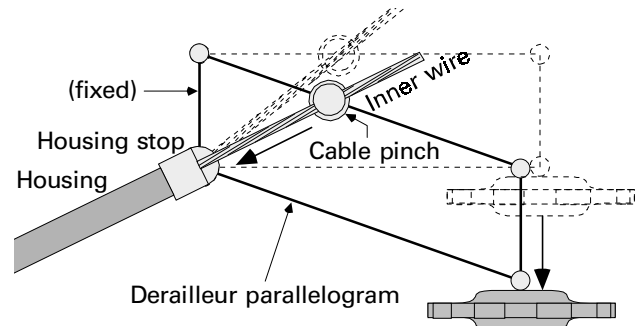
UNDERSTANDING HOW REAR DERAILLEURS WORK

The operation of a rear derailleur is relatively complex. By understanding what is happening in a rear derailleur, the sense of the procedures will become more apparent, and what to do when problems arise will be clearer.

How the cable moves the derailleur in and out

When the shift-control mechanism is operated in a way that pulls on the inner wire, the inner wire moves through the pieces of housing. This extra wire has to come from somewhere. That "somewhere" is the piece of exposed inner wire between the adjusting barrel and the pinch mechanism on the derailleur.

This piece of exposed wire is routed diagonally across the derailleur parallelogram. When the wire is pulled, the distance across the parallelogram is shortened, which deflects the lower end of the parallelogram inward. Figure 32.6 below shows this in a simplified form.



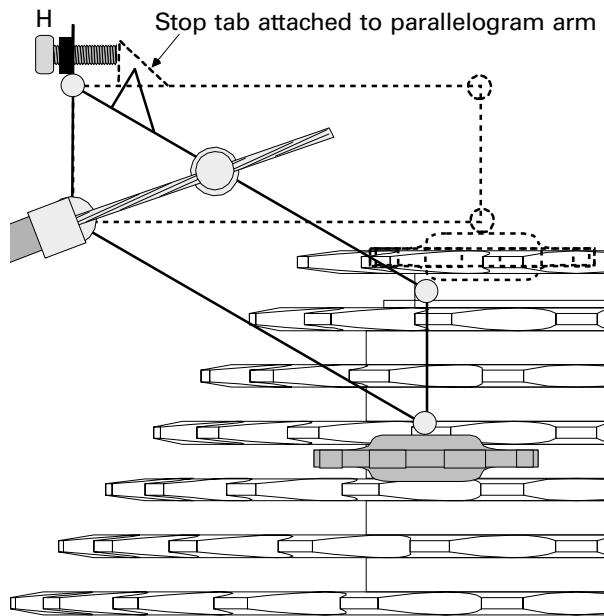
32.6 When the inner wire is pulled through the housing, it shortens the distance from the housing stop to the pinch mechanism, which changes the distance from one end of the parallelogram to the other. This translates into lateral motion of the derailleur cage.

When the tension on the cable is released, a spring in the parallelogram causes it to return in the direction of its starting point.

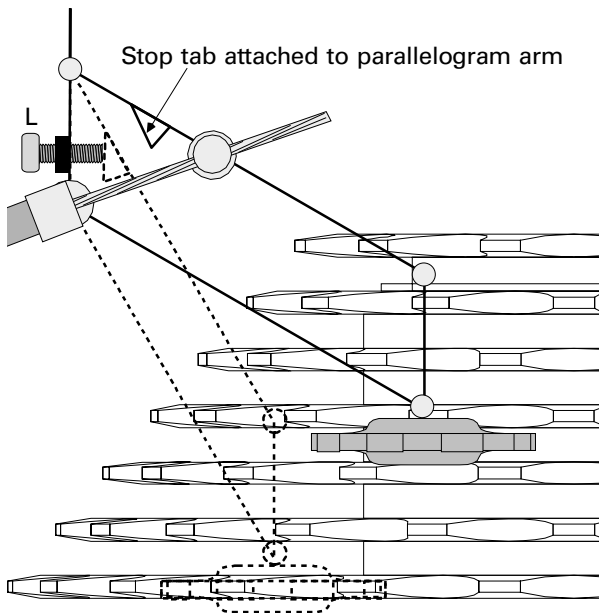
How limit screws work

The two limit screws are like two adjustable barricades. There is usually some projection or surface on a parallelogram arm that the limit screw butts up against. By adjusting one limit screw, the limit of the range of travel for the parallelogram in *one* direction will be altered. By loosening the H-screw, the barricade that stops the outward motion of the parallelogram is moved further out, so the parallelogram may move further out. By loosening the L-screw, the barricade that stops the inward motion of the parallelogram is moved further inward.

Changing the H-screw setting only changes the shift to the outermost cog. Changing the L-screw setting only changes the shift to the innermost cog. Figures 32.7 and 32.8 (page 32-9) shows a simplified and exaggerated model of how limit screws affect the range of motion of the parallelogram.



32.7 When the derailleur moves outward, a stop fixed on one of the parallelogram arms bumps into the end of the H-screw to stop the derailleur's motion.



32.8 When the derailleur moves inward, a stop fixed on one of the parallelogram arms bumps into the end of the L-screw to stop the derailleur's motion.

Why and how the guide pulley tracks close below the cogs

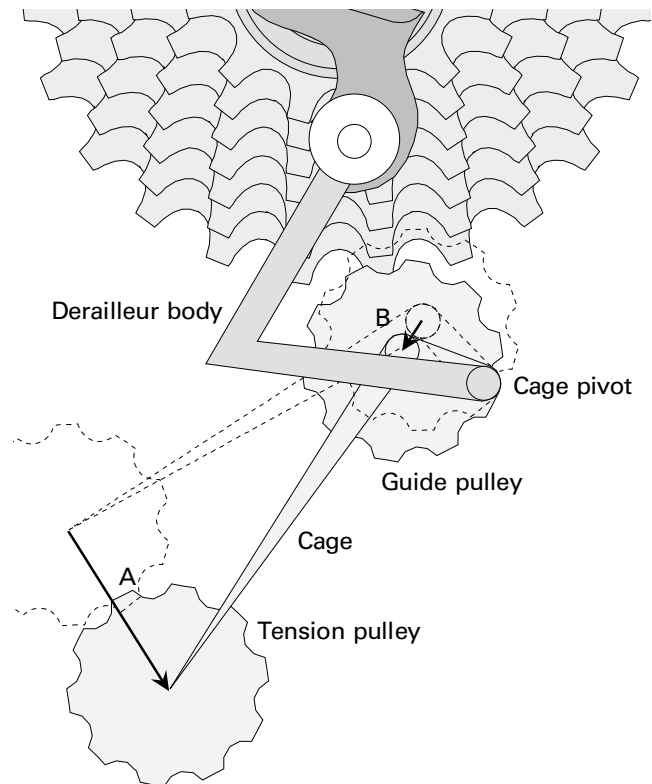
One of the most important factors in shift performance is the distance from the guide pulley to the bottom of the cogs. Between the guide pulley and the cog, there is an unsupported section of chain. When the

distance between the guide pulley and cog is short, it takes less lateral motion of the guide pulley to deflect the chain and get it to derail from one cog and engage another. For example: if 6mm of lateral motion of the guide pulley caused a 20° chain deflection when the length of unsupported chain was one link, then it might take 8mm of lateral motion of the guide pulley to cause a 20° chain deflection when the unsupported chain length was two links long. Consequently, for good index-shifting performance, the distance of the guide pulley from the cogs must be kept short and consistent.

This is done by a complex set of mechanical processes.

The simplest to understand is that the parallelogram is slanted. This is done so that the end of the parallelogram will move down as it moves inward towards the bottom of the larger cogs.

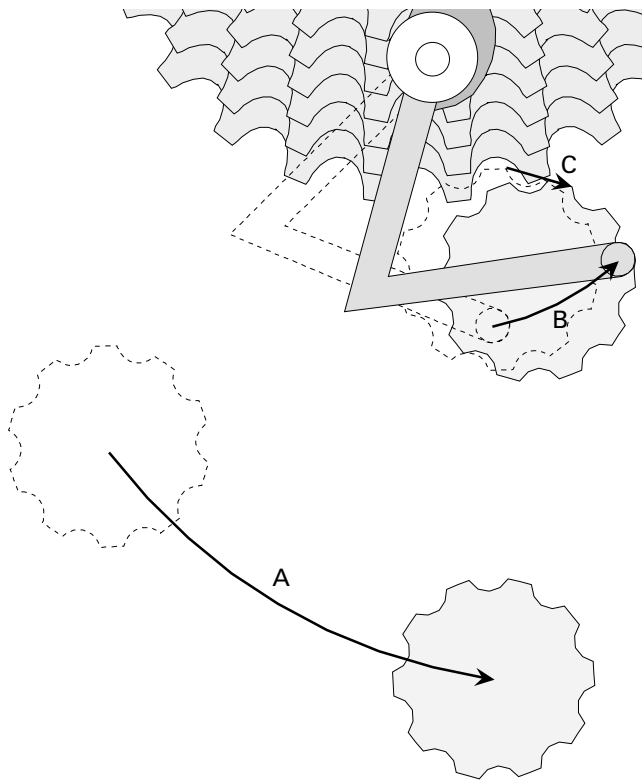
On most derailleurs, the center of the guide pulley is offset from the center of the cage pivot. The result of this is that as the cage rotates to take up more or less slack chain, the center of the guide pulley rotates around the cage pivot and changes its position relative to the cogs. It is this offset of the guide pulley to the cage pivot that makes chain length so important to shift performance.



32.9 If the chain is shortened a link or two, the tension pulley moves (A) and the pivoting cage moves the guide pulley away from the cogs (B).

32 – REAR DERAILLEURS

The last thing that affects guide-pulley position is the balance of the opposing springs in the mounting pivot and the cage pivot. One spring tends to move the guide pulley down, and the other moves it up. The mounting-pivot spring tension is adjustable by adjusting the B-screw. The cage-pivot spring tension is adjustable by disassembling the rear derailleur and moving the spring to a different mounting hole in the derailleur-cage plate. Consider this example: when the chain is shifted to the larger chainring, it pulls the bottom of the derailleur cage forward, which moves the guide pulley down. This counterclockwise cage rotation also increase the tension on the cage-pivot spring, which counterbalances the mounting-pivot spring more, and causes the derailleur body to rotate counterclockwise, moving the guide pulley back up.



32.10 When the chain is shifted to a larger chainring, the tension pulley moves (A), this moves the cage pivot counterclockwise (B). Due to the offset between the guide pulley and the cage pivot, the guide pulley moves less (C) than the cage-pivot moved.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into seven parts. The sections are:

INSTALLATION AND ADJUSTMENT

TESTING INDEX PERFORMANCE
REAR DERAILLEUR SERVICE
DERAILLEUR-HANGER THREAD REPAIR
REAR-DERAILLEUR TROUBLESHOOTING
SHIMANO RAPID-RISE DERAILLEURS
EIGHT-AND NINE-SPEED COMPATIBILITY

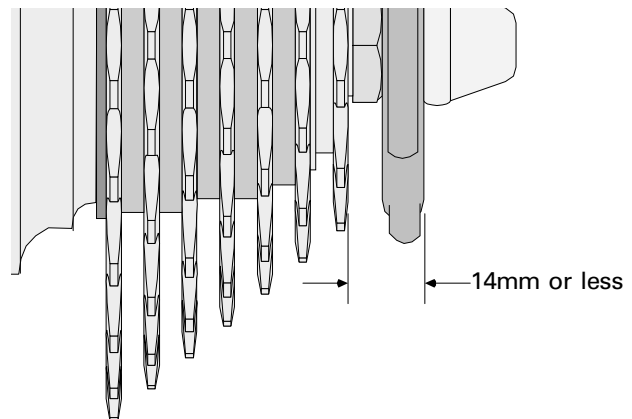
INSTALLATION AND ADJUSTMENT

INSTALLATION

NOTE: before proceeding further, be sure to be acquainted with the section, **NAMING COGS AND GEAR COMBINATIONS** (page 32-3).

Compatibility checks

1. [] Check reference information to determine that derailleur and shift-control mechanism are compatible.
2. [] Check reference information to determine that inner wire, housing, and shift-control mechanism are compatible.
3. [] Check reference information to determine that shift-control mechanism is compatible with brand of cogset and number of cogs.
4. [] Check reference information to determine if chain is compatible with cogset.
5. [] Check that face of A cog is no more than 14mm from face of derailleur hanger.



32.11 Measuring hanger face to A cog face.

Hanger alignment

The derailleur hanger is aligned to the plane of the rear wheel. For this to work well, the wheel should be correctly dished, reasonably true, and in the frame in good alignment. See the **WHEEL REMOVAL, REPLACEMENT, AND INSTALLATION** chapter (page 18-17) about install-

ing wheels. To measure whether the wheel is centered between a pair of stays, butt the end of the caliper up against a stay and extend the depth gauge to the rim. Get a similar reading from the opposite side, making sure the caliper is aligned in the same way and touches the rim at the equivalent point. If the readings are 1mm or less different, the wheel is well centered. If not, try re-aligning it by moving the axle slightly in the slots. The length of the slot allows adjustment in one direction, and the fact that the slot is wider than the axle allows some limited adjustment in the other direction. Lack of precision in the rear triangle may make it impossible to achieve the desired tolerance, in which case the wheel should be left as close as possible to centered.

- 6. [] Install correctly dished and trued rear wheel, so that there is $\leq 1\text{mm}$ centering error to seat stays and chain stays.**

When aligning the hanger, measurements will be taken at the 12:00, 3:00, 6:00, and 9:00 positions on the rim. If the bike is tipped at the wrong angle, then the chain stay may interfere with getting the tool to the 3:00 position, or the seat stay may interfere with getting the tool to the 12:00 position. If the bike is positioned with the chain stay parallel to the ground or sloping slightly up to the front, then the tool will access all the points easily.

- 7. [] Put bike in position that puts chain stay parallel to ground or sloping up to front slightly.**

NOTE: Some bikes have replaceable derailleur hangers that are brittle and prone to failure while being aligned. Do not align replaceable hangers unless a replacement is at hand.

- 8. [] Thread Park DAG-1 into hanger.**

The Park DAG-1 can be adjusted to reduce play at the mounting-bolt pivot. This is done by means of tightening a small set screw in the portion of the tool that houses the mounting bolt. Reducing this play is critical to the accuracy of the tool, so do not skip the following step.

- 9. [] Check for excess play in tool pivot and adjust out play with set screw, if necessary.**

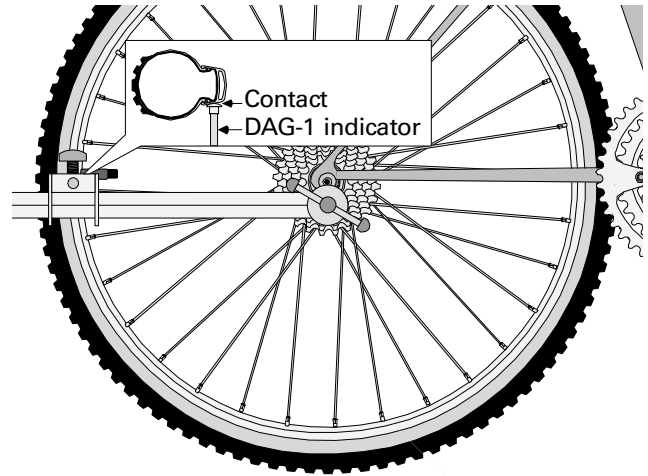
To reduce the significance of true errors, the rim will be rotated to the same four points as the tool, so that the reading is always being done to the same point on the rim. If the tire is installed, the valve stem makes a great rim reference point (RRP). If not, then put a piece of tape of the rim to make a RRP.

- 10. [] Put a piece of tape or a mark on rim for a rim reference point (RRP), or use valve stem.**

Horizontal error is determined by measuring at the 9:00 and 3:00 positions. If there is error, there is no way to know in advance whether it will be a gap at 9:00 or 3:00. The procedure starts at 9:00, and then

goes to 3:00, anticipating that the gap will be found there. If there is a gap at 3:00, then it must be measured to determine if it is significant. If the tool indicator overlaps the rim at 3:00, then the tool should be reset at 3:00 and the gap should be checked at 9:00.

- 11. [] Adjust DAG-1 to just contact RRP at 9:00 position.**

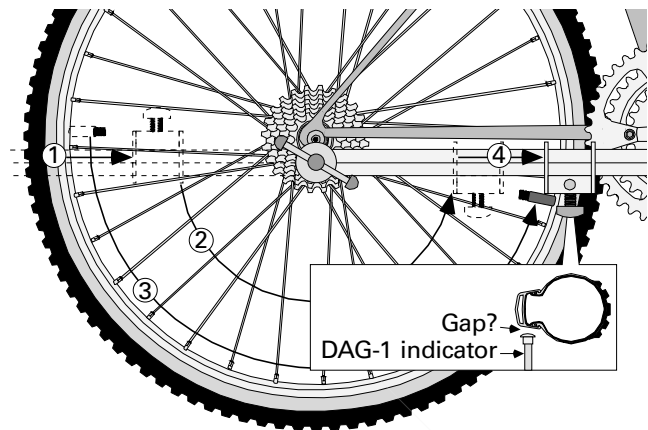


32.12 Set the tool to contact the RRP at 9:00.

To easily move the DAG-1 to 3:00, slide the indicator assembly in towards the tool pivot a few inches, then move the RRP and the end of the tool to 3:00. Once there, slide the indicator assembly out to the rim.

- 12. [] Move DAG-1 and RRP to 3:00 position (if tool overlaps rim, skip to step 14).**

In the following step, use a 4mm stack of feeler gauges or a 4mm Allen wrench to check whether the gaps is more or less than 4mm. If 4mm or less, the hanger alignment in the horizontal plane is good. If more than 4mm, then the error should be corrected.



32.13 1) move the indicator assembly in towards the wheel center, 2) rotate the DAG-1 to the 3:00 position, 3) rotate the RRP to the 3:00 position, 4) move the indicator assembly until the indicator is at the rim. Now, check the gap (or overlap) between the rim and indicator.

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To correct the error, slide the indicator along the main bar, away from the rim, then push in on the main bar of the tool. Keep in mind that a full correction will be done by pushing in enough to reduce the gap by half. If an over-correction is done, then the gap will switch to the position where the tool was initially set to have contact. It does not matter if the gap switches to the other position, as long as it ends up at 4mm or less.

13. If there is error, circle whether it is:

0–4mm gap, *minor error — go to step 17*

Overlaps rim, *go to step 14*

>4mm gap, *continue below:*

☐ Correct by applying leverage to tool until gap is reduced by 50%.

☐ Return tool and RRP to 9:00 and reset tool to just contact.

☐ Return tool and RRP to 3:00 and check that gap is <4mm. (If overlap was created, correction was too much and should be reversed.)

☐ Repeat correction as necessary until gap is <4mm, then *go to step 17*.

NOTE: If tool did not overlap rim at 3:00 in step 13, skip step 14–16.

14. ☐ Reset tool at 3:00 position to just contact RRP.

15. ☐ Move DAG-1 and RRP to 9:00 position:

16. If there is error, circle whether it is:

0–4mm gap, *minor error — go to step 17*

>4mm gap, *continue below.*

☐ Correct by applying leverage to tool until gap is reduced by 50%.

☐ Return tool and RRP to 3:00 and reset tool to just contact.

☐ Return tool and RRP to 9:00 and check that gap is <4mm. (If overlap was created, correction was too much and should be reversed.)

☐ Repeat correction as necessary until gap is <4mm.

After correcting the horizontal error, the vertical error needs to be checked and corrected. The procedure is exactly the same, other than the fact the two positions are 12:00 and 6:00.

17. ☐ Adjust DAG-1 to just contact rim at 12:00 position.

18. ☐ Move DAG-1 and rim reference point (RRP) to 6:00 position. (If tool overlaps rim skip to step 20.)

19. If there is error, circle whether it is:

0–4mm gap, *minor error, done*

Overlaps rim, *go to step 20*

>4mm gap, *continue below:*

☐ Correct by applying leverage to tool until gap is reduced by 50%.

☐ Return tool and RRP to 12:00 and reset tool to just contact.

☐ Return tool and RRP to 6:00 and check that gap is <4mm. (If overlap was created, correction was too much and should be reversed.)

☐ Repeat correction as necessary until gap is <4mm.

NOTE: If tool did not overlap rim at 6:00 in step 19, skip step 20–22.

20. ☐ Reset tool at 6:00 position to just contact rim.

21. ☐ Move DAG-1 and rim reference point (RRP) to 12:00 position:

22. If there is a gap, circle whether it is:

0–4mm gap, *minor error, done*

>4mm gap, *continue below.*

☐ Correct by applying leverage to tool until gap is reduced by 50%.

☐ Return tool and RRP to 6:00 and reset tool to just contact.

☐ Return tool and RRP to 12:00 and check that gap is <4mm. (If overlap was created, correction was too much and should be reversed.)

☐ Repeat correction as necessary until gap is <4mm.

While correcting the vertical alignment at 12:00 and 6:00, it is easy to mess up the horizontal alignment slightly. After correcting the vertical, check the horizontal again and correct whatever minor error may have been created. This need for a repeat correction can be reduced by achieving a near-perfect alignment when first doing the 3:00/9:00 alignment.

23. ☐ Recheck at 3:00 and 9:00 for a difference of 4mm or less, and correct as necessary in same fashion.

Lubrication of derailleur

24. Lubricate following points:

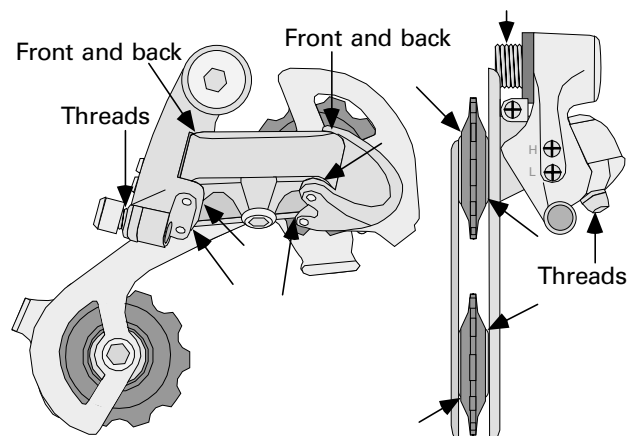
☐ Edge of each pulley-wheel dustcap.

☐ Both ends of all four parallelogram pivots.

☐ Mounting-bolt threads.

☐ Adjusting-barrel threads.

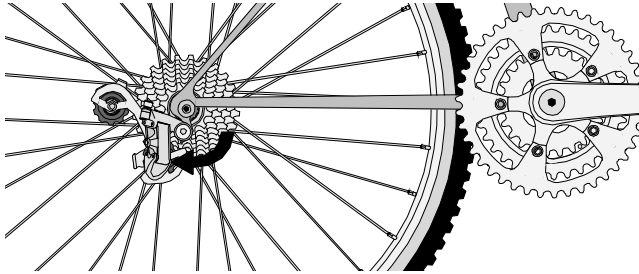
☐ Pinch-mechanism threads.



32.14 Oil at all points indicated by arrows.

Attaching derailleur to hanger

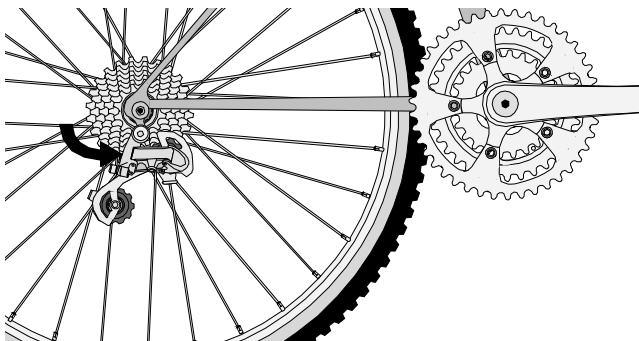
When mounting the derailleur to the hanger, it is easy to damage the derailleur or hanger if the derailleur is not lined up properly as the mounting bolt is tightened. To prevent this, rotate the derailleur considerably clockwise from its operating position, so that the stop tab or B-screw on the back of the derailleur is behind the stop tab on the bottom of the derailleur hanger.



32.15 The derailleur should be kept in this position while engaging and threading the mounting bolt into the hanger.

25. [] Line mounting bolt up with mounting hole in hanger.
26. [] Rotate derailleur clockwise until stop tab on mounting plate or end of B-screw is clockwise of stop tab on derailleur hanger.
27. [] Use T-handle Allen to thread mounting bolt into hanger, but do not secure.

Although it does not matter with most modern derailleurs, the derailleur should be rotated fully counterclockwise when the bolt is being secured. Some older derailleurs would hold any position they were in at the point the mounting bolt was secured. Rather than trying to figure out whether the derailleur being installed is one of the ones that holds whatever position it is secured in, just rotate all derailleurs fully counterclockwise just before the mounting bolt begins to tighten.



32.16 The derailleur should be kept in this position while securing the mounting bolt.

28. [] Rotate derailleur counterclockwise until stop tab on mounting plate or end of B-screw is against stop tab on derailleur hanger.
29. [] Secure mounting bolt to 70in-lbs (18lbs@4").

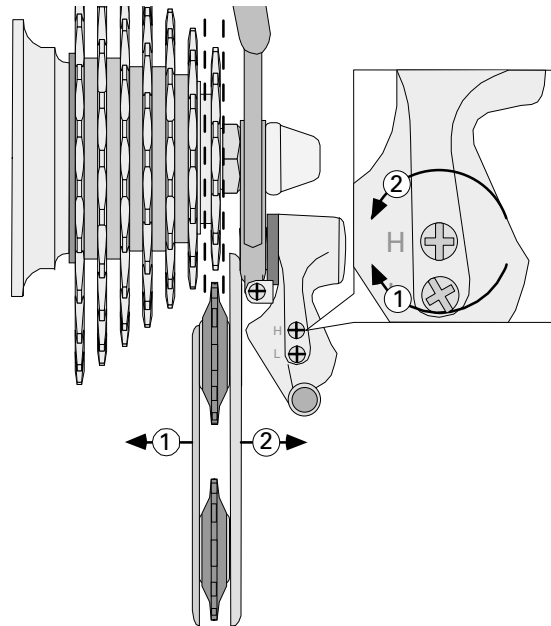
ADJUSTMENT

The processes of describing cogs by their relative positions and describing gear combinations involving different front chainrings and rear cogs can get very wordy and awkward. For this reason, all the following procedures use a code system to name different cogs and gear combinations. This code system is described in detail in the earlier section of this chapter, **NAMING COGS AND GEAR COMBINATIONS** (page 32-3). Become acquainted with this before attempting the following procedures.

NOTE: before proceeding further, be sure to be acquainted with the section, **NAMING COGS AND GEAR COMBINATIONS** (page 32-3).

Pre-setting limit screws

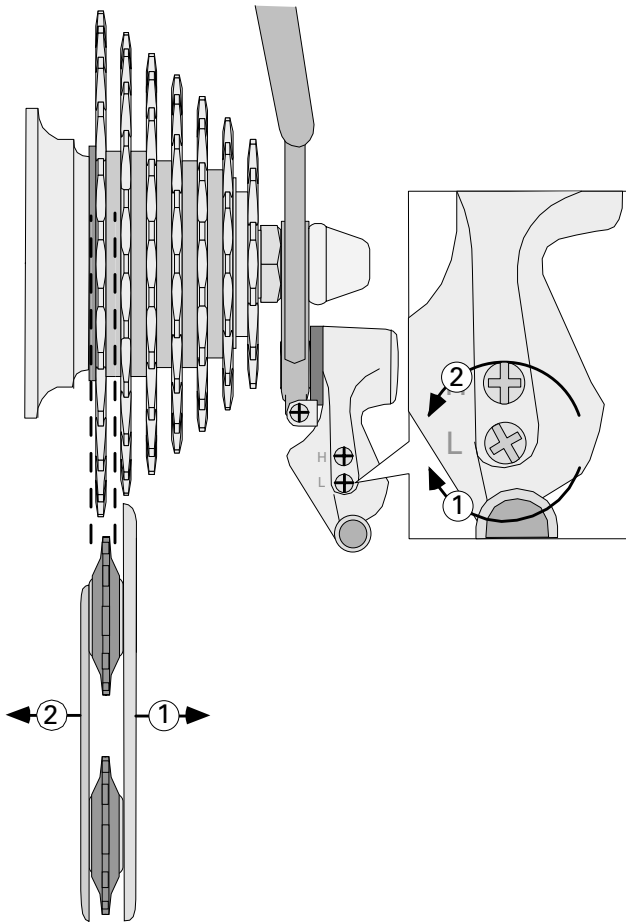
The limit screws need to be set in a very approximate fashion before the cable and chain are installed. The purpose of this is to keep the chain from shifting off the cogset while performing the final adjustments. *Precise adjustment of the limit screws is done later; do not waste effort doing step #30 and #31 too precisely!* When the H-screw is tightened, it reduces the outward range of motion of the derailleur. When the L-screw is tightened, it reduces the inward range of motion of the rear derailleur.



32.17 Turning the H-screw will change the derailleur's outward rest position in the direction indicated by the corresponding numbers. Adjust the screw so that the guide pulley ends up in the range indicated by the dashed lines.

30. [] Standing behind bike, check whether guide pulley is lined up below A cog. Tighten H-screw to move guide pulley in, or loosen to move guide pulley out.

32 – REAR DERAILLEURS



32.18 Turning the L-screw will change the derailleur's most inward position in the direction indicated by the corresponding numbers. Adjust the L-screw so that the innermost position of the guide pulley ends up in the range indicated by the dashed lines.

- 31. []** Standing behind bike, move derailleur inward by hand to its limit of motion and check whether guide pulley lines up below Z cog. Tighten L-screw to restrict guide pulley from moving inward of cog, or loosen to allow guide pulley to move inward more.

Cable attachment

When adjusting an indexing derailleur, cable setup is critical to get good performance. Even if adjusting a derailleur on a bike with the cable already installed, removing the cable and setting it up by the procedures outlined in the preceding chapter, **DERAILLEUR-CABLE SYSTEMS** is highly recommended.

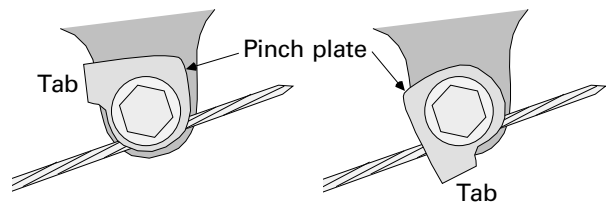
- 32. []** Use procedures in **DERAILLEUR-CABLE SYSTEMS** chapter to install cable system.

- 33. []** Loosen or disassemble pinch mechanism to find groove covered by pinch plate or washer.

Routing the inner wire through the pinch mechanism correctly can be counter-intuitive. The best procedure is to disassemble the pinch mechanism in order

to find the groove that the inner wire should sit in. The inner wire usually approaches the pinch mechanism in close to a straight line from the adjusting barrel, and goes through the pinch mechanism without bending.

Some pinch mechanisms have an irregularly-shaped plate that presses on the top of the inner wire. It is not always obvious how this plate is rotated. There are some that will fit in two different positions, but only one is correct. These plates typically have a narrow tab that hangs over one edge of the plate that is beneath the inner wire. See figure 32.19 for the correct orientation of this type of pinch plate.



32.19 The left picture shows correct orientation of the pinch plate, and the right one shows the wrong orientation.

- 34. []** Lay inner wire into groove and gently secure pinch bolt/nut just enough to keep cable from falling out of pinch mechanism. If the pinch plate has a narrow tab that folds over edge of plate with groove, narrow tab always goes clockwise of section of wire entering pinch mechanism.

The inner wire needs slack removed, but not too much or it will interfere with the setting of the H-screw (particularly if the preliminary setting of the H-screw was somewhat too tight). In the next step, just pull *most* of the slack out of the inner wire before torquing the pinch nut/bolt.

- 35. []** Pull most of slack out of inner wire by hand and secure pinch mechanism to 35in-lbs (12lbs@3") and check that inner wire is still in groove.

NOTE: Install front derailleur to roughly final position and attach front-cable system at this time, if front derailleur not already installed.

Chain length and capacity checks

- 36. []** Install chain and size by procedure in **CHAINS** chapter (page 26-10).

- 37. []** Shift chain to A/L position and check that chain does not hang slack or touch itself or derailleur cage an extra time, indicating length is too long or derailleur maximum capacity is exceeded.

- 38. Check whether maximum-cog-size capacity of rear derailleur is exceeded:**

[] Loosen B-screw fully.

- ☐ Shift chain to *Z/L* position.
- ☐ Backpedal and push up on cage pivot housing to check whether guide pulley is jammed against bottom of *Z* cog, indicating maximum-cog-size capacity is exceeded.

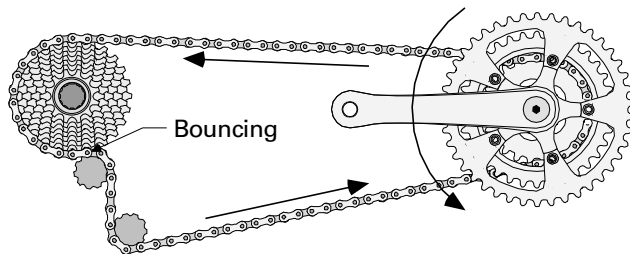
39. Check whether chain is too short:

- ☐ Shift chain to *Z/H* position
- ☐ Check whether chain has double bend where it passes through derailleur cage, indicating chain is *not* too short.

B-screw setting

To maximize shift performance, the B-screw (if any) should be set to keep the guide pulley as close to the bottom of the cogset as possible. This procedure is based on starting with the B-screw as loose as possible, then turning it in if symptoms indicate that the guide pulley is too close to the *Z* cog.

The third check-off in step #40 suggests looking for a symptom that indicates that the guide pulley is too close to the *Z* cog. This symptom is described as *bouncing*. What will be experienced is either a grinding or rumbling noise, or it will appear that the derailleur is jerking up and down slightly at the guide pulley as each cog tooth passes by the pulley. It is possible that the symptom is caused by poor alignment of the guide pulley to the *Z* cog, because the L-screw and the indexing have not yet been finally adjusted. This can easily be checked. Rotate the derailleur body clockwise just enough to move the guide pulley 1/8" further from the *Z* cog. If the symptom goes away, the B-Screw needs adjustment. If the symptom does not go away, the guide pulley needs to be aligned more precisely with the *Z* cog before continuing with the B-screw check and adjustment.



32.20 With the chain in the gear combination shown, back-pedal and check for the bouncing symptom that indicates the B-screw is too loose.

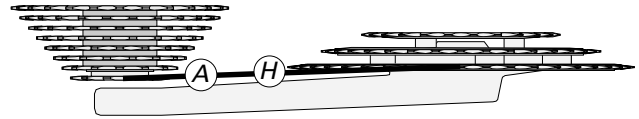
40. Adjust B-screw:

- ☐ Turn B-screw fully counterclockwise, if not already.
- ☐ Shift chain to *Z/L* position by using the shift control for front derailleur, and pulling on exposed inner wire with fingers to operate rear derailleur.

- ☐ While keeping rear derailleur in position under *Z* cog by maintaining pull on inner wire, backpedal to check whether guide pulley is bouncing off teeth on bottom of *Z* cog.
- ☐ Tighten B-screw by 1 turn increment if bouncing experienced, and repeat checks and adjustment until symptom is eliminated.

H-screw setting

When the chain is on the *H* chainring, the rear-derailleur pulley wheel is pulled further from the *A* cog, making the shift more challenging. For this reason, the chain should *always* be on this chainring while performing an H-screw adjustment.



32.21 Proper chain position for beginning the check of the H-screw adjustment.

41. ☐ Shift chain to *H* using front-derailleur shift-control mechanism.

The shift-control mechanism should not be used to operate the rear derailleur because it can introduce variables that may make it appear as though the H-screw needs adjustment, when it does not. To bypass the shift-control mechanism, operate the rear derailleur by pulling out on the exposed inner wire at the down tube or top tube (wherever it is routed).

42. ☐ Shift chain to *B* by pulling on exposed inner wire at down tube or top tube with hand.

Pedaling cadence is very important when checking the shift to the *A* cog, because slow chain motion creates slow shifting. The normal time for a rider to shift to the *A* cog is when pedaling speed in the *B* cog has gotten too fast, so there is nothing realistic about checking the shift from the *B* cog to the *A* cog at low pedaling speed. The 60rpm recommended below is conservatively slow, so do not pedal any slower.

The inner wire should be released quickly, not gradually, because that is the way it will happen when the rider is using the shift-control mechanism to operate the rear derailleur. Slow release of the inner wire will create a false impression that the H-screw is too tight.

If the chain shifts promptly to the *A* cog when first checked, it does not mean the adjustment is acceptable. There is always a range of settings of the H-screw that will create an acceptable shift, but only the *tightest* setting that does so is a good one. The reason for this is that all settings of limit screws tend to change from tighter to looser with time and wear. By setting the screw at the tightest good setting, the longest time before the need

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for readjustment is assured. Consequently, if the initial check of the shift to the *A* cog shows no negative symptoms, then step #44 is done in order to *deliberately create a condition of the H-screw being too tight*.

When the H-screw is too tight, one of two symptoms will be experienced: either there will be unacceptable noise after completing the shift, or there will be a delay, hesitation, or failure to complete the shift.

Unacceptable noise after the completion of the shift can be subtle, and can be confused with normal noises that are always occurring as a chain feeds onto a cog. Two things will clarify whether the noise is normal, or from the H-screw being too tight. First, when the H-screw is too tight, the noise is created by the inner face of the chain rubbing against the outer face of the *B* cog while the chain is on the *A* cog. By standing behind the bike and looking under the cogset, this rubbing can be seen. If there is noise but no contact between the chain and the *B* cog, then the noise is not due to the H-screw being too tight. The second way to confirm whether the noise is because the H-screw is too tight is to loosen the screw one quarter turn more. If the noise is reduced, the over-tight H-screw was the cause. If the noise does not reduce, then the noise is normal chain noise.

The other symptom that the H-screw is too tight is that the chain hesitates when shifting to the *A* cog. This hesitation can be a function of slow pedaling or slow release of the inner wire, so be sure these things are avoided. Not all derailleur systems shift equally quick, so this evaluation is somewhat subjective. The chain should *begin* to shift the instant the cable is released. If the cable is released and the shift happens half a pedal stroke later, that is definitely hesitation. Most modern derailleurs perform well enough that the primary symptom of a tight H-screw will be noise after the shift, not a hesitant shift. Obviously, if the chain will not shift to the *A* cog at all, then the H-screw is too tight.

When repetitive loosening of the H-Screw creates no progress, then the inner wire is probably too tight!

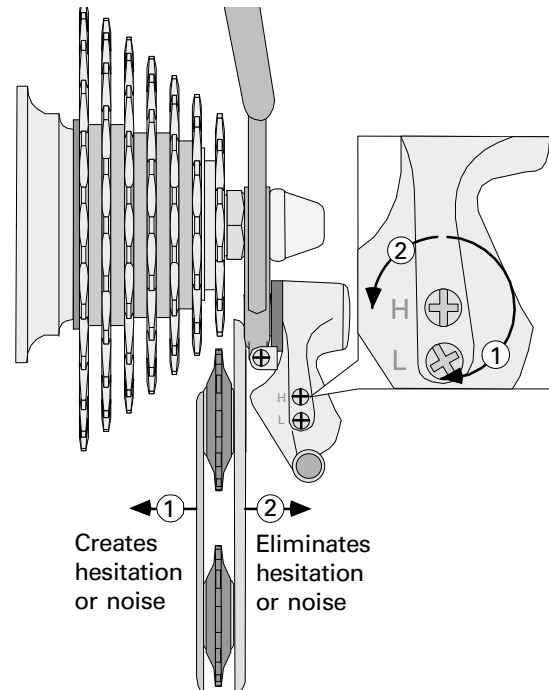
43. While pedaling at 60rpm or better, quickly release rear-derailleur inner wire and observe whether (check one):

☐ Chain does not hesitate shifting to *A*, H-screw should be tightened, go to step 44.

☐ Chain hesitates or clatters after shifting to *A*, H-screw should be loosened, go to step 45.

NOTE: Skip step 44 if chain hesitated or clattered after shifting in step 43.

If there was no symptom of the H-screw being too tight in step #43, then one must be created in step #44. There is no great precision needed when creating this symptom, so half-turn adjustments of the H-screw will get quick results. Later, when eliminating the too-tight symptom, greater precision is needed, so the H-screw will be loosened by quarter-turn increments.



32.22 *Turning the H-screw will change the derailleur's outward rest position in the direction indicated by the corresponding numbers.*

44. ☐ Turn H-screw 1/2 turn and repeat shift from *B* to *A*, checking for whether hesitation or post-shift clatter happens. Repeat this step as many times as necessary until either there is hesitation, or clatter after shifting.

If the too-tight H-screw symptom was experienced when first checking the shift to the *A* cog in step #43, it could take any number of quarter turns of the H-screw to eliminate the symptom. On the other hand, if the too-tight symptom was deliberately created in step #44, then it should take either one quarter turn or two quarter turns of H-screw loosening to eliminate the symptom. This is because the H-screw was turned 1/2 turn to create the too-tight symptom from a setting that was not too tight in step #44.

45. ☐ Turn H-screw counterclockwise 1/4 turn and repeat shift from *B* to *A*, checking for whether hesitation or post-shift clatter is eliminated. Repeat this step as many times as necessary until symptoms are eliminated.

A simple double-check can be done after the completion of the H-screw adjustment to check that it is not too loose. Tighten the H-screw 1/2 turn and check the shift. Too-tight symptoms should be *obvious* at this point, if the H-screw was set at the best possible setting.

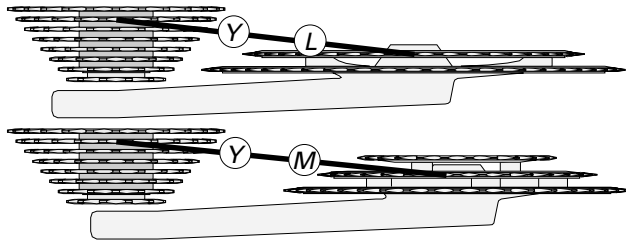
L-screw setting

Having the chain on the correct chainring when shifting to the Z cog to check the L-screw is important because the size of chainring changes the distance between the guide pulley and the Z cog. The largest chainring that would *normally* be used when the chain is on the Z cog is the *M* chainring on a triple-chainring set, or the *L* chainring on a double-chainring set. If the L-screw is set when the chain is on the *H* chainring, then the L-screw would end up even looser. On modern high-performance derailleurs this would usually be a small difference and only reduce the time before the L-screw would need readjustment by a small amount. On low-performance derailleurs the consequence would be more critical; setting the L-screw while the chain is on the *H* chainring could result in the chain shifting into the spokes, particularly when shifting onto the Z cog while the chain is on the *L* chainring (particularly on a bike with three chainrings).

46. [] Shift chain to *M* (triple chainrings) or *L* (double chainrings) using front derailleur shift control.

The shift-control mechanism should not be used to operate the rear derailleur because it can introduce variables that may make it appear as though the L-screw needs adjustment when it does not. To bypass the shift-control mechanism, operate the rear derailleur by pulling out on the exposed inner wire at the down tube or top tube (wherever it is routed).

47. [] Shift chain to *Y* by pulling on exposed inner wire at down tube or top tube with hand.



32.23 These are the correct positions for the chain when preparing to check the shift to the Z cog.

Pedaling cadence is very important when checking the shift to the Z cog because slow chain motion creates slow shifting. The normal time for a rider to shift to the Z cog is when the pedaling speed in the *B* cog has gotten too slow, so there is nothing realistic about checking

the shift from the *Y* cog to the Z cog at too high a pedaling speed. The 60rpm recommended here is somewhat fast, so do not pedal faster than 60rpm.

The inner wire should be pulled quickly, not gradually, because that is the way it will happen when the rider is using the shift-control mechanism to operate the rear derailleur. Slow pulling of the inner wire will create a false impression that the L-screw is too tight.

If the chain shifts promptly to the Z cog when first checked, it does not mean the adjustment is acceptable. There is always a range of settings of the L-screw that will create an acceptable shift, but only the *tightest* setting that does so is a good one. The reason for this is that all settings of limit screws tend to change from tighter to looser with time and wear. By setting the screw at the tightest good setting, the longest time before the need for readjustment is assured. Consequently, if the initial check of the shift to the Z cog shows no negative symptoms, then step #49 is done in order to *deliberately create a condition of the L-screw being too tight*.

When the L-screw is too tight, one of two symptoms will be experienced. Either there will be unacceptable noise after completing the shift, or there will be a delay, hesitation, or failure to complete the shift.

Unacceptable noise after the completion of the shift can be subtle, and can be confused with normal noises that are always occurring as a chain feeds onto Z cog. Two things will clarify whether the noise is normal, or from the L-screw being too tight. First, when the L-screw is too tight, the noise is created by the inner plates of the chain rubbing against the teeth of the Z cog as the chain feeds onto the Z cog. By standing behind the bike and looking under the cog set, this rubbing can be seen and the guide pulley should appear obviously outward from the Z cog. If there is noise, but the guide pulley lines up directly under or inward of the Z cog, then the noise is not being caused by a too-tight L-screw. The second way to confirm whether the noise is because the L-screw is too tight is to loosen the screw 1/4 turn more. If the noise is reduced, the over-tight L-screw was the cause. If the noise is not reduced, then the noise is normal chain noise, a too-loose B-screw, or even a *too-loose* L-screw.

The other symptom that the L-screw is too tight is that the chain hesitates when shifting to the Z cog. This hesitation can be a function of slow pedaling or slow pulling of the inner wire, so be sure these things are avoided. Not all derailleur systems shift equally quick, so this evaluation is somewhat subjective. The chain should *begin* to shift the instant the cable is pulled. It should not clatter while shifting. If the cable is pulled

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and the shift happens half a pedal stroke later, that is definitely hesitation. Obviously, if the chain will not shift to the Z cog at all, then the L-screw is too tight.

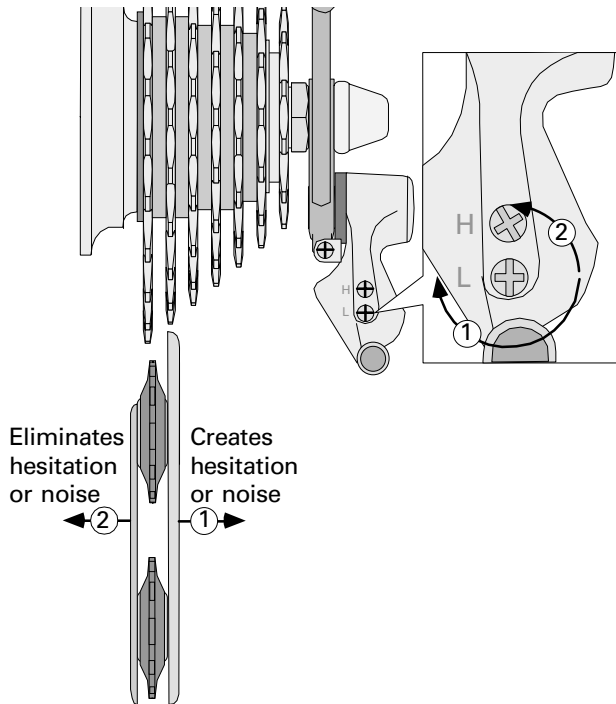
48. While pedaling at approximately 60rpm, pull rear-derailleur inner wire quickly and observe whether (check one):

[] Chain does not hesitate shifting to Z, L-screw should be tightened, go to step 49.

[] Chain hesitates or clatters after shifting to Z, L-screw should be loosened, go to step 50.

NOTE: Skip step 49 if chain hesitated or clattered after shifting in step 48.

If there was no symptom of the L-screw being too tight in step #48, then one must be created in step #49. There is no great precision needed when creating this symptom, so half-turn adjustments of the L-screw will get quick results. Later, when eliminating the too-tight symptom, greater precision is needed, so the L-screw will be loosened by quarter-turn increments.



32.24 Turning the L-screw will change the derailleur's most inward position in the direction indicated by the corresponding numbers.

49. [] Turn L-screw 1/2 turn and repeat shift from Y to Z, checking for whether hesitation or post-shift clatter happens. Repeat this step as many times as necessary until either there is hesitation on the shift, or clatter after the shift.

If the too-tight H-screw symptom was experienced when first checking the shift to the Z cog in step #48, it could take any number of quarter turns of the L-screw to eliminate the symptom. On the other hand,

if the too-tight symptom was deliberately created in step #49, then it should take either one quarter turn or two quarter turns of L-screw loosening to eliminate the symptom. This is because the L-screw was turned two quarter turns to create the too-tight symptom from a setting that was not too tight in step #49.

50. [] Turn L-screw counterclockwise 1/4 turn and repeat shift from Y to Z, checking for whether hesitation or post-shift clatter is eliminated. Repeat this step as many times as necessary until symptoms are eliminated.

A simple double-check can be done after the completion of the L-screw adjustment to check that it is not too loose. Tighten the L-screw 1/2 turn and check the shift. Too-tight symptoms should be *obvious* at this point if the L-screw was set at the tightest good setting.

Cable stressing

A frequently used term is *cable stretch*. There is never a great enough force on the inner wire to permanently change its length (stretch). Somehow, however, cable systems develop slack rapidly after installation. This development of slack can compromise the indexing adjustment. What causes this slack is the inner wire head seats into its socket, and the housing ends and fittings seat into their sockets. This can happen gradually as shifting loads are repeatedly put on the cable systems, or it can be simulated by stressing the cable system one time at a substantially higher load than normal. This over-load stressing also tests the cable system for integrity.

Since the systems will be over-loaded, it is important that the shift-control mechanism and the derailleur be in positions that can support the load. The derailleur should be at its innermost position, supported by the L-screw. The shift-control mechanism should be at its fully-released position, supported by its own internal stop. To accomplish this, the lever must be operated to put the chain on the A cog, and then the inner wire must be pulled manually while pedaling to put the chain on the Z cog. Once the chain is in place, stop pedaling and pull out hard on the inner wire a few times. Protect the hand from damage by using a multi-folded rag between your hand and the inner wire.

51. [] Make sure rear shift-control mechanism is fully released.

52. [] While pedaling, pull on exposed inner wire at down tube or top tube until chain is on Z cog and stop pedaling.

53. [] With chain still on Z cog, pull hard on exposed inner wire to seat cable heads and housing ends in stops and sockets, and to test integrity of pinch mechanism and cable system.

54. [] Pedal crank so chain returns to A cog.

Basic cable tensioning

Coarse adjustment of the inner-wire tension is done by pulling or releasing wire through the pinch mechanism on the derailleur. Fine tuning will be done afterwards by using the adjusting barrel on the rear derailleur.

55. [] Loosen inner-wire pinch mechanism.

The derailleur adjusting barrel should be turned back three full turns from fully in so that it can be turned in or out to loosen or tighten the inner-wire tension.

The shift-control-mechanism adjusting barrel should be turned back one full turn from fully in so that the rider can easily adjust the wire tension tighter or looser while riding.

56. [] Set derailleur adjusting barrel so that it is three full turns out from fully in, and shift-mechanism adjusting barrel so that it is one full turn out from fully in.

The fourth-hand tool is a very convenient tool for removing inner-wire slack, but it can easily be used to make the inner wire much too tight. If the inner wire is being tightened too much by the fourth-hand tool, it will usually show up as inward motion of the derailleur parallelogram. Watch for this while squeezing the fourth-hand tool.

57. [] Using fourth-hand tool, gently pull slack out of inner wire, being sure to stop before derailleur begins to move.

It is easy for the inner wire to slip out of its groove in the pinch mechanism while the tension is being reset. Be sure to check that the inner wire is in place before torquing the bolt/nut. If it is out of place, then the correct torque may not keep it secure.

58. [] Making sure inner wire is still seated in groove in pinch mechanism, secure pinch nut/bolt to 35in-lbs (12lbs@3").

59. [] Put chain in H/B position and check shift to A cog. If shift hesitates, inner wire was tightened too much in step 58.

Indexing adjustment

The concept of making an index adjustment is similar to a limit-screw adjustment. There is a range of adjustments that work, but only the tightest setting is best because it allows the greatest amount of deterioration to happen before the system becomes non-functional. The fundamental approach to the adjustment, therefore, is to deliberately create symptoms that the inner wire is too tight, then loosen the adjustment by small increments until the symptom is eliminated. The complication comes from the fact that when a shift is good to one cog, there may still be symptoms of a too-tight adjustment when shift-

ing to another cog. Consequently, the indexing adjustment consists of shifting into many different gear combinations, and loosening the index adjustment each time a too-tight symptom is encountered.

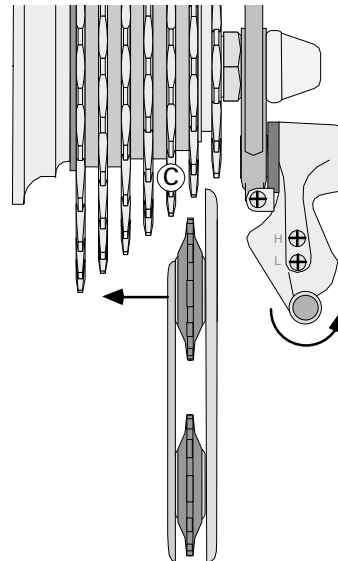
The index adjustment should start with the chain on the H chainring and the A cog.

60. [] Shift chain to H/A with shift-control mechanisms.

In the next step, the shift-control mechanism is used to move the chain to the B cog. One of three things may happen. First, the chain may fail to make the shift at all, indicating that the inner-wire slack was not adequately removed in step #57 (which should be redone). Second, the chain will complete the shift and it is time to continue with step #61. Third, the chain may shift all the way to the C cog, indicating that the inner wire was pulled too tight in step #57 (which should be redone).

61. [] While pedaling, move rear shift control one position to shift chain to B cog.

If the inner-wire tension was set correctly in step #57, the chain has just shifted to the B cog. Step #62 assumes that the chain is not rattling against the C cog and starts by creating that condition. If that condition exists from the beginning, just perform the portion of step #62 that loosens the adjusting barrel by 1/4 turn increments to eliminate the rattle.



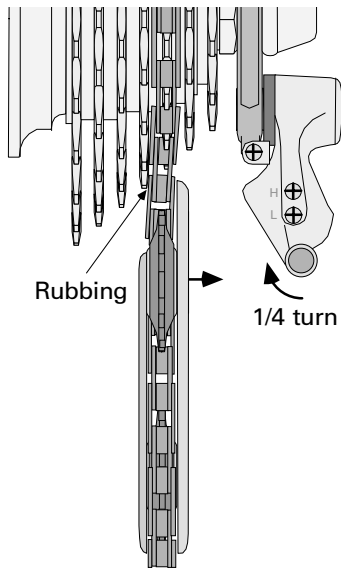
32.25 *Turning the adjusting barrel counterclockwise to cause the chain the rub against the C cog.*

62. [] While pedaling, turn adjusting barrel counterclockwise until chain begins to rattle against C cog, then turn in adjusting barrel by 1/4 turn increments to eliminate rattle. (At the point where rattle is detected, make a visual check from behind that the chain is touching the C cog.)

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Step #63 through #65 check whether there are any too-tight symptoms when shifting the rest of the way inward on the cogset (only to the *Y* cog) and all the way back out to the *A* cog. At any point a too-tight symptom is encountered, the adjusting barrel should be turned clockwise just enough to eliminate the symptom.

- 63. [] Shift chain to *C* cog and check for rattle against next cog inward. Turn in cable adjusting barrel by 1/4 turn increments to eliminate rattle if found.**



32.26 Turn adjusting barrel 1/4 turn clockwise to eliminate rattle of chain against next cog inward. Repeat if necessary and check in all other gear combinations.

- 64. [] Continue in-shifts one cog at a time, eliminating any rattles found with 1/4 turn adjustments of the adjusting barrel, until the chain is on *Y* cog.**
- 65. [] Shift out one cog at a time, eliminating rattles by turning in adjusting barrel in 1/4 turn increments, until chain is on *A* cog.**

After all gear combinations with the *H* chainring have been checked and too-tight symptoms eliminated, it is time to run a similar check with the chain on the *L* chainring. The difference this time is that the chain needs to be shifted all the way to the *Z* cog.

- 66. [] Shift chain to *L* with shift control.**
- 67. [] Pedal and check for chain rattling on *B* cog and turn in adjusting barrel to eliminate rattle if found.**
- 68. [] Shift chain to *B* cog and check for rattle against next cog inward. Turn in cable adjusting barrel to eliminate rattle if found.**
- 69. [] Continue in-shifts one cog at a time, eliminating any rattles found, until the chain is on *Z* cog.**

- 70. [] Shift out one cog at a time, eliminating rattles by turning in adjusting barrel in 1/4 turn increments, until chain is on *A* cog.**

If at any time during the index adjustment, symptoms that the cable is too loose are experienced at the same setting that creates symptoms that the inner wire is too tight, then something is set up wrong or parts are damaged, worn out, or not compatible. At this point, review the entire set up and refer to the troubleshooting information (page 32-29).

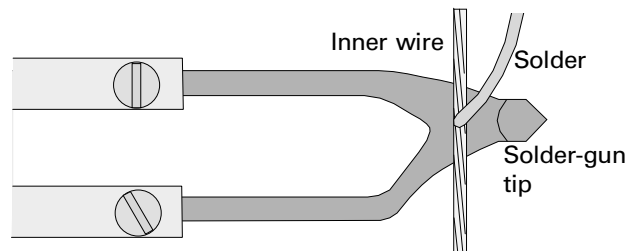
Inner-wire finish

Excess inner wire should be trimmed and finished. Excess length is unsightly and may get caught in the chain. Soldering prevents fraying, which allows reuse of the cable whether a wire cap is being used or not. Wire caps do not prevent fraying, but they do prevent someone getting poked by the wire.

The fourth hand is put on the inner wire to act as a gauge to determine how much wire to leave. This remainder does not need to be any more than the fourth hand needs to grab.

- 71. [] Put fourth-hand tool on inner wire as if removing slack.**
- 72. [] Trim inner wire with wire cutters just past fourth-hand tool.**

The next step suggests soldering the end of the wire. This is easy to do and prevents fraying. To solder, a soldering gun, thin 40/60 rosin-core solder, and soldering flux are needed. Put flux on the inner wire. Hold the soldering-gun tip flat against one side of the wire until the flux sizzles away. Still holding the soldering-gun tip flat against one side of the wire, hold the tip of the solder against the other side of the wire, until the heated wire causes the solder to melt and flow into the wire. Some wires have a coating or are stainless steel and will not accept solder. In these cases, the wire will melt the solder, but the solder will not flow into the wire. Instead it beads up and runs off the wire.



32.27 Correct soldering technique.

- 73. [] Solder inner wire end.**

Wire end caps are sometimes used instead of solder to prevent fraying. This will not work. Crimping the cap onto the wire frequently *causes* fraying. A soldered wire will not fray when the cap is crimped on. The real function of the wire cap is to cover the sharp end of the wire.

74. [] Put cap on end of inner wire if desired.

TESTING INDEX PERFORMANCE

The performance of any indexing-rear-derailleur system can be tested and measured. The procedures described above are designed to set the indexing adjustment at *the tightest setting that provides good shifting*. If the indexing system has normal performance, then there are probably looser settings for the cable that also enable shifting into all the gears. The range of adjusting-barrel positions from the tightest that provides good shifting to the loosest that will allow shifting into all the gears is called the *Functional Range of Adjustment* (or FRA).

The performance of all systems deteriorates with wear, a bent derailleur hanger, and the accumulation of dirt. When the FRA is narrow, then it will take only a small amount of riding before service is needed to restore acceptable shifting. When the FRA is extremely narrow, finding a correct adjustment at all is a challenge. When the FRA is broad, it will take much longer before service is needed. Consequently, it is to the rider's and the mechanic's advantage for the system to have a broad FRA.

There are two reasons to measure the FRA: first, it enables an accurate determination of whether parts might need replacement or cleaning on a used system; second, it permits an evaluation of whether a non-recommended part compromises indexing performance unacceptably.

There is no absolute value for an adequate amount of FRA. It varies with the brand and quality of equipment, as well as some other factors. For seven- and eight-speed systems, a FRA of at least three quarter turns of the cable adjusting barrel should be expected of new equipment. It is not unusual to get something more like four to six quarter turns.

If evaluating properly set-up used equipment that all meets manufacturer's specifications for compatibility and the FRA is not at least three quarter turns, then something in the system needs cleaning or replacement.

If evaluating any equipment, used or new, that *does not* meet manufacturer's specifications for compatibility and the FRA is not at least three quarter turns, then the non-matched equipment probably needs to be replaced.

If considering installing equipment in a system that may not be compatible, measure the FRA before the change, and again afterwards. If it is reduced, then the equipment change will downgrade shift performance. If it is still above three quarter turns, then it may be acceptable even though it is a downgrade of performance. This test process applies to mis-matching pulley wheels, chains, derailleurs and shifters, cable systems, and even mis-matching derailleurs with cogsets.

MEASURING THE FUNCTIONAL RANGE OF ADJUSTMENT (FRA)

1. [] **Perform an index adjustment using steps 60–65 of the *INSTALLATION AND ADJUSTMENT* procedure for rear derailleurs.**
2. [] **Mark adjusting barrel at 12:00 so turns of adjustment can be tracked.**
3. [] **Turn adjusting barrel in (clockwise) 1/4 turn.**

In the next step, a somewhat subjective evaluation of whether the adjustment is too loose must be made. As the adjustment is loosened, it is normal for performance to degrade *before* shifting actually is unacceptable. In an in-the-stand test, this loss of performance will be quite noticeable. It will even reach a point where a delay in releasing the shifter (after the click is reached) will be required to effect the shift. For the rider on the bike, this deterioration of performance will take place gradually over a long period of time, without being nearly so noticeable.

For this reason, consider a symptom of the cable adjustment being too loose to be either of the three following things: first, when an in-shift cannot be completed except by moving the shifter two positions, the cable adjustment is too loose; second, when moving the shifter one position to create an out-shift and the chain unavoidably moves two cogs, then the cable adjustment is too loose; third, if after completing a shift, the chain *clearly* is making a noise as a result of trying to shift to the next cog outward, then the cable adjustment is too loose. Before concluding that the adjustment is too loose based on chain noise after the shift, always look below the cogset to see that the chain is actually angled obviously out from the cog it is on.

4. [] With chain on *H* chainring, shift chain from *A*, to *B*, to *C*, etc., until cog *Y* is reached, then out one at a time until back to *A*. Pedal several crank revolutions at each cog and check for symptoms of indexing adjustment too loose (circle result).

At 1 quarter turn in: too loose?	No	Yes
At 2 quarter turns in: too loose?	No	Yes
At 3 quarter turns in: too loose?	No	Yes
At 4 quarter turns in: too loose?	No	Yes
At 5 quarter turns in: too loose?	No	Yes
At 6 quarter turns in: too loose?	No	Yes
At 7 quarter turns in: too loose?	No	Yes
At 8 quarter turns in: too loose?	No	Yes
5. [] With chain on *L* chainring, shift chain from *A*, to *B*, to *C*, etc., until cog *Z* is reached, then out one at a time until back to *A*. Pedal several crank revolutions at each cog and check for symptoms of indexing adjustment too loose (circle result).

At 1 quarter turn in: too loose?	No	Yes
At 2 quarter turns in: too loose?	No	Yes
At 3 quarter turns in: too loose?	No	Yes
At 4 quarter turns in: too loose?	No	Yes
At 5 quarter turns in: too loose?	No	Yes
At 6 quarter turns in: too loose?	No	Yes
At 7 quarter turns in: too loose?	No	Yes
At 8 quarter turns in: too loose?	No	Yes
6. [] Repeat steps 3–5 as many times as necessary until first symptom of indexing adjustment being too loose is encountered. Record how many quarter turns it takes to reach this point here: ____ quarters.
7. [] If comparing performance between two equipment choices, install other equipment and repeat steps 1–6, but record new number of indexing turns needed to create symptom of indexing adjustment too loose in this blank: ____ quarters.

The resulting numbers in step #6 and #7 are not the FRA because the last adjustment made the shifting non-functional. The actual functional range of adjustment would be described as 1/4 turn less than the number in either of these steps. Thus, if the first symptom of too loose showed up at three quarter turns, then the FRA would be two quarter turns (truly poor).

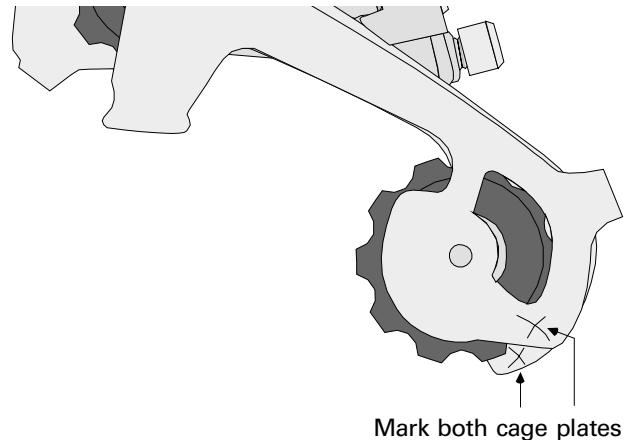
REAR-DERAILLEUR SERVICE

PULLEY-WHEEL REPLACEMENT AND CAGE CLEANING

The rear-derailleur cage and pulleys may need service when nothing else in the rear derailleur needs service, because of wear and the accumulation of grime that builds up in this area. This is a very simple service to do. It can be done without derailleur, cable, or chain removal; usually no adjustments are required (unless they were already needed).

Pulley-wheel removal

1. [] Shift chain to *A/L* position, then manually drop chain off to inside of *L* chainring so that chain rests on bottom-bracket shell.
2. [] Use marker or scribe to put mark on each derailleur-cage plate near bottom end so that marks line up with each other and are both visible from same side of derailleur cage.



32.28 *Mark both cage plates to make it easy to restore their correct orientation.*

When the tension pulley is removed (if it is an after-market cartridge-bearing pulley) there is a good chance that there are small washers between the pulley wheel and cage plates so that the cage plates end up correctly spaced from each other. Look carefully for these washers, as they are easy to loose and hard to replace.

3. [] Remove bolt through tension pulley (lower) from either front or back of cage, and catch tension pulley as it falls out of cage. (Watch carefully for any washers that might be sandwiched between tension pulley and inner faces of cage plates.)

Tension pulleys and guide pulleys are often not identical on indexing derailleurs. The word “tension” or the letter “T” may appear on the tension pulley. The

only difference that may be seen, at this time, is that the tension pulley may have thinner teeth than the guide pulley, or there may be a wear difference. If any difference can be seen at this time, note it in step #4. If no difference can be seen now, it is still possible that a difference will be apparent once the guide pulley is removed. There will be another opportunity to note marks or features when the guide pulley is removed.

4. ☐ **Inspect tension pulley for any marks or features that might distinguish it from guide pulley, which is often different. Note features or marks here:** _____
5. ☐ **If bolt through guide pulley has head on outer face of cage, rotate cage counter-clockwise until bolt head is easily accessed.**
6. ☐ **Remove bolt through guide pulley and catch inner cage plate and guide pulley as bolt is withdrawn from them. (Watch carefully for any washers that might be sandwiched between tension pulley and inner faces of cage plates.)**

The guide pulley often has special features that enhance shift performance. It may be marked or have features that distinguish it from the tension pulley. The word “guide” or letter “G” may appear on the pulley. Shimano pulleys may have the word “Centeron” on the guide pulley, or the guide pulley may have a white ceramic bushing and sleeve inside the pulley. The guide pulley is likely to have thicker teeth than the tension pulley. The guide pulley may show more wear on the teeth than the tension pulley.

7. ☐ **Inspect guide pulley for any marks or features that might distinguish it from tension pulley, which is often different. Note features or marks here:** _____

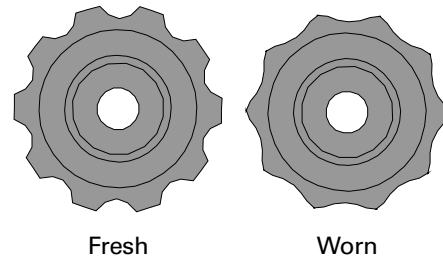
Shimano pulley wheels sometimes have soft rubber seals around the metal dustcaps. These seals have an inner and outer face, and it is not intuitive which face is which, so observe closely as the seals are removed. Sealed cartridge-bearing pulley wheels have a broad flat rubber seal and no dustcap. This seal can be carefully pulled out with a seal pick, so that the bearings can be cleaned and greased. Be careful not to bend the seals. The front sides are black rubber, but the back faces of these seals are thin metal plates that are easily bent.

8. ☐ **Carefully remove any dustcaps or seals from faces of pulley wheels.**
9. ☐ **Remove any bushings from inside of pulley wheels, noting whether bushings in guide and tension pulleys are different.**
10. ☐ **Clean all parts thoroughly, including both cage plates.**

Inspection of pulley wheels

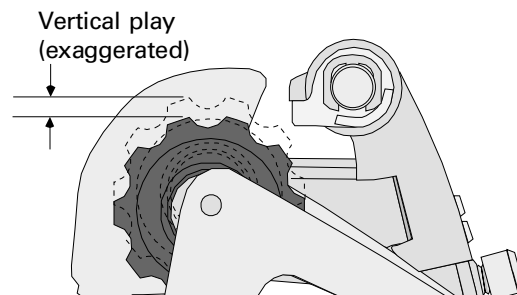
Conventional pulley wheels (with bushings) wear out two different ways, and both affect shifting performance.

Guide pulleys, in particular, develop tooth wear. The teeth are normally shaped like short plateaus. As they wear, the width of the top of the plateau is narrowed and the tooth may actually develop a point on top. See figure 32.29 below. When there is tooth wear on the tension pulley, it is usually more on one face of the teeth than the other. This often indicates a problem with chainline, hanger alignment, or a bent cage.



32.29 A fresh guide pulley and a worn one.

Pulleys also wear between the bushing and the hole in the pulley. This may show up two ways. When the pulley wheel is mounted in the cage, if it has obvious radial play then it is worn out. Radial play is detected by jerking the pulley wheel up and down on its pivot. See figure 32.30. Also, when the pulley wheel is apart, a groove may be apparent in the surface of the bushing.



32.30 If the pulley wheel can be moved up and down, the bushing and sleeve are worn out and the pulley should be replaced.

Cartridge-bearing pulleys fail regularly due to grease failure in the bearings. If, after removing the seals, cleaning out the grease and adding fresh grease, the pulley does not turn smoothly on its bearing, it should be replaced.

Replacement of pulley wheels

Always replace pulley wheels with original equipment. Even simple brand matching may not be enough. For example, an older Shimano Deore XT derailleur

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for use with 7-speed cogsets has pulley wheels that are fatter than the ones that are used on newer Deore XT derailleurs that are 8-speed compatible.

“Upgrade” pulley wheels are marketed heavily to the consumer. These products promote that they have more durable teeth and bearings, and that they provide lower friction. Their metal teeth often make the drive train noisier. Their “sealed” bearings are prone to seizure because of water-caused grease failure. However, their teeth are generally more durable. Some make claims of index compatibility, yet have none of the key features of the pulley wheels they are supposed to replace. If curious about index compatibility of pulley wheels, test for it by using the indexing performance test described earlier in this chapter (page 32-21).

Pulley-wheel installation

11. [] Oil bushings and inside faces of dustcaps lightly, or stuff bearings of cartridge-bearing pulley wheels with grease.
12. [] Assemble bushings into pulley wheels, and install dustcaps and seals to each pulley wheel.
13. [] Treat threads in cage plate for cage bolts with Loctite 222.
14. [] Hold inner plate and outer plate together and find orientation that puts marks together and visible from same side.
15. [] Insert bolt through upper hole in cage plate that has no threads in holes, and slip guide pulley over hole.

After torquing the cage bolt, the next step checks whether the pulley rotates freely. If it does not rotate freely, the bushing may have been left out or switched between pulleys, spacing washers on cartridge-bearing pulleys may be out of place, the dustcap or seals may be out of place, the inner cage plate may be upside down or facing backwards, or non-compatible pulley wheels are being used. *Failure of the pulley wheel to rotate freely is never caused by too much torque on the bolt!*

16. [] Line up other cage plate and thread bolt into hole, torquing to 35in-lbs (12lbs@3"). Check that guide pulley rotates freely.
17. [] If derailleur and chain are on bike, place tension pulley inside loop of chain and push tension pulley into lower end of cage.
18. [] Line up lower holes of cage plates and tension pulley, and insert bolt through holes.
19. [] Thread in lower bolt and torque to 35in-lbs (12lbs@3"). Check that tension pulley rotates freely.

There is often a keeper tab on one or both of the cage plates that helps keep the chain inside the cage. When assembling the cage, it is possible to get the chain

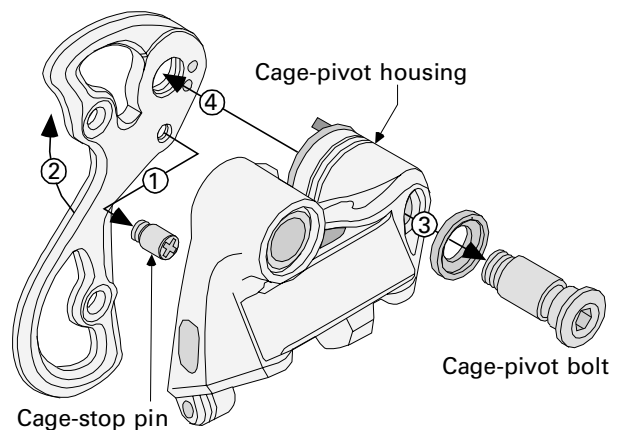
stuck *outside* this keeper tab. In the next step, check that the chain goes straight from the front of the guide pulley to around the back and bottom of the tension pulley, without interfering with any parts of the cage plates.

20. [] If derailleur and chain are installed, backpedal briefly and observe that chain runs over pulley wheels and through cage without interference.
21. [] If pulley wheels were replaced, check limit screws and indexing adjustment.

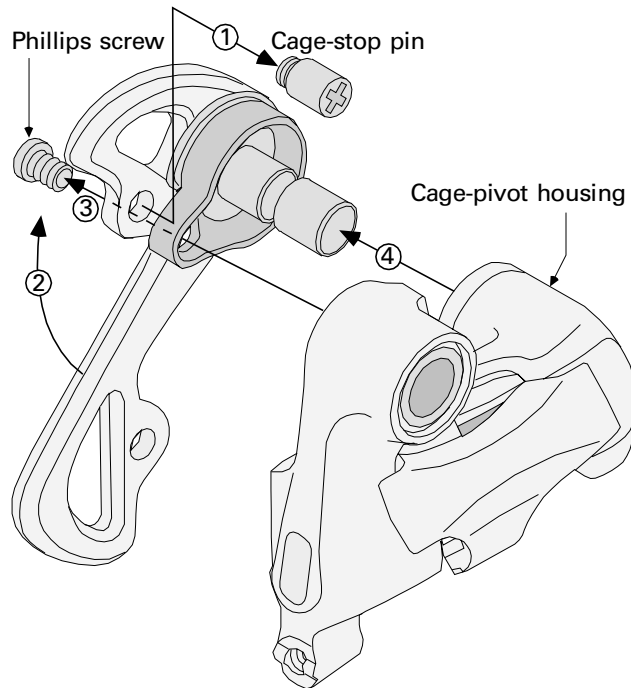
PIVOT SERVICE AND SPRING ADJUSTMENTS

It is important to service the mounting pivot and cage pivot because dirt and lack of internal lubrication can severely handicap derailleur performance. The sealed nature of the pivots makes it pointless to try to flush the mechanism with solvent and inject lubricant, without disassembling the pivots. Additionally, disassembling the cage pivot allows changing the cage-spring tension, which is useful when mounting the derailleur to an unconventional derailleur hanger (or other special circumstances).

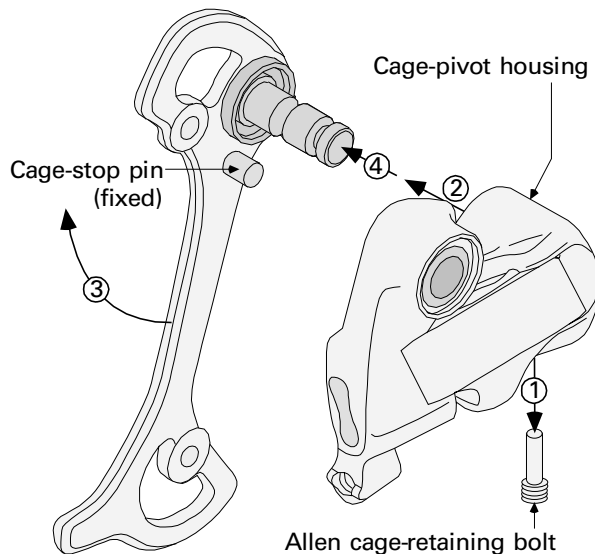
Over the decades there have been more models of derailleur made than anyone could ever remember. Many of them are still in use. Most of them require different techniques to service. It is not practical to write comprehensive instructions on disassembling and servicing rear derailleurs. The following procedure is suitable for a variety of modern Shimano derailleurs, which are both dominant in the market, and somewhat consistent to each other.



32.31 Blow-up of a typical Shimano derailleur with a cage-mounting bolt accessed from the front of the cage-pivot housing.



32.32 Blow-up of a typical Shimano derailleur with a cage-mounting screw accessed from the back side of the cage-pivot housing.



32.33 Blow-up of a typical Shimano derailleur with a cage-retaining bolt accessed from the bottom side of the cage-pivot housing.

Disassembling the cage pivot

The procedure assumes that the cage plates are separated and the pulley wheels are removed, which is covered earlier in this chapter (page 32-22).

1. The derailleur may have one of several configurations. Either there is a cage-stop screw in the face of the outer cage plate immediately adjacent to the cage-pivot housing, or the cage stop is a fixed pin that does not unscrew.

[] If cage-stop screw is fit by a Phillips screwdriver, wind derailleur cage slightly counterclockwise and unscrew Phillips screw.

[] If there was no Phillips screw in face of outer cage plate, look for 2mm Allen set screw recessed in bottom side of cage-pivot housing and remove screw completely.

2. Cage and derailleur body will separate in one of three ways:

[] If there is an Allen bolt head in hole in outward end of cage-pivot housing, turn bolt counterclockwise to remove it.

[] If cage-stop pin was unthreaded from face of outer cage plate, but there is no hole in outward end of cage pivot housing, look on backside of cage pivot housing for small Phillips screw accessible just past edge of cage plate.

[] If cage-stop pin did not thread out of cage plate, look for 2mm Allen screw to thread out of bottom side of cage-pivot housing. When this is removed, cage can be pulled away from back side of housing, at which time it will unwind.

[] If cage-stop pin is not removable and there is no Phillips screw accessible from back, no bolt head accessible from front face of cage pivot housing, or no 2mm Allen screw accessible from bottom side of cage pivot housing, then cage pivot assembly cannot be serviced.

There are usually two holes in the cage plate that the cage-pivot spring can engage in. Looked at from the outer face of the cage plate, the more clockwise hole is the normal position that creates the lower spring tension. The more counterclockwise hole creates an optional high-tension setting.

3. [] Remove cage from derailleur and observe which hole that cage return spring engaged in outer plate. Which hole? _____
4. [] Remove any seals from cage-pivot housing or face of cage plate.
5. [] Remove spring from cage-pivot housing, noting which end of spring inserts into housing.

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Disassembling the mounting pivot

The B-screw will get in the way of manipulating the mounting plate when re-assembling the mounting pivot. It should be removed now, but measured first, in which case the setting was correct and should be re-stored. Use a depth gauge to measure from either end of the screw to the face of the tab it is threaded into.

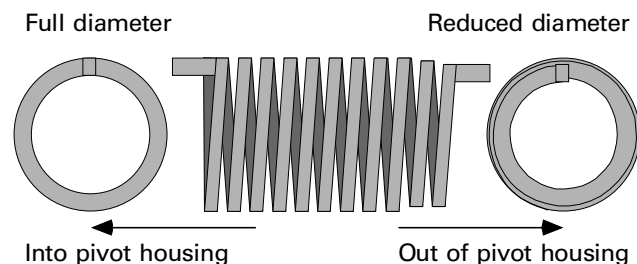
6. [] Measure length of B-screw protruding from plate on back of mounting pivot and record here so that B-screw can be removed and installed without having to readjust.
B-screw protrusion: _____ mm

7. [] Remove B-screw from plate on back of mounting pivot, and pull off any plastic cover.

In step #8 through #10, the clip that holds the pivot assembly together is removed. The assembly is spring-loaded and prone to blowing apart once the clip is removed. The clip itself is prone to flying a long distance when it is removed. To prevent this, the removal is done with a rag draped over the derailleur and tools, so that everything will be trapped if the parts try to fly.

8. [] Find clip that engages groove in mounting bolt on back side of mounting pivot, and insert tip of small screwdriver between clip and mounting bolt to prepare to pry clip out of groove.
9. [] With screwdriver in place and ready to pry out clip, drape rag over hand and derailleur so that parts will be trapped inside rag when clip is pried out.
10. [] Pry out clip.
11. [] If plate and spring did not pop off when clip was removed, pull out on plate and allow to unwind clockwise.

Shimano mounting-pivot springs are not symmetrical. One end fits in the housing and the other end fits in the mounting plate. The difference is not obvious, but the illustrations below should make it clear. The end that has the spring leg set in from the full diameter of the spring never goes into a pivot housing.



32.34 *The end of the spring that goes in the housing is on the left. The spring ends shown on the right never go into the housing.*

12. [] Remove plate, seals, and spring from back-side of mounting-pivot housing, noting which end of spring was inserted in housing.

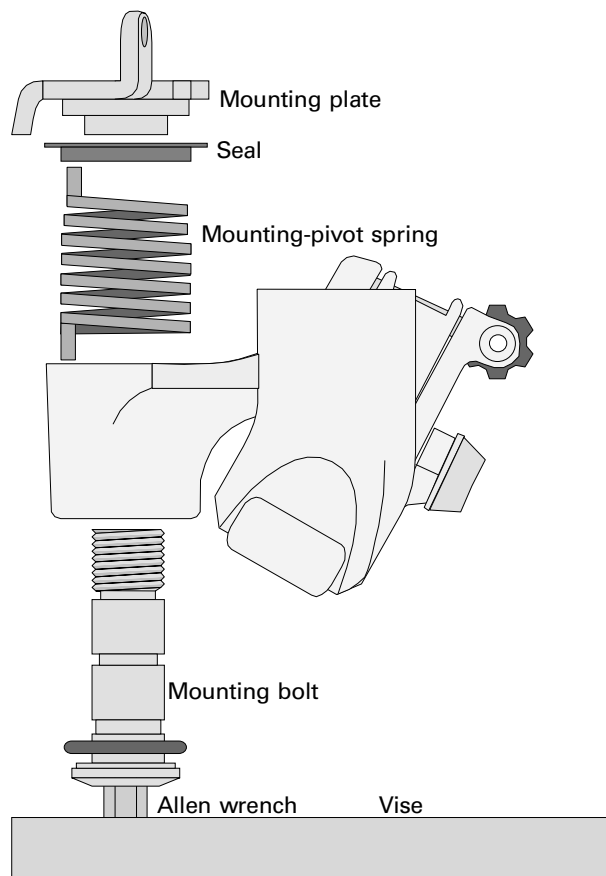
13. [] Remove mounting bolt from front of mounting-pivot housing.

Cleaning and lubrication

14. [] Soak derailleur and parts in solvent, then scrub with stiff brush to remove all dirt and grease. Dry thoroughly.
15. [] Grease springs, cage-pivot stud in outer cage plate, and smooth shaft of mounting bolt.
16. [] Oil parallelogram pivots, pinch-mechanism threads, and adjusting-barrel threads.

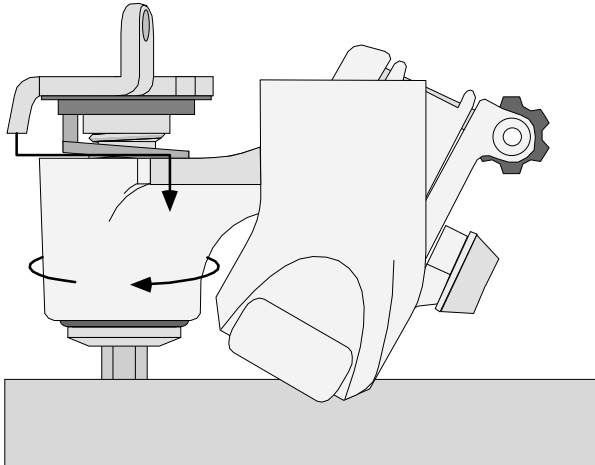
Assembling the mounting pivot

17. [] Place Allen wrench securely in vise with end pointing up, and place mounting bolt upside down on Allen wrench.
18. [] Install any seals in outer face of mounting-pivot housing and slip derailleur (outer face down) over mounting bolt.
19. [] Insert spring into mounting-pivot housing and engage end of spring in hole. Make sure that end of spring with reduced diameter coil is facing out of mounting-pivot housing.
20. [] Put seal in place between mounting plate and mounting-pivot housing.
21. [] Place mounting plate over bolt and engage end of spring in hole in mounting plate.



32.35 *Assembling the mounting pivot.*

22. [] Using pliers to hold mounting plate by the tab that B-screw threads into, press mounting plate down until it is against upper end of mounting-pivot housing.
23. [] Holding mounting plate down, rotate derailleur clockwise until tab on mounting plate stops against tab on outside of mounting pivot-housing.
24. [] Carefully pull up mounting plate with pliers so that tab on outside of mounting-pivot housing can rotate clockwise past tab on mounting plate, then push mounting plate back in.



32.36 Loading the mounting pivot spring.

25. [] Insert clip in groove in mounting bolt.

In the next step, the B-screw position is restored. If it was not recorded or correct to start with, thread the B-screw in just enough to engage the threads. It will be adjusted when the derailleur is installed and adjusted.

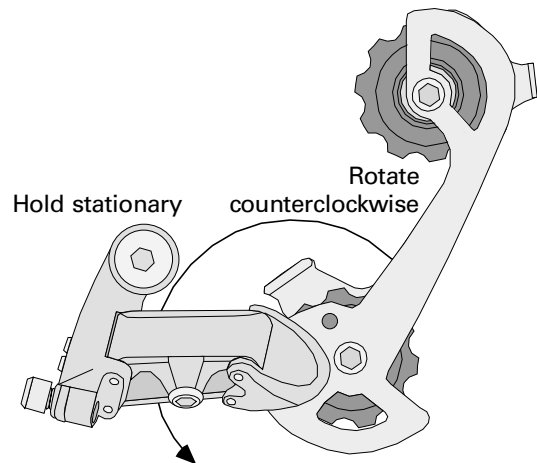
26. [] Put any plastic cover over mounting plate and thread in B-screw until protrusion equals measurement in step 6.

Assembling the cage pivot

27. [] Insert spring into cage-pivot housing and engage end of spring in hole. Make sure that end of spring with reduced-diameter coil is facing out of cage-pivot housing.
28. [] Put seal in place on outer face of outer plate, or on inward end of cage-pivot housing.
29. [] Place outer cage pivot into hole in cage-pivot housing.

Which cage hole the spring engaged should have been recorded in step #3. Facing the outer face of the outer cage plate, the most clockwise hole is the normal position that provides less tension for the cage-return spring. The most counterclockwise hole provides a high-tension setting for the return spring that compensates for age, small cogsets, and non-standard derailleur-hanger designs.

30. [] Rotate cage plate to align desired hole with end of spring and engage plate to spring.
31. [] Push outer cage plate firmly to end of cage pivot housing.
32. [] Except models where removal of 2mm Allen bolt disengaged cage from derailleur body, insert small Phillips screw from back, or cage-pivot bolt from front, to retain cage to derailleur body.
33. [] Holding derailleur *so that outer face is visible*, rotate outer cage plate counterclockwise until cage-stop pin or mounting hole for cage-stop screw clears tab on outside of cage-pivot housing. If cage-stop pin is still fixed to cage plate, cage plate will need to be pulled away from cage-pivot housing just enough to allow cage-stop pin to clear tab on cage-pivot housing.



32.37 Winding up the cage tension spring.

34. [] Thread in cage stop pin, or 2mm Allen screw into hole in bottom of cage-pivot housing.

DERAILLEUR-HANGER REPAIR

THREAD CHASING

Derailleur-hanger threads may be fouled with contaminants, or cross-threaded, leading to difficult installation of the derailleur-mounting bolt. To solve either, use a tap of the correct size (usually 10mm × 1mm) from the back side of the hanger to clean out the threads.

THREAD REPLACEMENT

There are several brands of thread-replacement coils. These work by enlarging the hole, tapping the hole to an over-size-thread description, and then using a tool that comes with the coil kit to insert a wire coil that matches the new thread description on the outside and creates a new set of original threads on the inside. The instructions that come with the kit should be adequate, and should differ depending on the brand of thread-repair kit being used. The following steps are generic, and may not exactly match the brand of kit being used.

1. [] **Drill or ream hole in hanger to 13/32" diameter.**
2. [] **Tap hole with oversize tap provided with kit.**
3. [] **Treat hole threads with heaviest grade of Loctite available.**
4. [] **Use tool that comes in kit to thread in coil from outer face of dropout, until end of coil is flush with outer face of hanger.**
5. [] **Remove coil-insertion tool.**
6. [] **Use diagonal side cutter to clip off excess coil length on back side of hanger.**
7. [] **Allow Loctite to cure before installing and securing derailleur.**

SLEEVE INSERTS

Sleeve inserts to repair damaged hanger threads are sleeve nuts that go into an enlarged hanger hole. At the time of this writing, the primary product available is the Wheels Manufacturing Dropout Saver (DS-1 and DS-2). When a sleeve insert is used, the hanger is basically being sandwiched between a nut on the inside face of the hanger and the derailleur on the outside face. The sleeve inserts are effective. The worst problem with them is a tendency for them to disappear when someone unfamiliar with the repair removes the derailleur at a later time. To perform the repair, the old threads should be drilled or reamed out to 15/32" diameter. The sleeve nut should be installed from the backside. Loctite RC680 can be used to reduce the likelihood of the sleeve nut falling out when the derailleur is not mounted, but this is no guarantee.

The nut should be held with a cone wrench while the derailleur-mounting bolt is being secured or loosened.

HANGER REPLACEMENT

A number of brands of bikes with aluminum dropouts now have replaceable hangers. These are entirely brand specific and cannot be used on any frame except the original one that they were designed for. The are usually held in place by small screws or bolts. The threads should be prepared with Loctite 222 or 242.

REAR-DERAILLEUR TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>The shift to the A cog is slow.</i>	
The H-screw is too tight.	Loosen H-screw; Look for rapid improvement if the H-screw is the source of the problem.
If the H-screw is not too tight, then the inner-wire tension may be too tight.	Turn in an adjusting barrel or let more inner wire through the pinch mechanism; expect instant improvement if inner-wire tension was the source of the problem.
If none of above, the B-screw may be too tight or the chain may be too short, causing the guide pulley to be too far below the A cog.	Check B-screw adjustment and chain length. Try setting chain at longest length that works to attempt to eliminate symptom.
If none of the above, the cable system may have too much friction.	Check for poor cable routing, housing damage, inner-wire damage, inner-wire rust, dirt on inner wires, or lack of lubrication.
If none of the above, the guide pulley may be worn out.	Check guide-pulley teeth and bushing for wear.
If none of the above, the chain may be worn out.	Check chain wear.
If none of the above, dirt may be fouling the cage and/or mounting pivot, the return spring, or the parallelogram pivots; causing the guide pulley to track too low below the cogset or the parallelogram to be hesitant to return to its outermost position.	Disassemble, clean, and lubricate the derailleur.
If none of the above, the derailleur may have too little return-spring force to pull the inner wire through the housing bends. This is most likely if the derailleur and shifter are not brand and model matched.	Try installing a spring over the inner wire between the rear-derailleur adjusting barrel and the pinch mechanism. Use a compression spring 1.75" long, with a 3/8" diameter, and .035 wire gauge (or larger).
Old-style Campagnolo pulley wheels with low-profile teeth are being used with a new-style low-profile chain that does not have side plates extending above the rollers.	Change pulley wheels to Shimano type.
SYMPTOM: <i>There is excessive noise when the chain is on the A cog.</i>	
If the guide pulley is offset inward of the A cog, then H-screw or inner-wire tension is too tight.	Check guide-pulley position, then loosen H-screw and/or inner-wire tension.
If the guide pulley is offset outward of the A cog, then H-screw too loose.	Check guide-pulley position, then tighten H-screw
If the guide pulley is close to centered under the A cog, check if the chain is rubbing against the B cog where the top section of chain goes forward to the chainrings. If this is the case, then the chainline is off or the chain is a wide chain being used on a narrow-spaced cogset.	Check chainline and chain/cogset compatibility
SYMPTOM: <i>The chain shifts past the A cog when shifting from the B cog.</i>	
The H-screw is too loose.	Tighten the H-screw until the symptom goes away.
If tightening the H-screw creates the symptom that the H-screw is too tight before the original symptom goes away, the guide pulley is too far below the cog.	B-screw adjustment is too tight, chain is too short, or the mounting and cage pivots are fouled with dirt.

(continued next page)

REAR-DERAILLEUR TROUBLESHOOTING (continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>The shift to the Z cog is slow.</i>	
The L-screw is too tight.	Loosen the L-screw 1/4 turn at a time. Rapid improvement should happen with very little adjustment.
If derailleur is indexing and the symptom only occurs when using the shift-control mechanism, inner-wire tension is too loose.	Tighten inner-wire tension with the adjusting barrel.
The chain is on the <i>H</i> chainring.	The shift combination should be avoided.
SYMPTOM: <i>There is excessive noise when the chain is on the Z cog.</i>	
If the guide pulley appears offset inward of the Z cog, the L-screw is too loose.	Tighten the L-screw.
If the guide pulley appears offset outward of the Z cog, the L-screw is too tight.	Loosen the L-screw.
If the guide pulley appears somewhat centered under the Z cog, then the B-screw may be too loose.	Tighten the B-screw.
If the B-screw cannot be tightened enough to eliminate the symptom, the chain may be too long.	Check if the chain can be shortened without creating a too-short condition.
If the B-screw cannot be tightened enough, the chain cannot be shortened, and adjusting the L-screw is no help, the maximum cog size capacity of the derailleur may have been exceeded.	Check derailleur capacity.
SYMPTOM: <i>The chain shifts past the Z cog when shifting from the Y cog</i>	
The L-screw is too loose.	Tighten the L-screw.
If the guide pulley appears far below the Z cog, and tightening the L-screw creates a slow shift, the B-screw is too tight.	Loosen the B-screw.
If loosening the B-screw does not move the guide pulley reasonably close to the cog, then the derailleur is being used on a cogset smaller than was intended.	Use cogset with larger cogs, change derailleur, or try changing the spring tension in the cage pivot.
SYMPTOM: <i>Some or all in-shifts are slow (rear derailleur is indexing).</i>	
Inner-wire tension is too low.	Turn adjusting barrel out.
Guide pulley is worn out.	Check guide-pulley teeth and bushing for wear.
Chain is worn out.	Check chain for wear and replace if necessary.
SYMPTOM: <i>Some or all out-shifts are slow (rear derailleur is indexing).</i>	
Inner-wire tension is too high.	Turn adjusting barrel in.
Guide pulley is worn out.	Check guide-pulley teeth and bushing for wear.
Chain is worn out.	Check chain for wear and replace if necessary.
Excess cable-system friction.	Check for poor cable routing, housing damage, inner-wire damage, inner-wire rust, dirt on inner wires, or lack of lubrication.
If symptom is progressively worse as the chain is shifted further and further out, the guide pulley may be too far below the cogs.	Check for too tight a B-screw, too short a chain, or dirt in the cage and mounting pivots. Correct any problem found.

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>The chain moves out two positions when the shift-control mechanism is moved one position.</i>	
Inner-wire tension is too low.	Turn adjusting barrel further out, or pull more inner wire through the pinch mechanism if the adjusting barrel is running out of threads.
Shift-control mechanism is not compatible with derailleur and/or cogset.	Check component compatibility and test shift again after replacing any suspect components.
The shift-control mechanism had already been released one position when chain wasn't moving, so it had actually been moved two positions.	Recheck the shift.
SYMPTOM: <i>The chain moves in two positions when the shift-control mechanism is moved one position.</i>	
Inner-wire tension is too high.	Turn adjusting barrel further in, or release more inner wire through the pinch mechanism if the adjusting barrel is running out of threads.
Shift-control mechanism is not compatible with derailleur and/or cogset.	Check component compatibility and test shift again after replacing any suspect components.
The shift-control mechanism had already been moved one position when the chain was not moving, so it had actually been moved two positions.	Recheck the shift.
SYMPTOM: <i>The chain will not move inward to the next gear when the shift-control mechanism is moved one position, or the shift-control mechanism must be moved two positions to get the chain to move inward one position.</i>	
Inner-wire tension is too low.	Turn adjusting barrel further out, or pull more inner wire through the pinch mechanism if the adjusting barrel is running out of threads.
Shift-control mechanism is not compatible with derailleur and/or cogset.	Check component compatibility and test shift again after replacing any suspect components.
Chain is badly worn out.	Check chain wear.
Chain and cogs are not compatible.	Check manufacturer's chain recommendations.
SYMPTOM: <i>With an indexing rear derailleur, the chain makes noise against the next cog inward after an in-shift to a specific cog, but not after making an out-shift to the same cog.</i>	
Excess cable-system friction.	Check for poor cable routing, housing damage, inner-wire damage, inner-wire rust, dirt on inner wires, or lack of lubrication.
Excess friction in the shift-control mechanism caused by wear, dirt, or lack of lubrication.	Test by temporarily installing a different shift-control mechanism. Service the shifter if the test eliminates the symptom.

(continued next page)

REAR-DERAILLEUR TROUBLESHOOTING (continued)

Cause	Solution
SYMPTOM: <i>At one cable-tension adjustment, the shifting acts as though the cable is too tight for some shifts, but acts as though the cable is too loose for other shifts.</i>	
Excess cable-system friction.	Check for poor cable routing, housing damage, inner-wire damage, inner-wire rust, dirt on inner wires, or lack of lubrication.
Incorrect inner wire for shift-control mechanism.	Check inner-wire compatibility.
Distance from face of derailleur hanger to face of first cog is too great.	Reduce axle spacing to move first cog as close as possible to the dropout without chain-to-frame interference.
General system congestion from dirt.	Clean cogs, chain, inside and outside of . derailleur, and inside shift-control mechanism.
General component incompatibility.	Check that shift-control mechanism, derailleur, and cogset are all compatible.
General system wear.	Check chain wear, guide-pulley wear, and derailleur-pivot wear.
SYMPTOM: <i>The chain shifts out one position on its own when the shift-control mechanism is not being operated.</i>	
If derailleur is indexing, inner-wire tension is too low.	Check and adjust inner-wire tension by turning adjusting barrel out.
If derailleur is friction-type, shift-lever friction is too light.	Adjust shift-lever friction.
SYMPTOM: <i>When testing the FRA, the acceptable range is very narrow.</i>	
Parts are dirty.	Clean drive train, derailleur, and shift-control mechanism.
Parts are worn out.	Check chain wear, guide-pulley wear, or derailleur-pivot wear.
Excess cable-system friction.	Check for poor cable routing, housing damage, inner-wire damage, inner-wire rust, dirt on inner wires, or lack of lubrication.
Non-compatible chain is being used.	Check chain compatibility.
Non-compatible guide pulley is being used.	Use only manufacturer's original pulley.
Non-compatible cable system is being used.	Use only high-quality indexing inner wires of the correct diameter, and compressionless housing.
Shift-control mechanism is not compatible with derailleur or cogset.	Check manufacturer's specifications for compatible components.

SHIMANO RAPID-RISE DERAILLEURS

OVERVIEW

Shimano Rapid-Rise rear derailleurs differ from others in that they move outward when the cable is pulled, and move inward by means of the parallelogram spring when the cable tension is released. Their motion is the opposite of conventional derailleurs.

For many purposes, these derailleurs are no different to install, adjust, or service than regular derailleurs, but some of the sequences in which things are done need to be changed to make the procedures easier. The following procedure is very generalized for the purpose of illustrating the correct sequence to go through derailleur setup and adjustment. The assumption of this procedure is that you are already familiar with all the details of proper setup and adjustment as they are done on conventional derailleurs.

RAPID-RISE PROCEDURES

Derailleur, cable, and chain installation

1. [] Align hanger, lubricate derailleur and install.
2. [] With derailleur at rest under Z cog, pull down on derailleur cage to allow upper pulley to clear cog, then preset L screw so pulley is centered under cog.
3. [] Pull outward on derailleur to move upper pulley under A cog, then check if pulley stops centered under cog and preset H screw as necessary.
4. [] With upper pulley pulled out to A cog and parallelogram positioned parallel to chain stay, size housing loop to rear derailleur.
5. [] With derailleur at rest position under Z cog (pull down on cage if upper pulley catches against outer face of cog), install cable system, pull slack out of cable with fingers, then secure pinch mechanism.
6. [] Using shift mechanism, move derailleur so upper pulley is under A cog, then install and size chain normally.

Limit screw and indexing adjustments

7. [] To set H screw, use shifters to put chain in Z/H combo, then pull on exposed wire to shift chain from B to A cog. Adjust limit normally, but pull on cable to check shift to A instead of releasing cable.

8. [] To set L screw, use shifters to put chain in Z/M combo (Z/L if double chainring), then pull on exposed wire to shift chain from Z to Y cog. Adjust limit normally, but release cable to check shift to Z instead of pulling cable.

Setting the cable tension and adjusting the indexing are where the most significant differences between Rapid-Rise and conventional derailleurs are found. Everything involving the cable is exactly reversed with Rapid-Rise. Consequently, the slack is removed when the chain is on the Z cog instead of the A cog. Less obvious is the fact that when the indexing is adjusted, the adjusting barrel should always be turned the opposite way from normal to correct any symptom.

9. [] Use shifter to put chain on Z cog, then pull on exposed inner wire while pedaling until chain reaches A cog, then stop pedaling and stress cable system.
10. [] Pedal until chain returns to Z cog, then release pinch mechanism, set adjusting barrels, pull slack from inner wire, and secure pinch mechanism.

As always, the best indexing adjustment is the tightest good setting. With Rapid-Rise, however, the tightest good adjustment is one just short of the point where the chain tends to shift outward one cog if the cable is tightened further (opposite of normal).

11. [] Adjust indexing to tightest good setting, turning adjusting barrel out (ccl) to improve shifts outward and in (cl) to improve shifts inward (opposite of adjusting conventional derailleur).

EIGHT- AND NINE-SPEED COMPATIBILITY

Because nine-speed derailleurs have the same actuation ratio (the amount the derailleur moves for a specific amount of inner-wire travel) as derailleurs that are not nine-speed, they are technically acceptable to mix. However, Shimano made other changes coincidental with introducing nine-speed systems that also affect interchangeability. The primary concern is the derailleur capacity. Most Shimano nine-speed MTB derailleurs work with up to a 34T rear cog. Most pre-nine-speed derailleurs have a maximum capacity of 32T. Consequently, if the bike has a nine-speed cog set with a 34T cog, a nine-speed derailleur must be used. Otherwise, there are no derailleur compatibility issues.

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When replacing pulley wheels, it is important to be aware that there are nine-speed-specific pulleys. The significant difference is not the thickness of the pulley, but the number of teeth. Using a pulley wheel with the wrong number of teeth can adversely affect the capacities of the derailleur. If the teeth numbers match, the pulleys are generally compatible.

33 – FRONT DERAILLEURS

ABOUT THIS CHAPTER

This chapter is about installing, adjusting, and servicing front derailleurs. The procedures for installation and adjustment make references to installing the chain, shifter, and cable. These items are covered in the **CHAINS, SHIFT-CONTROL MECHANISMS**, and **DERAILLEUR-CABLE SYSTEMS** chapters.

The front derailleur procedure assumes that the rear derailleur is already installed. The rear derailleur need not be precisely adjusted, but must be able to move the chain to the innermost and outermost cogs. It may seem like a good idea to install and adjust the rear derailleur first, because of this. However, the rear-derailleur procedure requires that the front derailleur be able to shift the chain to the innermost and outermost positions, as well. Whichever is done first, to complete one derailleur adjustment it is necessary to do at least some preliminary work on the other derailleur.

There is some confusing and contradictory terminology used regarding derailleurs, so be sure to review the terminology section to become clear on the terms used by *this* book.

GENERAL INFORMATION

TERMINOLOGY

High gear: On front derailleurs, high gear refers to the chainring furthest from the frame. It is called high gear because using it results in the highest number when calculating gear ratios, not because the top of this chainring is higher than the other chainrings (as is commonly assumed). These two explanations of the term are consistent with each other, but if this same system is used with rear gears it can be confusing. For this reason, this book will always use the more wordy alternative, *outermost chainring*, or a letter code that is described in **NAMING COGS AND GEAR COMBINATIONS** (page 33-2).

Outermost chainring: The one that has the most teeth and is furthest from the frame.

Top gear: Same as *high gear*.

Low gear: On front derailleurs, low gear refers to the chainring closest to the frame. It is called low gear because using it results in the lowest number when cal-

culating gear ratios, not because the top of this chainring is lower than the other chainrings (as is commonly assumed). These two explanations of the term are consistent with each other, but if this same system is used with rear gears it can be confusing. For this reason this book will always use the more wordy alternative, *innermost chainring*, or a letter code that is described in **NAMING COGS AND GEAR COMBINATIONS** (page 33-2).

Bottom gear: Same as *low gear*.

Innermost chainring: The one that has the least teeth and is closest to the frame.

Limit screws: Adjustable stops that are used to stop the inward and outward motion of the derailleur at points that enable the chain to shift to the innermost and outermost chainrings without going too far.

H-screw: A limit screw for stopping the derailleur from shifting the chain out past the outermost chainring.

L-Screw: A limit screw for stopping the derailleur from shifting the chain in past the innermost chainring.

Derailleur cage: The assembly that surrounds and moves the chain.

Outer plate: The plate in the derailleur cage that is on the outward side of the chain.

Inner plate: The plate in the derailleur cage that is on the inward side of the chain.

Cage or plate tail: The rear end of the derailleur cage or of one of the cage plates.

Cage or plate nose: The front end of the derailleur cage or of one of the cage plates.

Parallelogram: In regard to the front derailleur, this is the part of the body (consisting of two arms on four pivots, between the mounting clamp and the cage) that moves the derailleur cage inward and outward.

Adjusting barrel: A hollow screw in the shift-control mechanism (and rarely, in the derailleur) that the inner wire passes through and the housing stops against. As it is screwed in and out, the relative length or tension of the cable system is changed.

Pinch mechanism: This is the mechanism that attaches the inner wire to the derailleur. The inner wire is usually routed through a groove in a plate on the derailleur, and a bolt or nut presses a washer or plate on top of the inner wire to trap and compress it in the groove. The groove in the plate is often hidden by the pressure washer/plate.

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Indexing: The type of shifting in which the shift mechanism moves in distinct increments. These increments are designed to precisely move the chain from one chainring to the next. Indexing has virtually replaced friction shifting. In friction shifting, the lever moves smoothly over its full range of motion without any incremented stops. It is up to the operator to decide what the correct amount of lever motion is to get from one chainring to the next.

Mounting bolt: This is the bolt through the derailleur clamp that attaches the derailleur to the seat tube.

Return spring: A spring inside the parallelogram that causes the derailleur to move in as far as the inner-limit screw will allow, when the tension on the inner wire is released.

Over-shift: When the chain moves too far to shift to, and align with, the intended chainring.

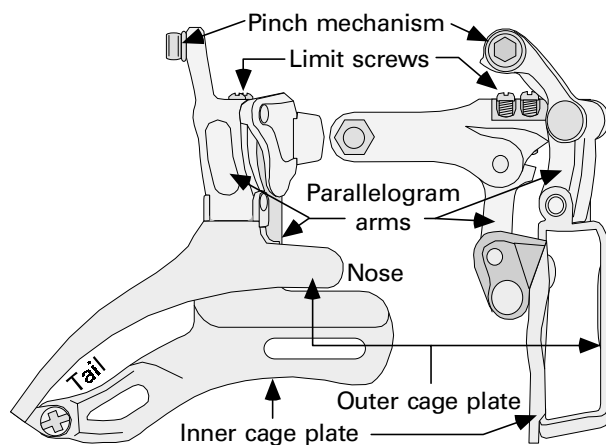
Under-shift: When the chain does not move far enough to shift to, and align with, the intended chainring.

In-shift: A shift to a chainring that is further inward than the one that the chain is currently on.

Out-shift: A shift to a chainring that is further outward than the one that the chain is currently on.

Up-shift: This is a term that will *not* be used, because it is an imprecise phrase.

Down-shift: This is a term that will *not* be used, because it too is imprecise.

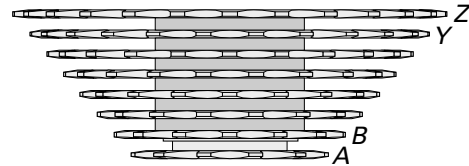


33.1 Back and face views of a front derailleur.

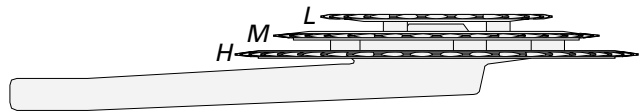
NAMING COGS AND GEAR COMBINATIONS

To perform certain adjustments, the chain needs to be in certain gear combinations. Numbering the gears to identify them does not work, because rear-cog sets have between 5 and 8 gears (so the innermost could be called 5, 6, 7, or 8), and cranksets have between 1 and 3 chainrings (so the innermost might be called 1, 2, or 3).

To avoid confusion, gears will be assigned codes as shown in figures 33.2 and 33.3 (below).



33.2 "A" is always the outermost cog. "B" is always the next-to-outermost cog. "Y" is always the next-to-innermost cog. "Z" is always the innermost cog.



33.3 "H" is always the outermost chainring. "M" is always the middle chainring of a triple. "L" is always the innermost chainring.

Using the above diagrams, it should be easy to conclude that putting the chain in a gear combination of A/M would place the chain in the outermost position in the rear, and the middle position of a triple crank. Y/L would mean the chain was in the next-to-innermost position in the rear and the innermost in the front.

PREREQUISITES

Shifter and cable installation

In order to adjust the front derailleur, the shift-control mechanism and cable system must be installed.

INDICATIONS

Maintenance

Dirt and wear both affect derailleur performance.

Dirt in the parallelogram can affect shifts. This can be cleaned by immersing the fully-assembled derailleur in solvent, which can quickly remove the dirt.

Wear can adversely affect the parallelogram pivots. When the pivots are worn out, the derailleur must be replaced.

Changing chainrings, right crank arm, or bottom bracket

Any time a chainring, the right crank arm, or a bottom bracket is changed, it is necessary to check the front derailleur adjustment.

Changing chain

Whenever a chain is replaced, shift performance is affected. Fresh chains have less lateral flexibility than worn chains. Different chains have different performance characteristics. After replacing a chain, the derailleur should be checked and readjusted if necessary.

Symptoms indicating adjustment is needed

There are a number of symptoms indicating a probable need for derailleur adjustment.

If the derailleur under- or over-shifts when shifting to the *H* chainring, or the cage rubs the chain while on the *H* chainring, the front-derailleur H-screw may need adjustment, or the derailleur height and rotation may be wrong.

If the derailleur under- or over-shifts when shifting to the *L* chainring, or the cage rubs the chain while on the *L* chainring, the front-derailleur L-screw may need adjustment, or the derailleur height and rotation may be wrong.

If any shift feels hesitant or results in the cage rubbing the chain after the shift is completed, the indexing needs adjustment.

Symptoms indicating derailleur service is needed

If the derailleur is dirty and the inward action is sluggish, the derailleur should be removed and cleaned, then installed and adjusted.

Symptoms indicating derailleur replacement is needed

The inner plate of the cage can get gouged and worn out from trying to shift when the derailleur is not properly adjusted. If the inner cage plate is gouged or scarred in any way, the derailleur should be replaced.

The derailleur cage can get bent from abusive shifting, crashes, or failure to secure the derailleur. Minor bends can be realigned, but sometimes the derailleur needs to be replaced.

Parallelogram pivots wear out, resulting in excess play in the derailleur. This excess play would show up by wiggling the tail of the cage in and out.

TOOL CHOICES

Table 33-1 (below) shows most of the tools available for front-derailleur adjustment. Most of them are the same tools used for rear derailleurs. Preferred choices are shown in **bold** type. These highlighted tools are recommended because of a balance among: ease of use, versatility, durability, and economy.

TIME AND DIFFICULTY

Front-derailleur adjustment, including hanger alignment and cable-system setup, is a 12–16 minute job of moderately-high difficulty. Front-derailleur removal, cleaning, installation, and adjustment is a 25–30 minute job of moderately-high difficulty.

COMPLICATIONS

Wobbling chainrings

Wobbling chainrings make it difficult to find a limit-screw setting that enables the shift, without ending up with the chain rubbing on the derailleur cage.

FRONT-DERAILLEUR TOOLS (table 33-1)

Tool	Fits and considerations
CAGE ALIGNMENT	
Park BT-3	Actually a brake tool for aligning caliper arms, this tool works well for bending the front-derailleur cage.
FOURTH-HAND (CABLE TENSION) TOOLS (These tools are same as those used for rear derailleurs and brakes.)	
Dia-Compe 556	Tends to let inner wire jam in tool
Hozan C356	Tends to let inner wire jam in tool
Lifu 0100	Consumer tool
Park BT-2	Least tendency for inner wire to jam in tool
VAR 233	Tends to let inner wire jam in tool

Chainring wobble can be caused by a number of things. It could be a loose bottom bracket, mis-mounted crankarm, mis-aligned chainring-mounting arms, or bent chainrings. Before adjusting the limit screws, the chainring wobble must be checked and whatever the problem (if any) must be fixed.

Component compatibility problems

See **COMPONENT COMPATIBILITY** (below), for the numerous complications you might encounter.

Damaged derailleur

Bent derailleur cages are fairly common, but not always obvious. It is not unusual to spend time adjusting the derailleur, only to find that it will never work well due to cage damage.

Worn components other than derailleur

Worn chains, chainrings, cables, and shift controls can all affect derailleur adjustment. It is usually not until the attempt to adjust the derailleur fails, that these other factors will get considered, resulting in duplication of effort to adjust the derailleur. If out-shifts are the problem, chainring-tooth wear should be checked.

Derailleur wear

Derailleur wear can be difficult to detect. The parallelogram pivots develop wear. This wear cannot be quantified or seen, except by comparing free play at the tail of the derailleur to a new one of the same model.

Dirty drive train

Dirt in the chain, cable system, shift-control mechanism, and chainrings can affect shift performance. Adjusting a derailleur (particularly an indexing one), without cleaning the related components, is a waste of time.

COMPONENT COMPATIBILITY

It is always best to follow manufacturer's recommendations when selecting components. When non-compatible components are used together, it is likely to show up as a shifting problem. Not all such problems are immediately obvious. If using unmatched components, do not assume that there are no compatibility problems until the indexing has been checked. There is a section in this chapter that explains how to test indexing performance.

Derailleur and shifter

With indexing systems, compatibility between the shifter and derailleur is critical. This is because an indexing shifter will pull a very specific amount of cable for each click. The derailleur must move a very spe-

cific distance in order to line up with the next chainring. If the amount of cable moved is wrong, the derailleur will move the wrong distance.

The shifter and derailleur should be brand-matched, whenever possible. There are, however, a few after-market shifter controls that are made specifically for a different brand of derailleur. Grip Shift controls made for Shimano derailleurs are the most common example.

Even within the same brand, there may be problems. For example, Shimano Dura-Ace shift controls and derailleurs are not compatible with other models of Shimano equipment.

Inner wire and shifter

The inner wire must be compatible with the shifter because it is the combination of the shifter-drum diameter *and* the inner-wire thickness that determines how much cable is moved for a given amount of lever motion. See **SHIFT-CONTROL MECHANISMS** (page 30-2) for more information on shifter and inner-wire compatibility.

Derailleur and seat-tube size

Derailleurs come with a variety of clamp sizes to fit a variety of seat-tube sizes. Some seat tubes have a fitting built into the side of the seat tube that the derailleur attaches to. This "braze-on" fitting is virtually universal, but requires a specially-designed derailleur.

The common seat-tube sizes are 1" (25.4mm), 1.125" (28.6mm), 1.25" (31.8mm), and 1.375" (34.9mm). The two middle sizes are most common. The 1.125" size is found on most steel frame bikes, except MTBs with over-size tubing. The 1.25" size is found on most MTB's and frames made of materials other than steel. The rarer 1" size is found on inexpensive bikes sold in department stores and on old Schwinn's. The 1.375" size is found on just a few bikes with extremely oversized tubing.

Maximum chainring-size difference

Every derailleur is rated for the largest size difference between chainrings that can be tolerated. This is called the derailleur's *maximum capacity*. The maximum capacity represents the greatest differential that can exist between the number of teeth on the smallest chainring and the largest chainring being used. When this capacity is exceeded, the chain will drag on the bottom of the derailleur cage, when the chain is in the A/L position. The rated capacity can sometimes be exceeded, and there are times when the full rated capacity cannot be used. The rating is based on an assumption of the angle between the seat tube and the line from the center of the bottom bracket to the cen-

ter of the rear wheel. If this angle is less than the assumption (shallow seat-tube angle or low bottom bracket), then the capacity can be exceeded. If this angle is more than the assumption (steep seat-tube angle or high bottom bracket), then the full rated capacity might not be available to use.

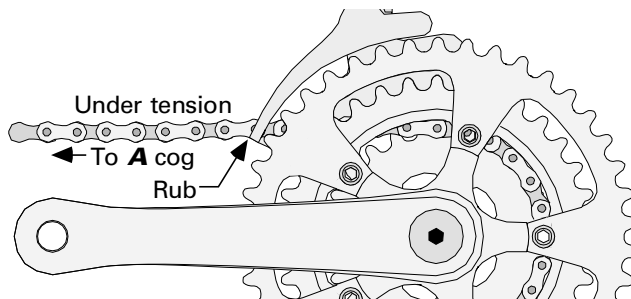
Ratings for derailleurs can be determined in several ways.

Manufacturer’s literature: There is often an instruction sheet that comes with a new derailleur. This instruction sheet normally includes the ratings for the derailleur. Some manufacturers will supply literature on request.

Sutherland’s Handbook for Bicycle Mechanics: This book includes ratings for a wide variety of derailleur models, but is up-to-date for only a brief time after publication. It is particularly useful if trying to figure out the capacity of an older-model derailleur.

Bike’alog: This computerized source reference for bicycle parts has capacity information for many currently-available models of derailleurs.

Test method: To test if a derailleur’s maximum capacity is being exceeded, follow this procedure. Install the derailleur at the correct height, and put a chain through the cage from the top of the innermost chainring to the top of the outermost rear cog. Pull the chain tight. If the chain drags on the cross-piece at the tail of the derailleur cage, then the maximum capacity has been exceeded. It is not meaningful if a slack chain dangles and touches the cross-piece that connects the cage plates together at the tail of the derailleur cage.



33.4 The chain drags on the cross-piece of the tail of the derailleur cage if the maximum capacity of the derailleur is exceeded.

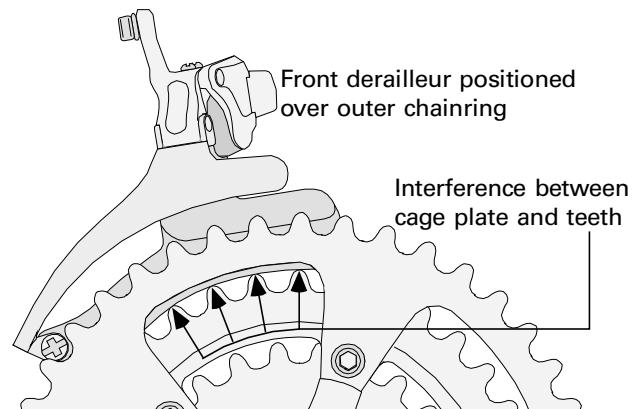
Minimum chainring-size difference

For every derailleur there is a minimum difference between the size of the outermost chainring and the next chainring inward. This is a rare problem, but it is important to be aware of it. On most bikes, the differ-

ences between chainrings are usually ten teeth or more. Since most derailleurs have a minimum capacity of eight or ten teeth, minimum capacity is rarely an issue.

It *does* show up as an issue when a bike is equipped with a “half-step” gear selection. Half-step gearing gets its name from the fact that changing from one chainring to another results in about half the change in gear ratio that results from changing from one rear cog to an adjacent rear cog. When the chainrings are a half-step configuration, they will have a difference only of 4–6 teeth between the outermost chainring and the next one in. If the chainrings are set up like this, it is important to check the front derailleur’s minimum capacity. Derailleurs that are described as “alpine” or “cross-over” are never suitable for use with half-step chainrings.

Some compact drive chainring sets that have an 8-tooth difference between a large chainring with 42 teeth have and a middle chainring with 34 teeth. Many MTB derailleurs are not suitable for this 8-tooth difference.



33.5 The bottom edge of the inner cage plate interferes with the teeth of the middle chainring on a triple crankset when the minimum capacity has been violated.

Ratings for derailleurs can be determined in several ways.

Manufacturer’s literature: There is often an instruction sheet that comes with a new derailleur. This instruction sheet normally includes the ratings for the derailleur. Some manufacturers will supply literature on request.

Sutherland’s Handbook for Bicycle Mechanics: This book includes ratings for a wide variety of derailleur models, but is up-to-date for only a brief time after publication. It is particularly useful if trying to figure out the capacity of an older-model derailleur.

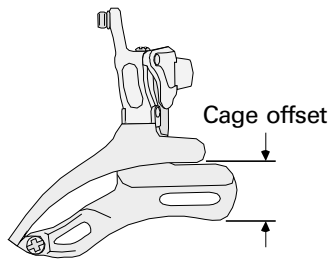
Bike’alog: This computerized source reference for bicycle parts has capacity information for currently-available models of de-

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raillleurs. Instead of numerical ratings, there may simply be a reference to “alpine,” “cross-over,” or “half-step.”

Test method: To test if a derailleur’s minimum capacity is being exceeded, follow this procedure. Install the derailleur to the correct height on the seat tube. Swing the derailleur out far enough that the inner plate swings over the top of the next-to-outermost chainring. If the inner plate clears, then the minimum capacity has not been exceeded.

Measurement method: If the bottom edge of the inner cage plate is never more than 10mm below the bottom edge of the outer cage plate, then the derailleur is half-step compatible. If the offset is greater than 10mm at any point, then the derailleur cannot be used with half-step chainrings.



33.6 Measure cage-plate offset here.

Derailleur and chainring-set position

It is possible for the chainring set to end up too close to the frame for the front derailleur to work. This can happen even though chainline is acceptable and chainring-to-frame clearance is adequate. When the chainrings are too close to the frame, the moving part of the derailleur may bump into the seat tube or itself before the cage has moved enough to complete the shift. The best solution to this is to change the bottom bracket to move the chainrings as far out as the chainline will allow. At times, it may be necessary to re-space the rear hub *and* move the chainring set, so that the chainrings and rear cog set can both be moved out together to maintain the chainline.

Derailleur and chain

Indexed derailleurs moved in fixed amounts. The chain must respond as expected for the shift to be completed. If the chain has more lateral flexibility than expected, when the derailleur moves its fixed amount, then the chain will not respond enough to complete the shift. Chains vary in lateral flexibility because of

brand differences and wear. If the derailleur manufacturer’s recommendations are not followed, shift performance may be compromised.

Chain and chainrings

The width of a chain must be suitable to the chainring set or it may rub against adjacent chainrings. See the **CHAINS** chapter (page 26-2 and 26-16).

The shaping of the side plates of the chain affects a chain’s ability to engage the chainring’s teeth. When not using the manufacturer’s recommended chain, shift performance may be compromised.

UNDERSTANDING HOW FRONT DERAILLEURS WORK

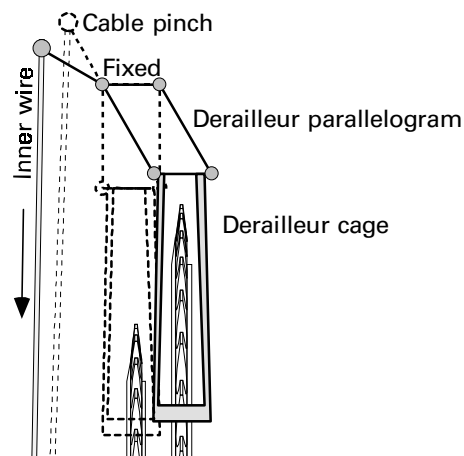
The operation of a front derailleur is relatively complex. By understanding what is happening in a front derailleur, the installation and adjustment procedures outlined here will become clearer.

How a cable moves the derailleur in and out

Most shift-control mechanisms operate by pulling the inner wire through one or more lengths of housing. The mechanism takes up excess inner wire and pulls the derailleur to its outermost position. Figure 33.7 shows this in a simplified form.

The piece of exposed wire closest to the derailleur is attached to an arm that serves as an extension of one of the parallelogram arms. When this lever is rotated about its pivot, the whole parallelogram structure changes shape so that it expands or contracts, moving the derailleur cage out or in.

When the tension on the cable is released, a spring in the parallelogram causes it to return toward its original position.

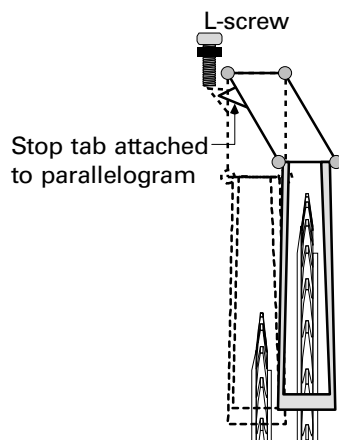


33.7 How a derailleur parallelogram is deformed across its diagonal, to deflect it laterally to a more outward position.

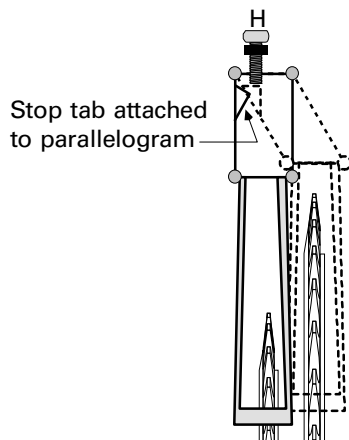
How limit screws work

The two limit screws act like two adjustable barricades. There is usually some projection or surface on a parallelogram arm that the limit screw butts up against. By adjusting one limit screw, the range of travel for the parallelogram in one direction will be changed. In other words, by loosening the H-screw, the barricade that stops the outward motion of the parallelogram is changed so the parallelogram can move further out. By loosening the L-screw, the barricade that stops the inward motion of the parallelogram is changed and the derailleur can move further in.

Changing one limit screw does not affect the other. Changing the H-screw setting only changes the shift to the outermost cog. Changing the L-screw only changes the shift to the innermost cog. Figures 33.8 and 33.9 show a simplified and exaggerated model of how limit screws affect the range of motion of the parallelogram.



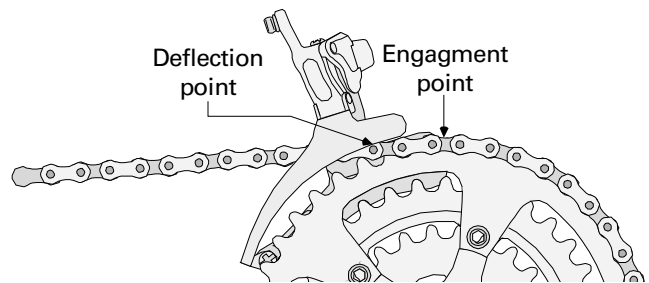
33.8 A stop tab attached to the parallelogram bumps into the H-screw to stop the derailleur's outward motion.



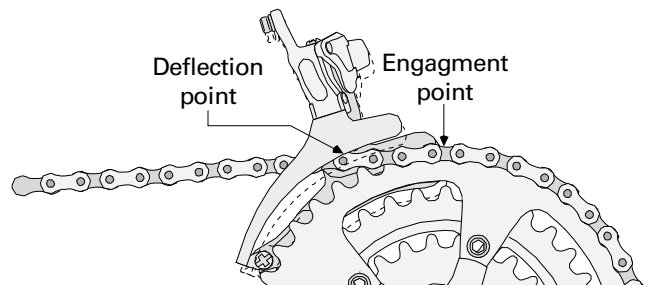
33.9 A stop tab attached to the parallelogram bumps into the L-screw to stop the derailleur's inward motion.

The importance of derailleur height

One of the most important factors affecting front shifting performance is the distance from the derailleur cage to the chainrings. Consider the point that the cage pushes on the chain to be the *deflection point* (see figure 33.10). Consider the point that the chain engages the chainring to be the *engagement point* (see figure 33.11). The engagement point is always at the top dead center of the chainring; it never moves. As the derailleur moves up, the deflection point on the chain moves further back in the derailleur cage. Consequently, as the derailleur moves up, the distance between the engagement point and the deflection point increases. The greater this distance is, the more derailleur motion is needed to deflect the chain enough to cause it to disengage one chainring and engage another. Figures 33.10 and 33.11 show in an exaggerated fashion how moving the derailleur up increases the distance from the engagement point to the deflection point.



33.10 With the derailleur at the recommended height, the deflection point is only two and a half links behind the engagement point.



33.11 Note how the deflection point has moved to three and a half links behind the engagement point now that the derailleur height has moved up.

What happens when the derailleur shifts the chain from the outermost chainring inward to the next chainring

Before reading this, put a bike in the stand and shift the chain off of the outermost chainring. As you shift, turn the crank very slowly and move the de-

railleur in very slowly. Observe exactly what is happening with the chain and derailleur cage for the duration of the shift.

When the derailleur moves inward, the nose of the outer plate deflects the chain just behind the engagement point. Since the distance between the deflection point and the engagement point is very small, only minimal cage motion is needed to cause the chain to derail to the inside of the outermost chainring.

Once the chain disengages from the outer chainring, it is moving inward. Something has to stop the chain from moving too far. That is accomplished by the inner plate of the cage. The rest position of the inner plate is determined either by the derailleur's L-screw on a double-chainring set, or by the indexing adjustment of the cable on a triple-chainring set. If either the L-screw or the cable-tension adjustment is too loose, then the derailleur cage will move too far inward.

After the nose of the outer plate starts the chain derailment and inward motion, two things can add to this inward motion. One is the angle of the chain coming from the rear cogs, and the other is the motion of the tail of outer plate.

Chains naturally want to run straight, rather than in the S-shaped curve that is required when the chain is on two gears that are not in line with each other. When the chain is on an inward cog in the rear, and the chain gets released from the chainring, it tries to straighten itself out. This straightening tends to move the chain inward. The opposite is true if the chain is on one of the outermost cogs when the shift in from the outermost chainring occurs. Since the chain is fixed to a rear cog that is already further out than to where the chain is being pushed, the tendency of the chain to straighten out actually resists the inward motion of the chain. Consequently, when a chain is on an inward cog in the rear, the inward shift of the chain in front is enhanced; when the chain is on an outward cog in the rear, the inward shift of the chain is restricted. Whenever chainline is off, one of these two tendencies becomes exaggerated. If the chainrings are too far out relative to the rear cogs, then the chain has a tendency to shift too far in the front, when being shifted in. If the chainrings are too far in relative to the rear cogs, then the chain resists inward shifts in the front.

The tail of the outer cage plate also affects the inward motion of the chain. When the in-shift starts, the chain is high on the outermost chainring and is being pushed by the highest, most forward, part of the outer plate. Once the chain derails, the chain begins to drop to the smaller chainring. At this point, it

is lower and further back in the derailleur cage. This is when the motion of the tail of the derailleur cage affects the shift inward from the outermost chainring.

Two things determine the range of motion of the tail of the outer plate. One is the L-screw setting (double-chainring sets) or cable tension (triple-chainring sets). The less the whole mechanism is allowed to travel inward, the less the outer plate will move. The primary function of the L-screw or cable tension setting, however, is to position the inner plate so that it will stop the chain from moving too far.

The second factor that influences the inward range of motion of the outer plate is the shape of the derailleur cage. If the tail of the cage is wide, the tail of the outer plate will not end up as far in when the inner plate arrives at its innermost position. If the tail of the cage is narrow, the tail of the outer plate will end up further inward when the inner plate stops at the same point. The width of a derailleur-cage tail can be modified by bending the plates or by changing spacers between the tail ends of the two plates.

What happens when the derailleur shifts the chain from a middle chainring to the innermost chainring

Before reading this, put a bike in the stand and shift the chain from the middle chainring in. As you shift, turn the crank very slowly and shift the derailleur in very slowly. Observe exactly what is happening with the chain and derailleur cage for the duration of the shift.

This is a more difficult shift than the shift from an outer chainring to a middle or inner chainring. The reason is that the top of the middle chainring is much further below the derailleur, so the deflection point is way back on the outer cage plate. This difference is what led Shimano to redesign their chainring teeth to make it easier for the chain to derail inward. This way, the outer plate does not have to move as far to achieve chain derailment.

Other than the fact that this shift naturally demands more of the derailleur, the principles are the same as the shift from the outer chainring.

What happens when the derailleur shifts the chain out to the outer chainring

Before reading this, put a bike in the stand and shift the chain from the next-to-outermost chainring out. As you shift, turn the crank very slowly and move the derailleur cage out slowly. Observe exactly what is happening with the chain and derailleur cage for the duration of the shift.

With this shift, the inner plate moves the chain and the outer plate prevents it from going too far. The shift starts when the tail of the inner plate contacts the chain and pushes it outward. The next thing to happen is that the teeth of the outer chainring (at about the 10:00 position), begin to catch the chain, causing it to rise. As the chain begins to rise, it moves in the derailleur cage and the deflection point moves forward. The nose of the inner plate completes the shift by pressing the chain the rest of the way onto the chainring, close to the engagement point. Because of the short distance between the nose of the inner plate and the engagement point, small changes in the nose position can make big differences in shift performance. Although it is the tail of the inner plate that begins the shift, the final position of the nose of the inner plate is the most critical factor affecting the completion of the shift to the outermost chainring.

Two factors influence the final position of the nose of the inner plate. These are: the H-screw setting and the width of the nose of the cage.

When the H-screw is set, it determines the range of motion of the entire cage. The function of this screw is to position the outer cage plate close enough to the outer chainring so that it is impossible for the chain to move out past the chainring. Consequently, the H-screw cannot be used to adjust the final position of the nose of the inner plate.

Unlike in-shifts, the width of the tail is relatively unimportant to out-shifts. It is the cage width at the nose that is the most important factor. This is controlled by toeing the nose of the inner plate. The final position of the nose of the inner plate is adjusted by bending the nose towards or away from the chain. This is called *toeing* the nose. These days, most derailleurs already come with a good amount of toe, but toeing can be used to speed up the shift to the outer chainring anytime it is sluggish.

Chain angle and load on the chain dramatically affect this shift. As in the case of in-shifting, the position of the chain in the rear affects the tendency of the chain to move one direction or the other. When the chain is in an inward position in the rear, it resists outward motion at the chainrings. When the chain is in an outward position in the rear, it encourages the outward motion of the chain. Load is important because the rising teeth on the chainring being shifted to must help the chain rise by just brushing against the chain. When there is load on the chain, it keeps the chain down.

What happens when the derailleur shifts the chain from an inner chainring to a middle chainring

Before reading this, put a bike in the stand and shift the chain from the innermost chainring to the middle chainring. As you do this, turn the crankset very slowly and move the derailleur cage out slowly, and observe exactly what is happening with the chain and derailleur cage for the duration of the shift.

Like the shift to the outermost chainring, this shift is initiated by the contact of the tail of the inner plate to the chain. This occurs at a considerable distance from the engagement point. Consequently, a great deal of lateral motion is required to move the chain enough to engage the middle chainring. As in the case of a shift to the outermost chainring, the teeth of the middle chainring intersect the chain, and cause it to rise. Unlike the shift to the outermost chainring, the chain never rises enough to engage the nose of the inner plate. This means that the deflection point never gets very close to the engagement point. The only way to keep the chain moving out is to move the inner plate outward more. Consequently, a lot more outward motion is required to shift out to a middle chainring than is required to shift out to an outer chainring. This is perhaps the most demanding shift for a front derailleur to make.

The amount of outward motion of the cage is controlled by the operator on a friction system. It is controlled by the cable-tension adjustment on an indexing system. It is the difficulty of this shift that led Shimano to develop the HyperDrive chainring design, which features an extra set of teeth on the inner face of the middle chainring. These extra teeth help pick up the chain. The HyperDrive chainring's primary teeth are also designed to make it easier for the chain to engage.

The importance of the rotational alignment of the cage

Rotational alignment of the derailleur cage (adjusted by rotating the derailleur mount around the seat tube), controls two important things. It affects the relative angles of the cage plates to the chain, and it affects the relative width of the cage.

Rotational alignment affects the relative angle of the cage plates to the chain. This is most critical when looking at the relationship between the chain and the outer cage plate, when the chain is on the large chainring. If the chain is on an outer rear cog, the outward motion of the chain is enhanced; the chance of the chain shifting out past the outer chainring is at

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its greatest. Consequently, it is at this time that it is most important to keep the nose of the outer plate as close to the outer chainring as possible. The chain angles out to the outermost cog. The outer plate should remain in a position so that it stays parallel to the chain when the chain is on the outermost chainring and rear cog. Make certain that the outer plate is parallel to the chain, and not the chainrings. Otherwise, there will be large gap between the chain and the nose of the outer plate at the point the chain just clears the tail of the cage. This reduces the effectiveness of the outer plate in preventing an over-shift.

Rotational alignment also affects the effective width of the derailleur cage. Think of the opening in the back of the cage like a window opening in a wall. If you are facing the wall directly and the window is right in front of you, then the full width of the window is apparent, and it would be relatively easy to throw a ball through the window. On the other hand, if the wall is rotated so that you are no longer facing the window squarely, its apparent width is reduced, and it becomes much more challenging to throw the ball through the opening. When a derailleur cage is not rotated correctly, it is effectively narrower, and it is a lot more likely that the chain will end up rubbing the cage in some gear combination.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into five parts:

INSTALLATION AND ADJUSTMENT

TESTING INDEX PERFORMANCE

FRONT-DERAILLEUR SERVICE

FRONT-DERAILLEUR TROUBLESHOOTING

EIGHT- AND NINE-SPEED COMPATIBILITY

INSTALLATION AND ADJUSTMENT

INSTALLATION

NOTE: Before proceeding further, be sure to be acquainted with the section, **NAMING COGS AND GEAR COMBINATIONS** (page 33-2).

Compatibility checks

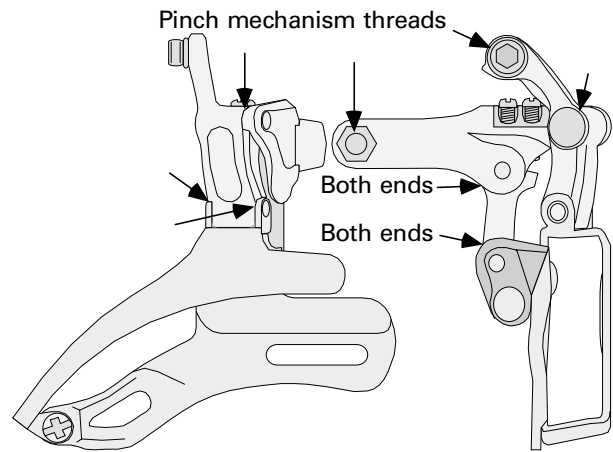
1. [] Check reference information to determine that derailleur and shift-control mechanism are compatible.

2. [] Check reference information to determine that inner wire, housing, and shift-control mechanism are compatible.
3. [] Check reference information to determine that shift-control mechanism is compatible with brand of crankset and number of chainrings.
4. [] Check reference information to determine if chain is compatible with chainring set.

Lubrication

5. Lubricate following points:

- [] Both ends of all four parallelogram pivots.
- [] Mounting bolt threads.
- [] Pinch mechanism threads.



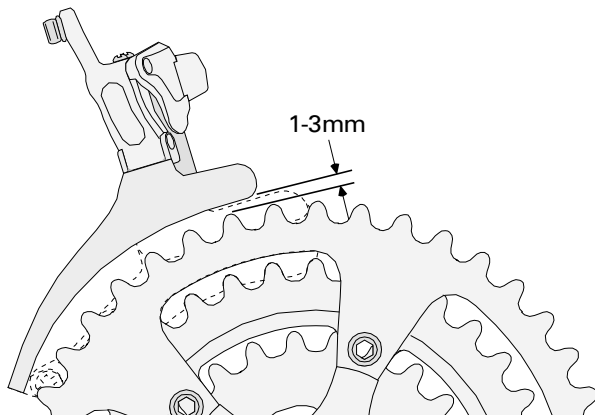
33.12 Oil at all these points.

Setting derailleur height

The derailleur height is critical to the performance of the front derailleur. The height is ideal when the outer cage plate clears the teeth on the outer chainring by 2mm, as it passes over the teeth. The height is acceptable within a clearance range of 1–3mm.

There are several complications to setting the height. The derailleur cage moves upward as it moves out, so if the height is checked when the outer plate is not exactly over the teeth of the outer chainring, then the setting will not be accurate. Another complication is that all the teeth on the outer chainring may not be equal in height. This may be because the chainring is deliberately not round, or it may be because some teeth are shaped differently to facilitate shifting. When setting the derailleur height, make sure that the crank is rotated to position the tallest teeth under the derailleur cage. The last complication is that the curve of the bottom edge of the outer plate may not be concentric to the curve created by the tips of the chainring teeth. This means that the clearance between the bottom edge of the outer plate and the teeth may not be uniform.

over the whole length of the outer plate. When setting the height, be sure the clearance is being checked at the point that the bottom edge of the outer plate comes closest to the chainring teeth.



33.13 *The correct range of derailleur height.*

6. ☐ Place derailleur clamp around seat tube, then install and gently secure mounting bolt (enough so derailleur will not slide down tube).
7. ☐ Check that outer plate is close to parallel to outer chainring, and reposition derailleur if it is not.
8. Perform one of following steps, depending on whether the derailleur is just being installed, or already has cable attached.
 - ☐ If cable is attached to derailleur, use shifter to position derailleur so that outer plate is directly above outer chainring teeth (raise derailleur if necessary).
 - ☐ If cable is not attached, use fingers to move derailleur cage out until outer plate is directly of outer chainring teeth (raise derailleur if necessary).
9. ☐ Turn L-screw in (usually innermost screw) until it supports derailleur so that the outer plate is held directly over teeth of outer chainring (release shifter at this time, if cable is attached).
10. ☐ Rotate crank so that tallest teeth are underneath derailleur cage and find point on outer plate that chainring teeth come closest to bottom edge of outer cage plate.
11. ☐ Arrange stack of feeler gauges until they total close to 2mm thickness.
12. Insert stack of feeler gauges between teeth and bottom edge of outer cage plate and determine if they:
 - ☐ just fit, height is good
 - ☐ fit loosely, derailleur should be lowered
 - ☐ fit too tight, derailleur should be raised.
13. ☐ Leave, lower, or raise derailleur on seat tube as determined in previous step, then recheck height.

Setting derailleur rotation

The derailleur's rotational alignment is critical to the shifting performance. The rotational alignment is ideal when the portion of the outer plate that overlaps the chain is parallel to the chain (when the chain is on the outermost chainring and outermost rear cog).

There are several items to consider when to setting rotational alignment.

One important consideration is that the outer plate of the derailleur cage is rarely a simple flat shape. Add to that the fact that the chain is not flat. Consequently, it is difficult to say that the two are parallel, or not parallel. Furthermore, the whole length of the outer plate does not overlap the chain all at one. The nose is generally above the chain and from the midpoint to the tail, the outer plate is generally below the chain. The only portion of the cage plate that matters is the short section that would rub the chain if the cage plate were moved in far enough to contact the chain (the overlap zone, see figure 33.14, next page).

Another consideration is the fact that the derailleur tends to move while the mounting bolt is being secured.

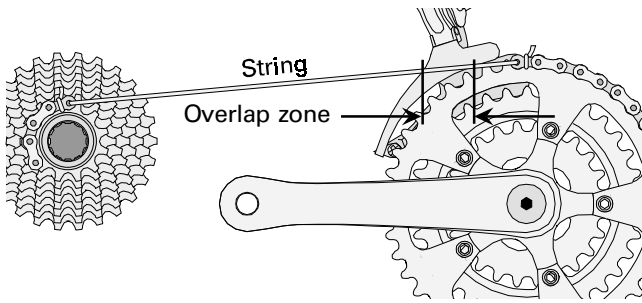
Finally, it makes a difference whether the chain is already installed, or the derailleur is being installed before the chain. With the chain already in place, the outer plate must be aligned to the chain. That can be somewhat awkward. With the chain not in place yet, a simple and superior substitute for the chain is used to align the derailleur.

This simple substitute for the chain must be hand-made. It cannot be purchased. The materials needed are two short sections of chain and some string. It works best if you use elastic string. Try a store that sells fabric and sewing supplies. One section of chain (3-4") will sit on top of the outer chainring. The other section of chain (3-4") will sit on top of the outermost rear cog. The string needs to be attached to both chain sections. If it is elastic, the length should be set so that it must be stretched slightly for the two segments of the chain to end up where they need to be.

To use the string tool, clamp or tie the wheel and the crank so that they cannot rotate. Place one piece of the chain on the outermost chainring so that the end with the string attached is close to 12:00. Place the other piece of chain on the outermost rear cog so that the slack is pulled out of the string. It is important that the string attaches to both sections of chain in the same way. If the string lines up with a chain roller on one section, it should line up with a chain

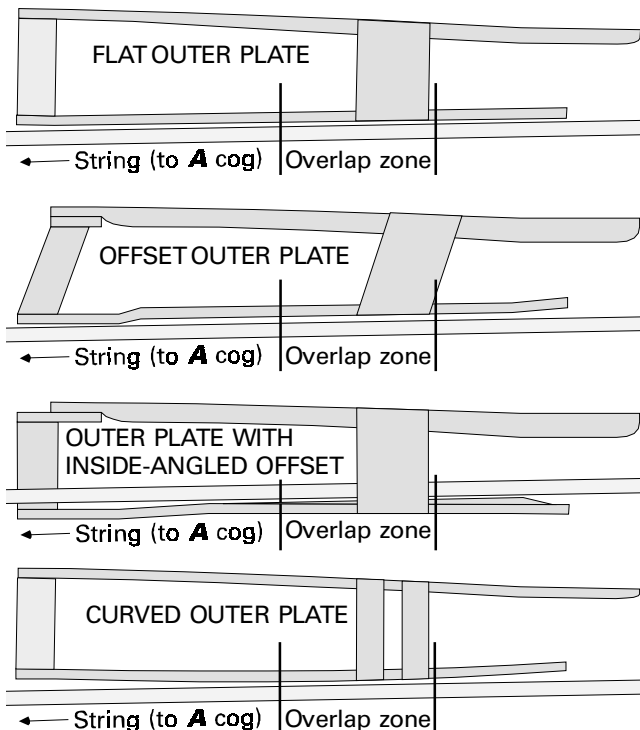
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roller on the other section. If the string comes out the outer face of one section of chain, it should come out the outer face of the other section of chain.



33.14 With the wheel and crank fixed from turning, install the derailleur-alignment-string tool in the fashion shown in this illustration (distance between the freewheel and chainrings is shortened for this depiction).

It is easiest if you leave the string outside of the derailleur cage. That way you may use it to line up the outer face of the outer cage plate. The design of some outer plates requires that the string be inside the derailleur cage. In these cases, line the string up with the inner face of the outer plate. See figure 33.15 to see how different shaped cage plates are lined up with the string.

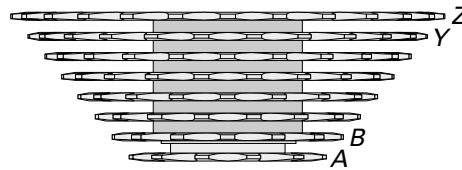


33.15 Regardless of the shape of the outer plate, rotate the derailleur so that the portion of the outer plate in the overlap zone (see figure 33.14) is parallel to the string (or chain) connecting cog A to chainring H. Note in the third example that the string needs to be inside the cage because the angle of the inside of the outer plate is different than the angle on the outside of the outer plate.

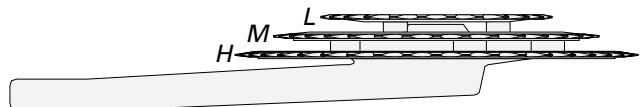
- 14.** Perform one of following steps, depending on whether chain and cable are installed, or not:
 - [] Shift chain to *A/H* position, and use shifter or cable-tension adjustment to position outer cage plate close to chain without contact occurring.
 - [] Place string tool on outermost chainring and outermost rear cog and adjust L-screw to hold outer cage plate close to string without touching it.
- 15.** [] With mounting bolt just loose enough to allow derailleur to twist around seat tube, twist derailleur until outer cage plate is parallel to chain or string.
- 16.** [] Secure mounting bolt to 40in-lbs (13lbs@3").
- 17.** [] Check rotational alignment again, and reposition and torque again if necessary, until alignment is maintained after torquing mounting bolt.

ADJUSTMENT

The processes of describing cogs and chainrings by their relative positions and describing gear combinations involving different front chainrings and rear cogs can get very wordy and awkward. For this reason, all the following procedures use a code system (illustrated below) to name different chainrings and gear combinations. This code system is described in detail in the earlier section of this chapter, **NAMING COGS AND GEAR COMBINATIONS** (page 33-2). Become acquainted with this method before attempting the following procedures.



Codes for freewheel cogs.

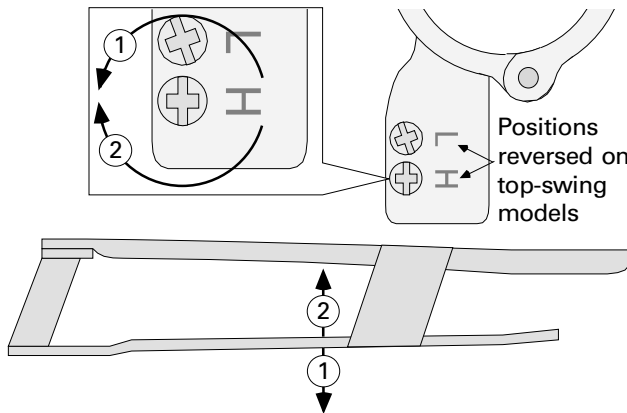


Codes for chainrings.

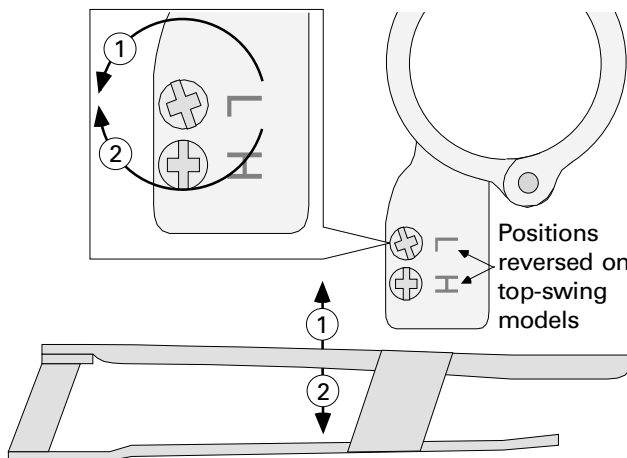
NOTE: before proceeding further, be sure to be acquainted with the section, **NAMING COGS AND GEAR COMBINATIONS** (page 33-2).

Pre-setting limit screws

The limit screws need to be set in a very approximate fashion before the cable and chain are installed. The purpose of this is to keep the chain from shifting off the chainring set while performing the final adjustments. *Precise adjustment of the limit screws must be done after cable installation. Do not waste effort doing steps #18 and #19 too precisely!* When the H-screw is tightened, it reduces the outward range of motion of the derailleur. When the L-screw is tightened, it reduces the inward range of motion of the rear derailleur. See figures 33.16 and 33.17 for clarification of the consequences on tightening and loosening each limit screw.

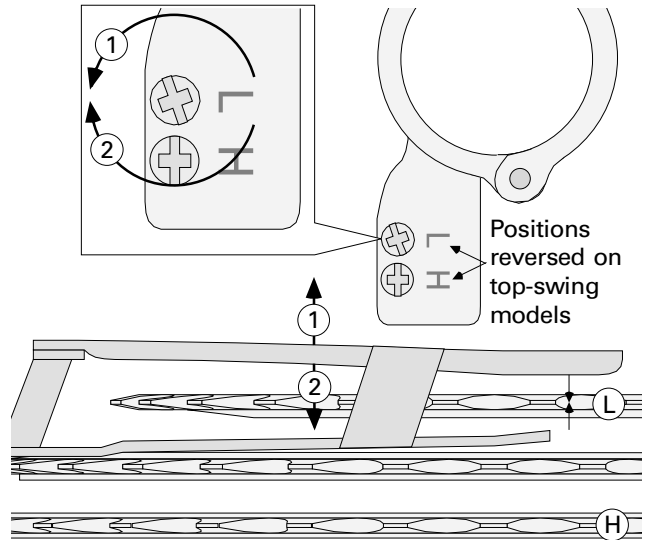


33.16 Turning the H-screw will change the derailleur's outward rest position in the direction indicated by the corresponding numbers.



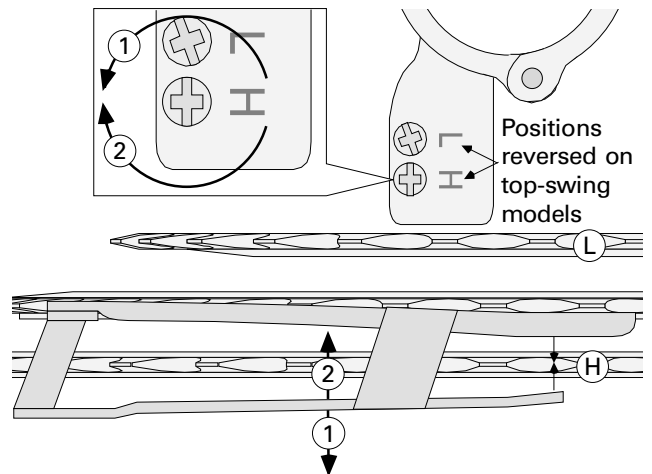
33.17 Turning the L-screw will change the derailleur's most inward position in the direction indicated by the corresponding numbers.

18. [] Adjust L-screw so innermost chainring appears in center of cage, halfway between noses of cage plates.



33.18 Adjust the L-screw so that the nose of the derailleur cage centers over the L chainring.

19. [] Adjust H-screw so that when derailleur is pushed out to its limit, outermost chainring appears in center of cage, halfway between noses of cage plates.



33.19 Adjust the H-screw so that when the derailleur is pushed outward, the nose of the cage ends up centered over the H chainring.

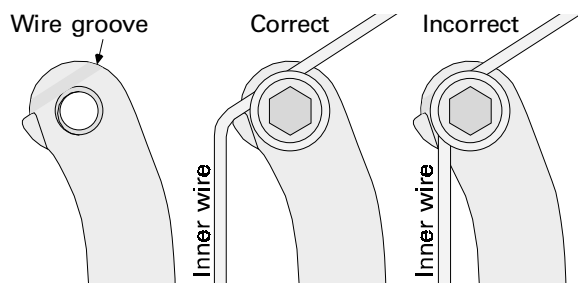
Cable attachment

When adjusting an indexing derailleur, cable setup is critical for proper performance. Even if adjusting a derailleur on a bike with the cable already installed, removing the cable and setting it up by the procedures outlined in the preceding chapter (**DERAILLEUR-CABLE SYSTEMS**, page 31-3) is strongly recommended.

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- 20. [] Use procedures in **DERAILLEUR-CABLE SYSTEMS** chapter (page 31-3) to install cable system.
- 21. [] Put front-derailleur shift-control mechanism in fully released position.
- 22. [] Loosen or disassemble pinch mechanism to find groove covered by pinch plate or washer.

Routing the inner wire through the pinch mechanism correctly can be counter-intuitive. The best procedure is to disassemble the pinch mechanism in order to find the groove that the inner wire sits in. The inner wire usually does not maintain a straight line as it goes through the pinch mechanism, but it bends to go over the top of the pinch mechanism. See the illustration below for examples of normal and incorrect cable routing.



33.20 Routing the inner wire through the pinch mechanism.

- 23. [] Lay inner wire into groove and gently secure pinch bolt/nut just enough to keep wire from falling out or slipping. If the pinch plate has a narrow tab that folds over edge of plate with groove, narrow tab always goes counterclockwise of section of wire entering pinch mechanism.

The inner wire needs slack removed, but not too much or it will interfere with the setting of the L-screw (particularly if the preliminary setting of the L-screw was too tight). In the next step, pull *most* of the slack out of the inner wire before torquing the pinch nut/bolt.

- 24. [] Pull of slack out of inner wire by hand and secure pinch mechanism to 35in-lbs (12lbs@3") (check that inner wire is still in groove).

NOTE: Install rear derailleur and attach rear cable system at this time, if not already installed.

Checking chainring wobble

If the chainrings wobble, it interferes with limit-screw setting. The next steps checks for wobble and refer to other chapters for correction of wobble.

- 25. [] Align nose of outer cage plate directly over teeth of outer chainring.
- 26. [] Rotate crank and observe whether outer chainring wobbles > .5mm.
- 27. [] See **CHAINRINGS** chapter (page 23-12) and **TAPER-FIT CRANKARMS** chapter (page 20-10) for procedures for aligning chainrings.

Chain installation and derailleur-capacity checks

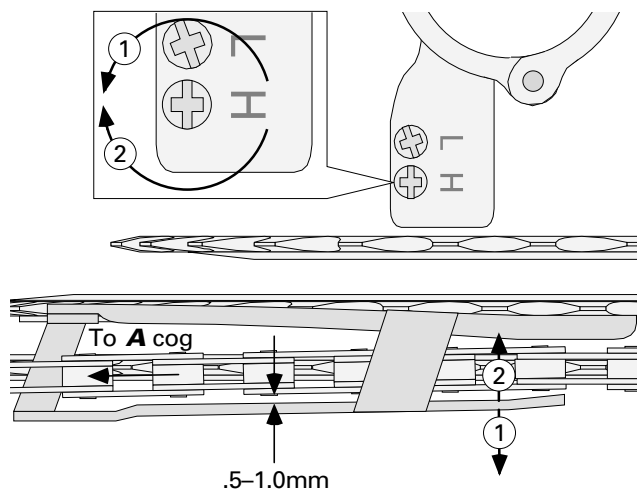
The derailleur should be checked for whether its maximum or minimum capacities have been exceeded.

- 28. [] Install chain and size by procedure in **CHAINS** chapter (page 26-10).
- 29. [] Put chain in *A/L* position, put load on chain, then check if chain touches cross-piece at tail of front-derailleur cage. If so, maximum capacity has been exceeded.
- 30. [] Shift front derailleur until inner cage plate is just above next-to-outermost chainring. If interference with teeth occurs, minimum capacity has been exceeded.

H-screw setting

Set the H-screw to stop the outward motion of the derailleur cage at a point where the outer plate clears the chain by .5–1.0mm (with chain in *A/H* position).

This is complicated by chainring wobble and chain wiggle. The crank must be turned for several revolutions, and stopped at the point that there is the least clearance between the chain and the outer cage plate. If the chainrings don't wobble much and the chain doesn't wiggle much, then the 1.0mm clearance should be safe. On the other hand, if there is a lot of lateral motion of the chain while the cranks are turning, once the closest point is found, the H-screw should be set closer to .5mm of clearance.



33.21 Set the H-screw so that this clearance is achieved when the derailleur stops its outward motion.

The best way to check clearance is to insert a feeler gauge between the cage plate and the chain.

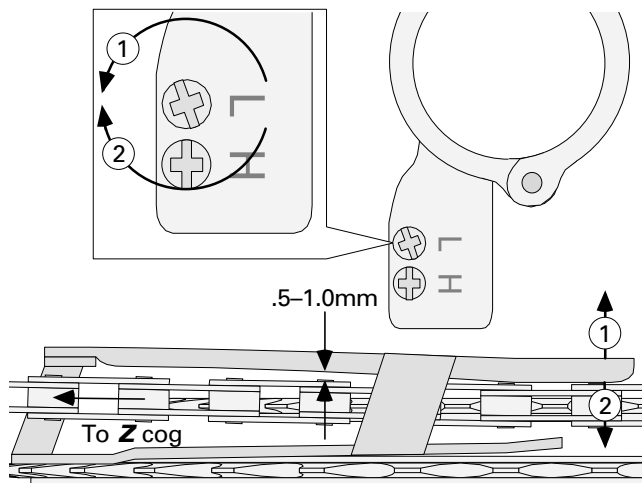
- 31. [] Shift chain to *A* position in rear.
- 32. [] While turning crank, pull on exposed section of inner wire to move front derailleur out as far as it will go, then hold it at this position.

33. [] Rotate crank several revolutions and stop at point where least clearance occurs between chain and outer cage plate.
34. [] Insert feeler gauge to check clearance between chain and outer cage plate.
35. Correct clearance error by one of following methods:
 - [] Clearance is .5–1.0mm, no change necessary.
 - [] Clearance is < .5mm, turn H-screw counterclockwise about 1/8 turn.
 - [] Clearance is > 1.0mm, turn H-screw clockwise about 1/8 turn.
36. [] After making adjustment of H-screw, repeat steps 33–35.

L-screw setting

Set the L-screw to stop the inward motion of the derailleur cage at a point where the inner plate clears the chain by .5–1.0mm (with chain in Z/L position).

This is complicated by chainring wobble and chain wiggle. The crank must be turned for several revolutions, then stopped at the point that there is the least clearance between the chain and the inner cage plate. If the chainrings don't wobble much and the chain doesn't wiggle much, then the 1.0mm clearance should be safe. On the other hand, if there is a lot of lateral motion of the chain while the cranks are turning, once the closest point is found, the L-screw should be set to get something more like the .5mm clearance.



33.22 Set the L-screw so that this clearance is achieved when the derailleur stops its inward motion.

The best way to check clearance is to insert a feeler gauge between the cage plate and the chain.

NOTE: If inner-wire is too tight, L-screw cannot be set.

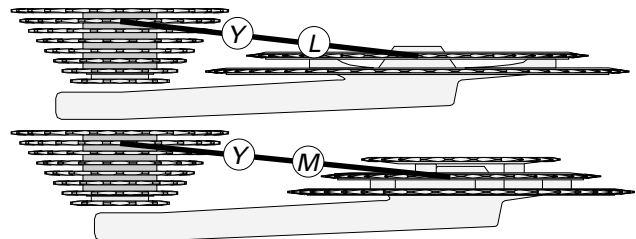
37. [] Shift chain to Z/L position.
38. [] Rotate crank several revolutions and stop at point where least clearance occurs between chain and inner cage plate.

39. [] Make sure shift-control mechanism is fully released.
40. [] Insert feeler gauge to check clearance between chain and inner cage plate.
41. Correct clearance error by one of following methods:
 - [] Clearance is .5–1.0mm, no change necessary.
 - [] Clearance is < .5mm, turn L-screw counterclockwise about 1/8 turn.
 - [] Clearance is > 1.0mm, turn L-screw clockwise about 1/8 turn.
42. [] After making adjustment of L-screw, repeat steps 39–41.

Fine-tuning shift to outer chainring

Once the H-screw is set, the chain should shift effortlessly to the H chainring. In some cases, the shift may be slow or hesitant. In this case, some further adjustment is needed, but not of the H-screw. Instead, the angle of the nose of the inner cage plate must be changed.

When the chain is in a more inward position in the rear, the angle of the chain retards out-shifting at the chainrings. Consequently, to test whether further tuning is needed, the chain should be on the most inward cog it would normally be on when shifting to the H chainring. This is the Y cog. The shift to the H chainring should always be made from the adjacent inward chainring, which would be the L chainring on a double-chainring set, or the M chainring on a triple-chainring set.



33.23 Correct chain position when checking the shift to the H chainring.

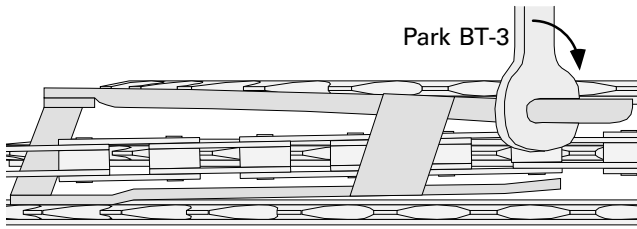
43. [] Put the chain in the Y/L position (double-chainring sets), or Y/M position (triple-chainring sets).

When the rider shifts to the H chainring, it is usually because the pedaling speed is getting too high in the current chainring. It is a false test to check the shift to this chainring while pedaling slowly. For this test, the minimum pedaling speed should be 60rpm and there is nothing unrealistic about testing the shift at 80rpm.

44. [] While pedaling at 60rpm or better, shift chain to H chainring and observe whether chain shifts promptly, or with clatter and/or hesitation.

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45. [] If shift is too slow, use Park BT-3 to bend nose of inner cage plate closer to chain (without bending it far enough that it will rub when chain is on *H* chainring).



33.24 Bending the nose of the inner plate closer to the chain to improve the shift to the *H* chainring.

46. [] Shift chain in one chainring and check shift to *H* chainring again. If shift hesitates, toe nose further and check shift again.

Cable stressing

Cable stretch is a commonly misused term. There is really never enough force on the inner wire to actually stretch it. Somehow, however, cable systems develop slack rapidly after installation. This development of slack can compromise the indexing adjustment. What causes this slack is: the inner-wire head seats into its socket, and the housing ends and fittings seat into theirs. This can happen gradually as shifting loads are repeatedly put on the cable systems, or it can be simulated by stressing the cable system one time at a substantially higher load than normal. This over-load stressing also tests the cable system for integrity.

Since the systems will be over-loaded, it is important that the shift-control mechanism and the derailleur be in positions that can support the load. The derailleur should be at its outermost position, supported by the *H*-screw. The shift-control mechanism should be at its fully released position, supported by its own internal stop. To accomplish this, the lever must be operated to put the chain on the *L* chainring, and then the inner wire must be pulled manually (while pedaling) to put the chain on the *H* chainring. Once the chain is in place, stop pedaling and pull out hard on the inner wire a few times. Protect your hand from damage by using a multi-folded rag between your hand and the inner wire.

47. [] Make sure front shift control mechanism is fully released.
48. [] While pedaling, pull on exposed inner wire at down tube or top tube until chain is on *H* chainring and stop pedaling.
49. [] With chain still on *H* chainring, pull hard on exposed inner wire to seat cable heads and housing ends in stops and sockets, and to test integrity of pinch mechanism and cable system.

Basic cable tensioning

Coarse adjustment of the inner-wire tension is done by pulling or releasing wire through the pinch mechanism on the derailleur. Fine tuning will be done afterwards, by using the adjusting barrel on the shift-control mechanism.

50. [] Loosen pinch mechanism.

Before starting, the shift-control-mechanism adjusting barrel should be two full turns out from fully in, so that it can be turned in or out to loosen or tighten the inner-wire tension.

51. [] Set shift-control-mechanism adjusting barrel so that it is two full turns out from fully in.

The *fourth hand* is a very convenient tool for removing inner-wire slack, but it can easily make the inner wire much too tight. Watch for any outward motion of the derailleur, indicating the fourth hand tool is being squeezed too tightly.

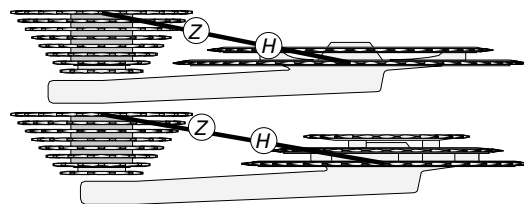
52. [] Using fourth hand tool, *gently* pull slack out of inner wire, *being sure to stop before derailleur begins to move*.

It is easy for the inner wire to slip out of its groove in the pinch mechanism while the tension is being reset. Be certain that the inner wire is in place before torquing the bolt/nut. If it is out of place, then the correct torque may not keep it secure.

53. [] Making sure inner wire is still seated in groove in pinch mechanism, secure pinch nut/bolt to 35in-lbs (12lbs@3").
54. [] Put chain in *B/H* position (double-chainring sets), or the *B/M* position (triple-chainring sets), then check shift to *L* chainring. If shift hesitates, inner wire was tightened too much in step 52.

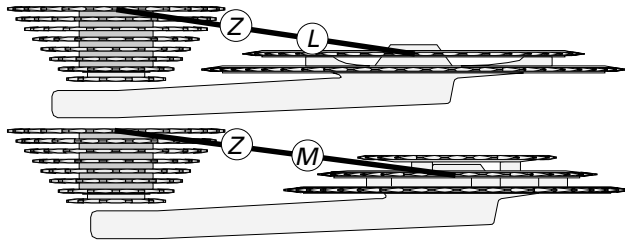
Indexing adjustment

The concept of making an index adjustment is similar to a limit-screw adjustment. There is a range of adjustments that work, but the tightest setting is best, since that allows for the greatest amount of deterioration to happen before the system becomes non-functional. The most effective approach to adjustment, therefore, is to deliberately create symptoms that the inner wire is too tight, then loosen the adjustment by small increments until the symptom is eliminated.



33.25 Starting chain position when checking the indexing adjustment.

55. [] Shift chain to **Z/H** position.
 56. [] Shift chain to next chainring inward.



33.26 Final chain position when checking the indexing adjustment.

57. Check clearance between chain and inner cage plate and check one of following choices:
 [] Chain rubs derailleur-cage inner plate, cable-adjusting barrel needs to be turned clockwise 1/4 turn.
 [] Clearance is $> .5\text{mm}$, cable-adjusting barrel needs to be turned counterclockwise 1/4 turn.
 [] Clearance is $> 0\text{mm}$ and $\leq .5\text{mm}$, cable tension is correct.
58. [] Shift chain back to **H** chainring.
 59. [] Repeat steps 56–58 until clearance is $> 0\text{mm}$ and $\leq .5\text{mm}$.

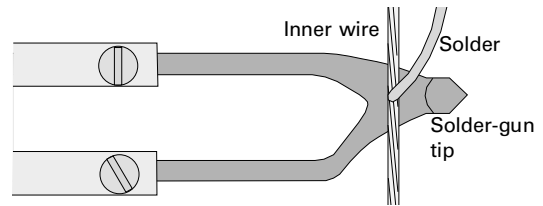
Inner-wire finish

Excess inner wire should be trimmed and finished. Excess length is unsightly and may get caught in the chain. Soldering prevents fraying, and, therefore, allows the cable to be reused whether a wire cap is used or not. Wire caps do not prevent fraying, but they do prevent someone getting poked by the wire.

The fourth hand is place on the inner wire to act as a gauge to determine how much wire to leave. This remaining wire does not need to be any more than what the fourth hand needs to grab.

60. [] Put fourth hand tool on inner wire as if removing slack.
 61. [] Trim inner wire with wire cutters just past fourth-hand tool.

The next step suggests soldering the end of the wire. This is easy to do and prevents fraying. To solder, a soldering gun, thin 40/60 rosin-core solder, and soldering flux are needed. Put flux on the inner wire. Hold the soldering gun tip flat against one side of the wire until the flux sizzles away. Still holding the soldering gun tip flat against one side of the wire, hold the tip of the solder against the other side of the wire until the heated wire causes the solder to melt and flow into the wire. Some wires have are specially coated or made of stainless steel and will not accept solder. In these cases the wire will melt the solder, but the solder will not flow into the wire. Instead, it beads up and runs off the wire.



33.27 Correct soldering technique.

As an easier alternative to using soldering wire, consider using a flux/solder paste mix (Galaxy Fluxo 50/50, or similar). Apply like flux, heat up until flux stops bubbling, then wipe off while still hot. This method will work on some coated wires and stainless-steel wires that the solder-wire method does not work on.

62. [] Solder inner-wire end.

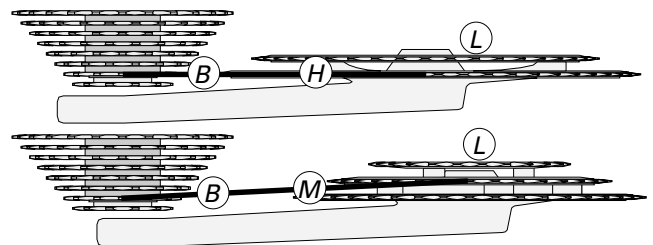
Wire-end caps are sometimes used instead of solder to prevent fraying. This will not work. Crimping the cap onto the wire frequently *causes* fraying. A soldered wire will not fray when the cap is crimped on. The real function of the wire cap is to cover the sharp end of the wire.

63. [] Put cap on end of inner wire if desired.

Fine-tuning shift to inner chainring

Occasionally, additional adjustment is needed to get the chain to shift quickly to the innermost chainring. The normal way to improve this shift is to sacrifice the .5–1.0mm clearance between the chain and the inner cage plate that has been set with the L-screw. Be careful; the clearance should never exceed 4mm.

The most difficult time for the chain to shift to the innermost chainring is when the chain is on the outermost portion of the rear cog set. The **B** cog is the furthest-out position that is normal for the chain to be in when shifting to the **L** chainring. When testing the shift to the **L** chainring, the correct starting position is with the chain in the **B/H** position (double-chainring sets), or the **B/M** position (triple-chainring sets).



33.28 Correct chain position to check the shift to the **L** chainring.

64. [] Put chain in **B/H** position (double-chainring sets), or **B/M** position (triple-chainring sets).

The rider will usually shift to the **L** chainring because the pedaling speed is too slow. It is unrealistic to check if the shift is too slow if the test is performed at

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a high pedaling speed. Too slow a pedaling speed is also unrealistic. Keep the pedaling speed close to 60rpm for the following test.

65. [] While pedaling at no more than 60rpm, check shift to *L* chainring.

66. Check one of following results:

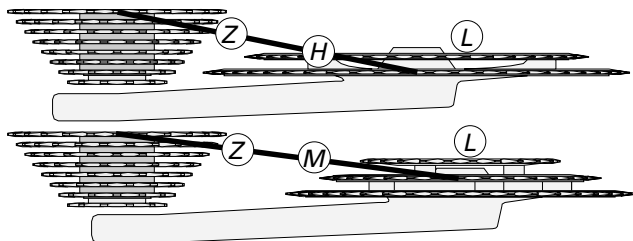
[] Shift hesitated, or chain did not complete shift to *L* chainring, L-screw needs to be turned 1/8 turn counterclockwise.

[] Shift was good, no further L-screw adjustment needed.

Often it is not possible to fully eliminate hesitation in the shift to the *L* chainring. There are three limits to how much the L screw can be loosened. First, part of the derailleur may bump into itself or the frame, in which case further loosening of the limit screw will not result in additional inward motion of the derailleur. Second, the cable tension, which has already been set for optimal indexing, may create an inner limit that is more restrictive than the screw. Consider a slightly looser indexing adjustment to allow a looser L-screw setting. In both these cases, stop adjusting the screw when the derailleur stops responding with additional inward motion. If the shift is still unacceptable, examine other factors, such as derailleur height and rotation. Third, if the inside clearance in the *Z/L* gear combination exceeds 4mm, stop loosening the screw, because more clearance than 4mm is certain to cause an overshift to occur.

67. [] Repeat step 65, and 66 if necessary, until shift is good. Stop if derailleur does not move further, or if chain/inner-cage-plate clearance reaches 4mm (with chain in *Z/L* position).

After loosening the L-screw to improve a hesitant shift to the *L* chainring, it is important to check that the chain does not then over-shift when in other gear combinations. If the L-screw is too loose, the chain will try to shift in past the *L* chainring. This is most likely to occur when the chain is on the inner portion of the rear cog set, because this position for the chain encourages inward motion of the chain. Put the chain in the *Z/H* position (double-chainring sets), or the *Z/M* position (triple-chainring sets) to test the chain's tendency to shift in past the *L* chainring.



33.29 Correct chain position when checking for an over-shift to the *L* chainring.

68. [] Shift chain to *Z/H* position (double-chainring sets), or to *Z/M* position (triple-chainring sets).

69. [] While pedaling at no more than 60rpm, shift chain repeatedly to *L* chainring to check for tendency of chain to shift too far.

If there is not an L-screw setting that eliminates slow shifting without introducing over-shifting, then there is a likely problem with chainline (chainrings are too far out). It could also be that the tail of the derailleur cage needs to be customized (widened) to reduce the tendency to over-shift.

70. Check one of following options:

[] Chain shows no tendency to over-shift in step 69, L-screw setting is final.

[] Chain does show tendency to over-shift in step 69, chainline should be checked and modifying width of tail of derailleur cage should be considered.

TESTING INDEX PERFORMANCE

The performance of any indexing front-derailleur system can be tested and measured. The procedures described above are designed to set the indexing adjustment at *the tightest setting that allows for good shifting*. If the indexing system has normal performance, then there are probably looser settings for the cable that also allow proper shifts into all the gears. The range of adjusting-barrel positions from the tightest that provides good shifting to the loosest that will allow shifting into all the gears is called the *Functional Range of Adjustment* (or FRA).

The performance of all systems deteriorates with wear and the accumulation of dirt. When the FRA is narrow, it will take only a small amount of riding before service is needed to restore acceptable shifting. When the FRA is extremely narrow, finding a correct adjustment at all is challenging. When the FRA is broad, it will take much longer before service is needed. Therefore, it is to the rider's and the mechanic's advantage for the system to have a broad FRA.

There are two reasons to measure the FRA. First, it enables an accurate determination of whether parts might need replacement or cleaning on a used system. Second, it permits an evaluation of whether a non-recommended part negatively affects indexing performance.

There is no absolute value for an appropriate FRA. It varies with the brand and quality of equipment, as well as some other factors. For popular systems, an FRA of about two quarter turns of the cable-adjusting

barrel should be expected of new equipment. One of the most critical things to getting a decent FRA is proper rotational alignment of the derailleur.

If evaluating properly set-up used equipment that all meets manufacturer's specifications for compatibility, and the FRA is not at least two quarter turns, then something in the system needs to be cleaned or replaced.

If evaluating any equipment, used or new, that *does not* meet manufacturer's specifications for compatibility and the FRA is not at least two quarter turns, then the non-matched equipment probably needs to be replaced.

If considering installing equipment on a system that may not be compatible, measure the FRA before the change, and again afterwards. If it is reduced, then the equipment change will downgrade shift performance. If it is still above one quarter turn, then it may be acceptable even though it is a downgrade of performance. This test process applies to mis-matching chains, derailleurs and shifters, cable systems, and even derailleurs with chainring sets.

MEASURING THE FUNCTIONAL RANGE OF ADJUSTMENT (FRA)

1. [] Perform an index adjustment using steps 55–59 of the *INSTALLATION AND ADJUSTMENT* procedure for front derailleurs (page 33-17).

2. [] Turn cable-adjusting barrel in 1/4 turn.
3. [] Shift chain to *A/H* position.
4. Check for chain rubbing outer cage plate and check one of following options:
[] No rub, shift chain back to *M* chainring and repeat steps 2–4.
[] Chain rubs, inner-wire tension is too loose, record number of turns to create too loose symptom here: _____ quarter turns.
5. [] If measuring FRA to evaluate a component change, install new component and repeats steps 1–4.

FRONT-DERAILLEUR SERVICE

The only service performed on front derailleurs is removal and cleaning of the fully-assembled derailleur; most front derailleurs are not designed to be disassembled to any significant degree. It is a good idea to perform a few inspections before installing the derailleur. Before installing the derailleur, inspect for cracks in the mounting clamp and roughness or gouges in the inner cage plate.

FRONT-DERAILLEUR TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>The shift to the H chainring is slow.</i>	
Inner wire is not tight enough.	Shift to <i>L</i> chainring and check inner-wire tension.
The inner-cage-plate nose needs toe adjustment.	Trying bending inner cage-plate nose toward chain.
The H-screw is too tight. This is only the cause if the chain is also rubbing the outer cage plate when the chain is in the <i>A/H</i> position.	Loosen H-screw only enough to create up to 1.0mm clearance between chain and outer cage plate (when the chain is in the <i>A/H</i> position).
The derailleur is mounted too high.	Check and correct derailleur height.
The chainring teeth are worn out.	Compare teeth to a new chainring of the same type.
The inner cage plate is chewed up.	Inspect plate and replace the derailleur if the cage plate is damaged.
SYMPTOM: <i>The chain is shifting past the H chainring.</i>	
If the derailleur rotation is correct, then the H-screw is too loose.	Check derailleur rotation, and tighten H-screw to create no more than 1.0mm clearance between the cage and the outer cage plate (when the chain is in the <i>A/H</i> position).
If the clearance between the chain and the outer cage plate is correct, then the derailleur is positioned with the tail rotated too far in.	Check and correct derailleur rotation, then set limit screws and cable tension again.

(Continued next page)

FRONT-DERAILLEUR TROUBLESHOOTING (continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>The chain rubs the outer cage plate continuously when the chain is in the A/H position.</i>	
The H-screw setting is too tight.	Adjust the H-screw so that the chain clears the outer cage plate by at least .5mm.
The inner-wire tension is too low on an indexing derailleur.	Follow the recommended procedure to set the indexing adjustment for the front derailleur.
SYMPTOM: <i>The chain rubs the outer cage plate intermittently.</i>	
The chainrings are out of true.	Check and align the chainrings until they wobble less than .5mm.
If clearance is good when checked in the bike stand, then the chainrings, bottom-bracket spindle, and/or frame are flexing under load.	No adjustment can be made to correct this condition.
There is play in the bottom-bracket bearings.	Check and adjust the bottom bracket.
SYMPTOM: <i>When the H-screw is loosened to eliminate a rub between the chain and outer cage plate, a rub develops between the chain and the inner cage plate.</i>	
The derailleur's rotational alignment is wrong.	Check and align the derailleur's rotation so that the outer cage plate is parallel to the chain when the chain is in the A/H position.
The chainrings have too much wobble.	Check and align the chainrings.
The nose of the inner cage plate is toed towards the chain too much.	Reduce the inner-cage-plate-nose toe and check whether the shift to the H chainring is still good when the chain is on the Y cog in the rear.
SYMPTOM: <i>The shift to the L chainring is slow.</i>	
The L-screw is too tight.	Loosen the L-screw by 1/8 turn increments until the shift improves.
The inner-wire tension is too tight.	Check and adjust the inner-wire tension.
The derailleur rotation is wrong, with the tail of the derailleur too far out compared to the nose.	Check and align the derailleur's rotation so that the outer cage plate is parallel to the chain (when the chain is in the A/H position).
The derailleur is too high, particularly if the chainring set is a triple.	Check and correct derailleur height.
There is excess friction in the cable system.	Remove, inspect, and correct any problems with the cable system.
The derailleur is fouled with dirt.	Remove and clean the derailleur.
SYMPTOM: <i>Loosening the L-screw makes no improvement in the slow shift of the chain to the L chainring.</i>	
The inner-wire tension is too tight.	Check and adjust the inner-wire tension.
The chainrings are too close to the frame and some part of the derailleur is bumping into the seat tube or itself before the cage has moved far enough.	Check for interference between the frame and the bottom inside pivot of the derailleur's parallelogram, or for a fully compressed parallelogram; if interference exists, replace the bottom bracket with one that moves the chainrings as far out as chainline will allow.
The derailleur is fouled with dirt.	Remove and clean the derailleur.

(Continued next page)

SYMPTOM: <i>The chain is shifting past the L chainring.</i>	
The L-screw is too loose.	Tighten the L-screw by 1/8 turn increments until symptom goes away.
If tightening the L-screw results in the chain being slow to shift to the L chainring without eliminating the over-shift, then the chainline is off (with the chainrings too far out relative to the rear cogs).	Check and correct the chainline error.
SYMPTOM: <i>When the L-screw is loosened approximately 1/8 turn to eliminate a slow shift to the L chainring, then the chain develops a tendency to shift past the L chainring.</i>	
The chainline is off, with the chainrings too far out relative to the rear cogs.	Check and correct the chainline error.
The rotation of the derailleur is wrong, with the tail end too far in compared to the nose.	Check and align the derailleur's rotation so that the outer cage plate is parallel to the chain (when the chain is in the A/H position).
The tail of the derailleur cage is too narrow.	Widen the tail of the cage by changing spacers, or by bending the tail end of the outer plate.
SYMPTOM: <i>The chain rubs the inner cage plate continuously when the chain is in the Z/L position.</i>	
The L-screw is too tight.	Loosen the L-screw.
The inner-wire tension is too tight.	Check and loosen the inner-wire tension.
There is excess friction in the cable system.	Remove, inspect, and correct problems in cable system.
SYMPTOM: <i>The rubs the inner cage plate intermittently when the chain is in the Z/L position.</i>	
Chainring wobble is excessive.	Check and align chainrings.
SYMPTOM: <i>The chain rubs the outer cage plate when the chain is on the L chainring and one of the outer rear cogs.</i>	
The L-screw is too loose.	Tighten the L-screw as much as possible without creating a slow shift to the L chainring, or a rub between the chain and inner cage plate (when the chain is in the Z/L position).
The derailleur's rotational alignment is off, with the tail too far in compared to the nose.	Check and align the derailleur's rotation so that the outer cage plate is parallel to the chain (when the chain is in the A/H position).
If the derailleur is non-indexing, it may not be designed to clear the chain in all gear combinations without its position being manually trimmed.	The operator needs to trim the cage position with the shift-control mechanism.
The tail of the derailleur cage is too narrow for the gear set-up and bike.	Add spacers to the tail of the cage or deform the outer plate at the tail end to widen the tail end of the cage.
SYMPTOM: <i>The shift from the L chainring to the M chainring is slow.</i>	
Inner-wire tension is too low if the derailleur is indexing.	Check the indexing adjustment of the front derailleur.
The teeth on the M chainring are worn out.	Compare teeth to a new chainring of the same type.
SYMPTOM: <i>The shift from the H chainring to the M chainring is slow.</i>	
Inner-wire tension is too tight if the derailleur is indexing.	Check the indexing adjustment of the front derailleur.
There is excess friction in the cable system.	Remove, inspect, and correct problems in the cable system.
The derailleur is fouled with dirt.	Remove and clean the derailleur.

(Continued next page)

FRONT-DERAILLEUR TROUBLESHOOTING (continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>The chain rubs the inner cage plate after shifting to the M chainring (the derailleur is indexing).</i>	
Inner-wire tension is too tight if the derailleur is indexing.	Check the indexing adjustment of the front derailleur.
There is excess friction in the cable system.	Remove, inspect, and correct problems in cable system.
The derailleur is fouled with dirt.	Remove and clean the derailleur.
SYMPTOM: <i>The chain rubs the outer cage plate when the chain is on the M chainring and is shifted to one of the outer rear cogs.</i>	
If the derailleur is indexing, the inner-wire tension is too low.	Check and correct the indexing adjustment.
The derailleur's rotational alignment is off, with the tail too far in compared to the nose.	Check and align the derailleur's rotation so that the outer cage plate is parallel to the chain (when the chain is in the A/H position).
If the derailleur is non-indexing, it may not be designed to clear the chain in all gear combinations without its position being manually trimmed.	The operator needs to trim the cage position with the shift-control mechanism.
The tail of the derailleur cage is too narrow for the gear set-up and bike.	Add spacers to the tail of the cage, or deform the outer plate at the tail end to widen the tail end of the cage.
SYMPTOM: <i>There is a tick once per crank revolution, whenever the chain is on the H chainring.</i>	
The tail of the derailleur cage is interfering with the crank arm.	The H-screw is too loose, or the derailleur is rotated with the tail too far out.
SYMPTOM: <i>The tail of the derailleur cage hits the crank arm when the derailleur is properly rotated and the H-screw setting is correct.</i>	
The crankset does not provide enough clearance between the arm and the outer chainring for the derailleur being used.	Change derailleurs to one with a flatter outer cage plate (no tail offset), or compromise the rotational alignment of the derailleur (check for ill consequences if the compromise is made).
SYMPTOM: <i>There is a continuous scraping sound when the chain is on the H chainring, but the chain is not rubbing either cage plate.</i>	
The minimum capacity of the derailleur has been exceeded, and the teeth of the next-to-outermost chainring are rubbing on the inner cage plate.	Change the derailleur or the size of the next-to-outermost chainring.
The outer cage plate is rubbing on a chainring guard.	Remove the chainring guard or compromise the derailleur height or rotation (check for ill consequences if the compromise is made).
SYMPTOM: <i>The chain drags over the cross-piece at the tail of the derailleur cage when the chain is in the A/L position.</i>	
Chain is dangling when there is no load.	If the symptom only occurs when chain is not under load, it is not a problem.
Derailleur is mounted too high.	Check and correct derailleur-mounting height.
If symptom occurs when derailleur height is correct and there is load on the chain, the maximum capacity of derailleur has been exceeded.	Change the derailleur to one that can handle the difference in largest and smallest chainring sizes, or change size of chainrings so that the difference is within the capacity of the derailleur being used.

EIGHT- AND NINE-SPEED COMPATIBILITY

COMPONENT COMPATIBILITY

The narrower chain and chainring spacing used in the Shimano nine-speed drive trains requires a narrower front derailleur cage for optimal performance. Therefore, Shimano derailleurs marked “Mega-9” are not fully interchangeable with other Shimano derailleurs.

Mega-9 front derailleurs have the same actuation ratio (the amount the derailleur moves for a given amount of cable movement), so there is full compatibility between all Shimano MTB front derailleurs and Shimano MTB front shift levers.

While there is no problem mixing shift levers and derailleurs there is a problem with mixing a Mega-9 front derailleur with a chain that is not nine-speed type. Obvious rubbing will occur that cannot be eliminated by any adjustment.

As long as the chain is changed also, excellent results can be attained when using a Mega-9 front derailleur on a Shimano chainring set that is not nine-speed spacing. Since the nine-speed chain works with all cog sets, this is a very acceptable mix of components.

The reverse combination of using a front derailleur that is not Mega-9 on a full nine-speed drive train will work, but you should expect a compromise in performance. In particular, the shift from the middle chainring to the inner chainring will be slow and unpredictable.

CHAINRING SIZE CAPACITY

In addition to the component compatibility issues, it is important to keep in mind that Mega-9 models of derailleurs sometimes have different minimum and maximum-tooth-difference ratings than the earlier version of the same derailleur. This is due to the fact that at the same time that Shimano introduced nine-speed drive trains, they also switched from compact chainring sets to “Mega” sized chainring sets. For example, the older seven- or eight-speed Deore LX model FD-M567 is rated for a minimum chainring size difference of 10 teeth and the matching crankset is a 22-32-42 configuration, but the more current Mega-9 type Deore LX model FD-M570 is rated for a minimum difference of 12 teeth. Consequently, the FD-M570 will not work on the older crankset, regardless of nine-speed issues.

34 – BRAKE LEVERS

ABOUT THIS CHAPTER

This chapter is about the levers used to operate the brakes. It covers brake levers for: flat bars on MTBs, drop-bars on road bikes, BMX/freestyle bars, and upright-bars. For most of these, several subjects are covered, including installation, inner-wire attachment, failures, and service.

GENERAL INFORMATION

TERMINOLOGY

Brake lever: The lever mechanism that is operated to control the brake calipers at the wheels.

Brake caliper: This is the mechanism at the wheel that closes the brake pads against the braking surface when pressure is applied to the brake lever.

Lever body: The part of the brake lever that is fixed to the handlebar and does not move when the lever is operated.

Lever arm: The part of the brake lever that is moved toward the handlebar to apply the brakes.

Mounting bolt: A bolt that causes a cast clamp or strap clamp to tighten around the handlebar to secure the lever body to the handlebar.

Lever pivot: The shaft on which the lever arm pivots.

Pivot stud: An unthreaded lever pivot that slides or presses into the lever body.

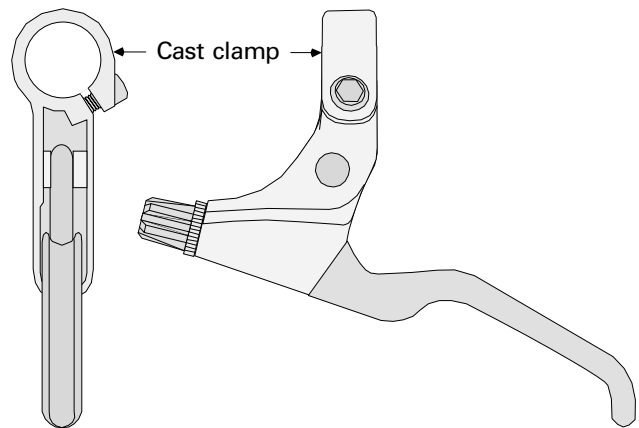
Pivot bolt: A lever pivot that threads into the lever body. It can also thread into a nut fixed to a socket in the lever body.

Pivot bushing: A plastic bushing that fits between the lever arm and the pivot stud/bolt.

Adjusting barrel: A hollow screw that changes the effective length of the brake inner wire. It is inserted into the lever body. The brake inner wire goes through the adjusting barrel. The outer end of the adjusting barrel has a socket into which the cable housing is inserted.

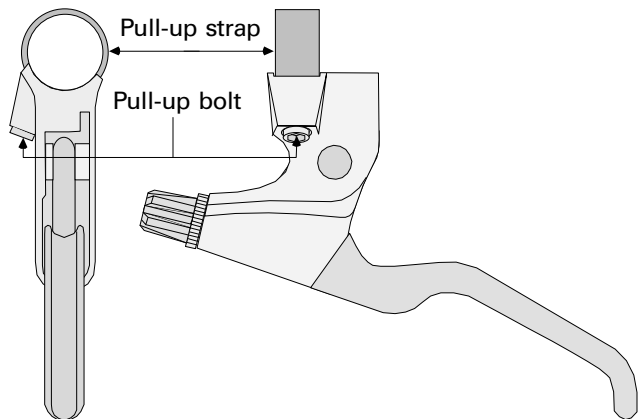
Barrel locknut: A nut threaded onto the adjusting barrel between the socket end of the adjusting barrel and the lever body. This nut is secured against the lever body to keep the position of the adjusting barrel from changing.

Cast clamp: The portion of a lever body that wraps around the handlebar. A cast clamp is usually an integrated part of the lever body, but sometimes the clamp is made in two pieces; half the clamp is cast as part of the lever body, and the other half is attached by two bolts (or a hinge and a bolt). Some brake levers are fixed to the handlebar with a cast clamp, and others are fixed to the handlebar with a pull-up strap.



34.1 An MTB lever with a cast clamp.

Pull-up strap: A flexible steel strap that holds the lever body to the handlebar. Some brake levers are fixed to the handlebar with a pull-up strap, while others are fixed to the handlebar with a cast clamp. See figures 34.2 and 34.3 (next page).

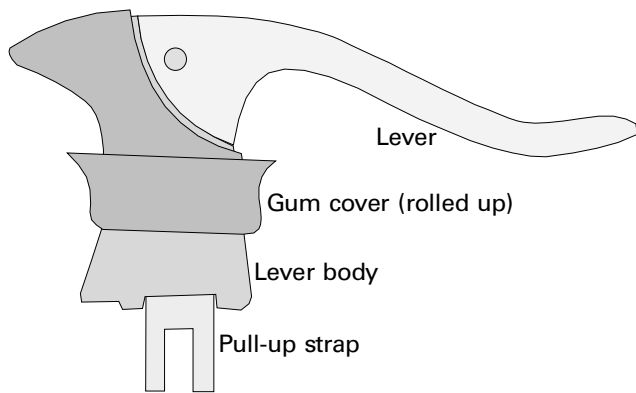


34.2 An MTB lever with a pull-up strap.

Pull-up bolt: A bolt that holds the lever body to the pull-up strap. As the bolt is tightened, it secures the body to the handlebar.

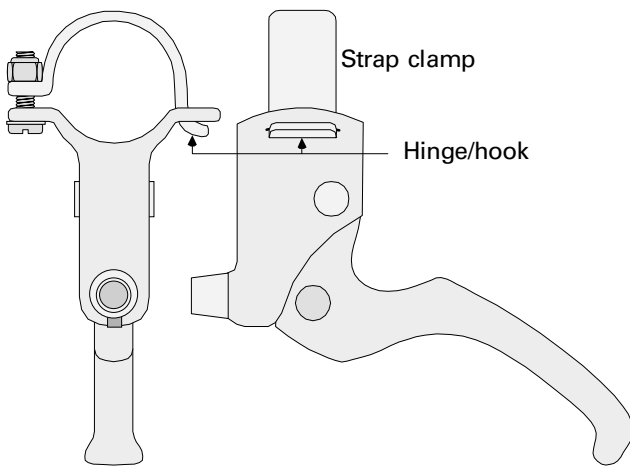
34 – BRAKE LEVERS

Pull-up nut: The nut that the pull-up bolt threads into.



34.3 A typical brake lever for drop bars on a road bike.

Strap clamp: This is like a cast clamp with a hinge or hook on one end, but the separate part that wraps around the side of the handlebar opposite the lever body is a semi-flexible plate of metal, rather than a rigid casting. The strap clamp is found most often on BMX/freestyle bikes, and on bikes with upright bars such as are found on classic 3-speeds.



34.4 An inexpensive BMX/freestyle lever. More expensive BMX/freestyle levers are similar in design to MTB levers.

Cable anchor: The part of the lever arm to which the brake inner-wire attaches. It might be a simple socket in the body of the lever arm, or it may be a pivoting mechanism (with a socket for the inner-wire head) attached to the lever arm.

Inner wire: The wire that attaches to the lever arm, passes through the lever body and adjusting barrel, through the cable housing, and attaches to the brake.

Cable housing: The outer sheath of the cable system. It stops against the adjusting barrel or a non-adjustable fitting on the lever body.

Ferrule: Any of a wide variety of shapes of fittings that adapt the end of the cable housing to fit to the socket in the lever body or adjusting barrel.

PREREQUISITES

To install a brake lever, it is necessary to know how to adjust the brake. In many cases it is also necessary to know how to install handlebar coverings, such as tape or grips.

INDICATIONS

Symptoms indicating a brake lever should be replaced

Brake levers need to be replaced for four reasons: bends in the lever at any point, cracks in any part of the lever, stripped threads for the mounting bolt in the cast body, or excessive play in the lever pivot that cannot be adjusted out or repaired by replacing pivot bushings.

Symptoms indicating brake levers need service

Brake levers need service for many reasons:

- Pull-up mechanisms fail and need to be replaced.
- Levers operate roughly because of dirt in the pivots.
- Levers operate roughly because of lack of lubrication in the pivots.
- Jerky brake operation or squeaks indicate that the cable anchors need lubrication.
- Bent adjusting barrels should be replaced.
- Slop in the lever pivots indicates that the pivots need adjustment or that the bushings need to be replaced.
- In some types of levers, sticky lever action might indicate that a bent pivot stud might need replacement.

Symptoms indicating a brake lever needs to be repositioned

The position of the brake levers is critical to the safe operation of the brakes. The brake levers need to be readily accessible from any normal riding position, and they should be positioned so that the rider can operate the levers with a minimum of hand and wrist contortion.

One way to identify whether brake levers need to be repositioned is to ride the bike and operate the levers from all normal hand positions on the handlebar. If some hand positions provide dramatically easier

access to the levers than others, then the levers should be repositioned. If the wrist must be cocked too close to its limit of range of motion to operate the brake lever, then a better position should be found.

You should also review the positioning guidelines offered in this chapter.

Symptoms indicating a brake lever needs to be secured

The issues of lever security are different for brake levers on road bikes with drop bars and for brake levers on off-road bikes. On drop-bar road bikes, the lever bodies are often used like handlebar extensions and twisted with great force, but on all other types of bikes the lever bodies are never grasped. For this reason, brake levers on drop bars should be virtually rigid on the handlebar. Any time the lever rotates easily around a drop handlebar, the lever should be secured to the limit of the equipment. For all other brake-lever types, there is a desirable degree of freedom to rotate; freedom to rotate prevents damage to the brake levers when they experience impact. More details on lever security are provided in the instructions for lever installation.

Handlebar and stem replacement

To replace a stem, at least one brake lever must be removed, and then properly installed on the bars. To replace the handlebars, both levers must be removed, and then properly installed on the bars.

General brake service

Any time a mechanic services the brakes in any way, the brake levers should be given a thorough inspection. If the levers are damaged they should be replaced. If misaligned they should be aligned. The levers should be torqued to the recommended torque and checked for security. If operating roughly, the levers should be cleaned or lubricated.

TOOL CHOICES

The only special tool recommended for brake lever service is a Park SD-1. This is a T-handled screwdriver with a hollow-ground tip. This tool is essential for the proper installation of slotted-head pull-up bolts.

TIME AND DIFFICULTY

Installing or servicing a brake lever is a relatively easy job of that should only take 1–2 minutes. The real work is the work comes as a result of installing a lever: adjusting the brakes or covering the bars.

COMPLICATIONS

Fit of brake levers to different-size bars

For most types of brake levers, fit to the handlebar is simple. For example, if installing a brake lever on an MTB handlebar, use an MTB brake lever; fit is assured. Brake levers that fit on road-bike handlebars are more complicated. There are three basic sizes of drop bars, and different pull-up straps available to fit the different sizes of bars. For more information on the sizes of straps and handlebars, see table 34-1 (page 34-6).

Interference with shift-control mechanisms

Brake levers and shift-control mechanisms are often mounted close together on MTB handlebars. The manufacturers of each cannot anticipate all the designs that might exist or be created. Consequently, there is sometimes interference between the brake lever and the shift-control mechanism even if both are mounted correctly. Sometimes a minor change in the position of the shift-control mechanism is all that is needed. Do not compromise the brake lever position. On rare occasions, it might be necessary to change either the brake lever or the shift-control mechanism to eliminate this interference.

Compatibility with brake calipers

Brake levers may be incompatible with some brake calipers. The distance from the center of the lever pivot to the center of the cable anchor determines the amount of inner wire that will be moved per degree of lever arm motion. If a replacement brake lever has a significantly larger dimension between the lever pivot and cable anchor, then the lever will move the pads much more quickly to the braking surface. This will result in greater maximum power, but less ability to modulate the brake. If a replacement brake lever has a significantly smaller dimension between the lever pivot and cable anchor, then the lever will move the pads much less quickly to the braking surface. This will result in less maximum power, but greater ability to modulate the brake.

Failure of pull-up-strap system

Pull-up-strap systems are prone to several types of failure that prevent the lever from securing fully.

Some types of pull-up nuts are not fixed to the pull-up strap. When the system has too much slack, the pull-up nut can disengage, resulting in a failure of the lever to secure, and damage to the pull-up strap. The strap is damaged because the nut usually remains engaged to one end of the strap; when the nut is pulled up, only one end of the strap is pulled, which destroys its symmetry.

A pull-up strap can crack or break where it joins the pull-up nut. This damage cannot be seen except when the brake lever is off the bar and disassembled.

The threads on the pull-up nut or pull-up bolt often strip. This damage is hidden inside the lever.

Levers will not secure

Levers may fail to secure for a variety of reasons due to fit problems or parts failure. In some cases, the lever will fail to secure adequately even when everything is the correct size and nothing has failed. This can be caused by two things. Plastic lever bodies do not offer enough friction against the bar to prevent slippage. Chrome-plated-steel bars are more slippery than aluminum bars and can keep levers from properly securing. The combination of a plastic lever body and a chrome-plated-steel handlebar is certain to be a problem. Without changing the equipment, there is no solution. The mechanic must make sure that everything is in working order and the maximum allowable torque is used.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into five sections. The first section is **MTB-BRAKE LEVERS**. It is followed, in order, by **DROP-BAR BRAKE LEVERS**, **BMX/FREESTYLE-BRAKE LEVERS**, **UPRIGHT-BAR BRAKE LEVERS**, and finally **BRAKE-LEVER TROUBLESHOOTING**.

Detailed information about removal, installation, inspection, and installation is provided about MTB brake levers and brake levers for drop-bars on road bikes. For BMX/freestyle levers and levers for upright-bars, only significant differences from the other types of levers are covered. The **BRAKE-CABLE SYSTEMS** chapter covers setup of the cable system. Individual chapters about different types of brake calipers cover the setup of the calipers and attachment of the cable system.

MTB-BRAKE LEVERS

For purposes of installation and removal, MTB-brake levers come in several varieties. These are closed-clamp types, open-clamp types, closed-strap types, and open-strap types. The open-clamp and open-strap types can be removed and installed without sliding the lever over the end of the bar. The closed-clamp and closed-strap varieties must be slid off and on the end of the bar. Since the vast majority of MTB-brake levers are of the “closed” variety, the following procedure assumes this type.

NOTE: If working on a bike with already-installed levers, go to the section of this procedure called INSPECTION for used bikes, or LUBRICATION for new bikes.

REMOVAL

1. [] Remove grip(s).
2. [] If mounted outward from brake lever, remove shift-control mechanism.
3. [] Unhook cable system from brake caliper(s).
4. [] Align slots in lever body, adjusting barrel, and barrel locknut.
5. [] Pull housing out of end of adjusting barrel and drop inner wire through slots in lever body, adjusting barrel, and barrel locknut.
6. [] Pull lever arm toward handlebar, align inner wire with slot in cable anchor, then pull inner-wire head out of cable anchor.
7. [] Loosen mounting bolt or pull-up bolt.
8. [] Slide lever off end of handlebar.

INSPECTION

9. [] Inspect lever body and lever arm for cracks.
10. [] Inspect lever arm for bends.

Loose lever pivots detract from the rider’s feeling of control. Wiggle the end of the lever arm side-to-side to check for excessive play. A couple of millimeters is normal, but more than that should be eliminated, if possible. Some MTB lever pivots are adjustable, and some are not. If the pivot bolt threads into a nut in a socket, then the lever pivot is probably not adjustable. If the nut is exposed, then the pivot is adjustable. To adjust, loosen the nut, turn the pivot bolt clockwise, then secure the nut while holding the bolt stationary. If the adjustment is made too tight, then the lever will not return when released (once the brake system is fully set up).

11. [] Inspect lever pivot for looseness and adjust if possible.

LUBRICATION

12. [] Oil both sides of lever arm at lever pivot.
13. [] Oil cable-anchor pivots, or inside cable-head socket in lever arm if socket is in aluminum casting.
14. [] Grease adjusting-barrel threads if not already obviously greased.

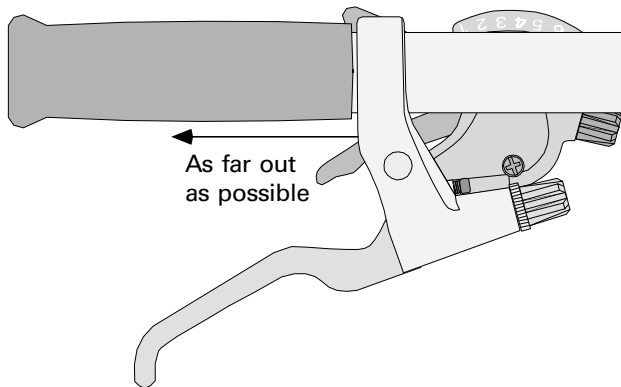
If the lever will be secured, it is critical that the mounting-bolt/pull-up-bolt threads are lubricated, because the recommended torques are based on the assumption that the threads are lubricated. If the threads are visible and clearly have lubrication on them, it is reasonable to assume that no more need be added. If the threads are not visible, or no lubrication can be seen, even if it means removing the bolt, the threads should be lubricated.

15. [] Oil mounting-bolt/pull-up-bolt threads if not obviously lubricated already.

INSTALLATION, ALIGNMENT AND SECURITY

There are right and left brake levers for MTBs. When the lever is on the correct side, the mounting bolt will be on the back/bottom face of the lever. If the wire head is installed in a socket that is on one face of the lever arm, this socket also will be on the back/bottom face of the lever.

16. [] If shift-control mechanism is to be mounted inward of brake lever (most non-integral shift-control mechanisms except twist grips), install it on bar first, but do not secure.
17. [] Slide brake lever over end of handlebar.
18. [] Install twist-grip-type shift-control mechanism onto handlebar (if any).
19. [] Install grip fully onto bar.
20. [] Position brake lever as far outward as grip (and twist grip) will allow. (Some old-style brake levers are so long that this positioning would place the tip of the lever arm past the outward end of the grip. In this case, position the brake lever as far outward as possible without the tip of the lever extending beyond the outward end of the grip.)



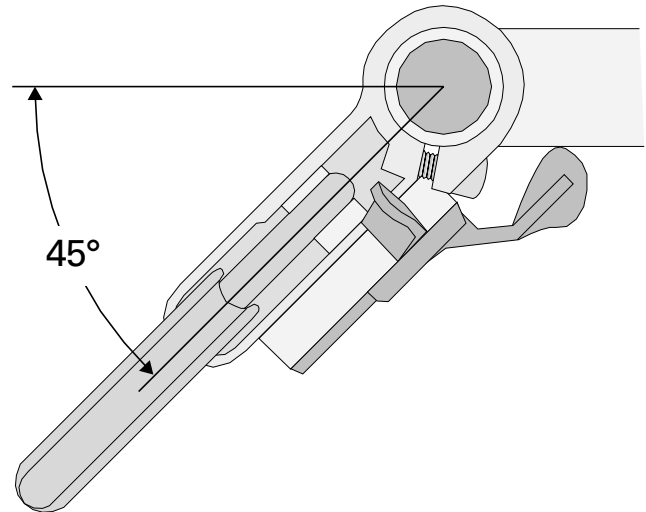
34.5 Set the lateral position of the brake lever as close to the grip as possible.

21. [] Gently secure mounting-bolt/pull-up-bolt. (Lever should still easily rotate around bar.)

To properly align the brake levers, the bike needs to be at the angle that it would be when sitting on level ground. This can be done several ways. If the bike is known to have a level top tube, then use a dial protractor to check that the top tube is parallel to the ground. If it is not known whether the top tube is level, or it is known that it is not, then use a tape

measure to measure from the center of each axle to the ground. If the axles are equidistant from the ground, then the bike is in the “on-ground” position.

22. [] Put bike at angle it would be when sitting on level ground.
23. [] Place dial protractor on lever body so that dial is visible from side of bike (if lever body has no flat surface, hold protractor so that its base is parallel to the plane in which the lever arm swings).
24. [] Adjust lever position until protractor reads 45° (±5° is acceptable range).



34.6 Set the rotational position of the lever so that the plane that the lever swings in is 45° down from flat.

25. [] **Lever with cast clamp:** Secure mounting bolt to 35–60in-lbs (12–20lbs@3").
Lever body held on by pull-up strap: Secure pull-up bolt to 60–70in-lbs (20–24lbs@3").
26. [] Viewing from rider’s perspective, check that both levers extend in front of handlebar equally, indicating that their rotational positions match.

INNER-WIRE ATTACHMENT

27. [] Align slots in adjusting barrel and barrel locknut with slot in bottom of lever body.
28. [] Pull lever to grip and place inner-wire head in cable anchor.
29. [] Swing wire up into slots in lever body, adjusting barrel, and barrel locknut.
30. [] Turn adjusting barrel or locknut so that slot no longer lines up with slot in lever body.

DROP-BAR BRAKE LEVERS

FIT OF LEVERS TO DROP BARS

Drop-style handlebars are made in several dimensions at the point the brake levers mount. Therefore, the pull-up straps used for mounting brake levers to drop bars also come in a variety of sizes. The nature of a pull-up strap permits it to work only within a limited range of handlebar dimensions. No pull-up strap will work across the full range of available handlebar diameters.

To determine the handlebar dimension, measure the diameter of the bar at the end. Measuring in the curve where the brake lever mounts will yield inaccurate results. Use a caliper and measure to the nearest tenth of a millimeter.

The size of pull-up straps cannot be determined by measurement because of their flexible nature. Virtually all straps are marked with a size. If there is no size on a strap, then a trial and error process is necessary to determine whether the strap will fit the bar. A strap that is too small will be difficult to slide over the end of the bar, even when the pull-up bolt is fully loosened. A strap that is too large will not secure the lever when the maximum torque is put on the pull-up bolt.

PULL-UP STRAP FIT (table 34-1)

Strap size	Fits handlebar sizes
22.0mm	22.0–22.2mm
23.5mm	23.5–23.8mm
23.8mm	23.5–23.8mm
23.8–24.2mm	23.8–24.2mm
24.2mm	24.0–24.2mm

NOTE: *If working on a bike with already-installed levers, go to the section of this procedure called INSPECTION for used bikes, or LUBRICATION for new bikes.*

REMOVAL

1. [] Remove handlebar covering.
2. [] Remove shift-control mechanism if mounted in end of handlebar.
3. [] Unhook or detach cable system from brake caliper(s).
4. [] Pull housing away from brake lever a few inches.
5. [] Push inner wire into brake-lever body to unseat inner-wire head from cable anchor.

6. [] Manipulate inner wire to move it through slot in cable anchor and remove inner wire from brake lever, or push inner wire fully through cable anchors that have no slot.
7. [] Loosen pull-up bolt until it almost disengages the pull-up nut.
8. [] Slide lever off end of handlebar.

INSPECTION

9. [] Inspect lever body and lever arm for cracks.
10. [] Inspect lever arm for bends.

Loose lever pivots detract from the rider’s feeling of control. Wiggle the end of the lever arm side-to-side to check for excessive play. A couple of millimeters is normal, but more than that should be eliminated, if possible. Most drop-bar brake levers have bushings between the lever arm and the pivot. That bushing can wear out, but replacement bushings are only sporadically available.
11. [] Inspect lever pivot for looseness and replace bushings if possible.

LUBRICATION

12. [] Oil both side of lever arm at lever pivot.
13. [] Oil cable-anchor pivots.
14. [] Grease adjusting-barrel threads if not already obviously greased (if any).

If the lever is to be secured, it is critical that the pull-up-bolt threads are lubricated, because the recommended torques are based on the assumption that the threads are lubricated. If the threads are visible and clearly have lubrication on them, it is reasonable to assume that no more need be added. If the threads are not visible, or no lubrication can be seen, even if it means removing the bolt, the threads should be lubricated.
15. [] Oil pull-up-bolt threads if not obviously lubricated already.

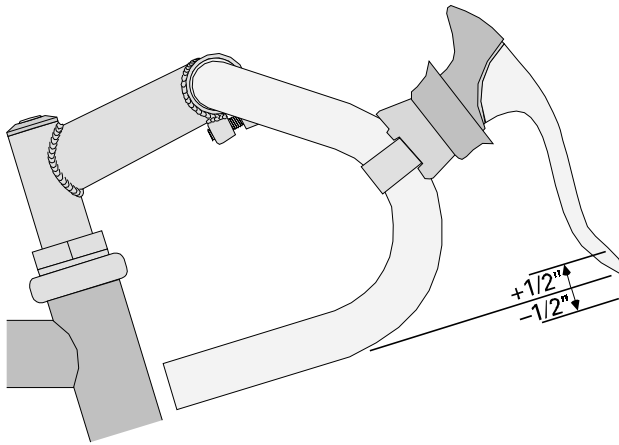
INSTALLATION, ALIGNMENT AND SECURITY

There are right and left brake levers for road bikes. If you’re mounting an aero’ lever, in nearly all cases the socket for the housing in the base of the lever will be on the inward face. Some inexpensive levers have auxiliary levers attached, or mounts for the future attachment of auxiliary levers. The auxiliary levers (or mounts for them) go on the inward side of the lever. Levers with integrated shifters should be the easiest to figure out. When the lever is correctly mounted, the shifter housing-stop should point inward.

16. [] Slide brake lever over end of handlebar.

17. [] Slide lever up bar until it is obviously too high.
18. [] Place straight edge flat on bottom side of handlebar so that it extend forward of handlebar by several inches.

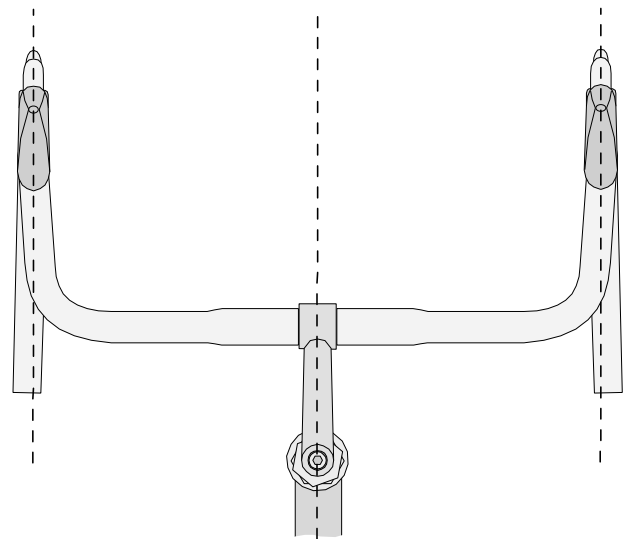
The brake-lever-height setting described in step #19 creates equal access to the lever, whether the rider is riding on the tops of the bars, or on the drops. Some riders might prefer favoring access from one riding position more than another. It is acceptable to move the tip of the lever up or down 1/2" from the position in step #19, at the customer's request, only. Deviations greater than 1/2" will make it too difficult to access the brake lever from one of the riding positions, and should not be done even at customer request.



34.7 Acceptable brake-lever height.

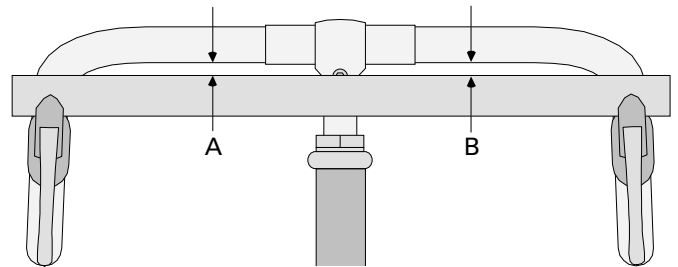
19. [] Slide brake lever down until tip of lever reaches straight edge (with lever arm fully released, or forward).
20. [] Adjust tip of lever arm up or down no more than 1/2" to suit rider preference, if any.
21. [] Gently secure pull-up bolt. (Lever should still easily rotate around bar.)

Lever rotation affects access to the lever as well. If the levers are rotated in, they are harder to use. If they are rotated out, they tend to get bumped and hit more. The best way to see the lever rotation is to get a viewpoint from high above the handlebars. The imaginary centerline of each brake lever should be parallel to the imaginary centerline through the stem (see figure 34.8, next column). If the wheel is in, it can be used as a reference, instead of the stem.



34.8 Brake lever rotational alignment.

22. [] Rotate brake lever so that centerline of lever body is parallel to centerline of stem.
23. [] **Hex- or Allen-head bolts:** Secure pull-up bolt to 70–85in-lbs (24–28lbs@3").
Slot-head bolts: Secure bolt to equivalent of 18–24lbs applied simultaneously at both ends of a Park SD-1 screwdriver handle.
24. [] When both levers are installed, lay straight edge across both lever bodies, and compare straight edge to flat center section of handlebar to see if brake-lever heights are equal.



34.9 If lever heights are equal, the straight edge should end up parallel to the center section of the handlebar (A and B should be equal).

25. [] When both levers are secure, press them firmly towards each other with force of approximately 75 pounds to check security.

INNER-WIRE ATTACHMENT

26. [] **Aero' levers only:** Compress lever arm, insert inner wire through cable anchor, then insert inner wire through lever body.
Non-aero' levers only: Compress lever arm, insert inner-wire head through hole in top of lever body, then hook inner wire into cable anchor.

BMX/FREESTYLE-BRAKE LEVERS

For most purposes, BMX/freestyle-brake levers are the same as MTB-brake levers. Refer to the earlier section about MTB-brake levers for full information. The primary differences are with the rotational angle, and with the torque required for levers that use a strap clamp, instead of the cast clamp found on MTB-brake levers. For these different specifications, see the following special notes.

NOTE: *The rotational position of a BMX/freestyle lever should be so that the lever is rotated down 25–30° from horizontal.*

NOTE: *Many BMX/freestyle levers have a strap clamp that holds the lever to the handlebar. The torque on the bolt that tightens this type of strap should be 25–35in-lbs (8–12lbs@3").*

UPRIGHT-BAR BRAKE LEVERS

Upright bars are the classic type of handlebar most often found on 3-speed bicycles. They are also called tourist bars. Upright bars might also be found on bikes with derailleurs.

The brake levers that go on these handlebars are unique, but simple. The general principles that apply to other types of brake levers apply to these as well. When installing or aligning these brake levers, use the following guidelines.

1. The rotational angle should be 15–30° out from directly below the grip.
2. If retained by a pull-up strap, the pull-up-bolt torque should be 60–70in-lbs (15–17lbs at both ends of a Park SD-1 screwdriver handle).
3. If retained by a strap clamp, torque bolt to 25–35in-lbs (8–12lbs@3").

BRAKE-LEVER TROUBLESHOOTING

Cause	Solution
SYMPTOM: <i>Brake lever will not secure on the handlebars at the recommended torque.</i>	
Pull-up strap is the wrong size.	Check strap and bar size, and look in table 34-1 (page 34-6) for fit.
Pull-up-bolt or mounting-bolt threads have seized.	If the threads are seized, the bolt will be difficult to loosen. Use penetrating oil and force the bolt loose, then replace damaged parts.
Lever body is plastic; normal security cannot be achieved.	Advise the customer of the problem and recommend replacement of the brake levers.
Handlebar is chrome-plated steel; normal security cannot be achieved with a pull-up-strap-type brake lever.	Advise the customer of the problem and recommend replacement of either the handlebars or brake levers.
SYMPTOM: <i>Mounting bolt or pull-up bolt will not reach recommended torque.</i>	
Threads of bolt or nut have stripped.	Replace the damaged part.
Threads in lever-body casting have stripped.	In some cases, a thread coil can be installed. If there is not enough material or access, replace the brake lever.
Pull-up strap has failed.	Replace the pull-up strap.
Lever body is cracked.	Inspect the lever body for cracks, and replace the brake lever if any cracks are found.
Pull-up stud is cracked.	Disassemble the lever and replace the pull-up stud.

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Brake lever will not return fully when released.</i>	
Cable system or caliper is causing the problem.	Detach the inner wire from the brake lever and see if the problem persists. If not, the problem is with the cable system or caliper (see appropriate troubleshooting charts for these items).
Adjustable pivot is too tight.	Loosen the pivot adjustment (if adjustable).
Lever pivot needs oil.	Oil the lever pivot.
Lever pivot needs cleaning.	Remove and clean the brake lever.
Rubber gum cover is interfering with lever.	Peel back the gum cover to check if the symptom persists. If it does, then reposition or trim the gum cover.
Pivot area of lever arm is bent.	Remove the lever arm and inspect for a bend in the pivot area. If there is one, replace the lever arm or the brake lever.
Pivot stud is bent.	Remove and inspect the pivot stud. Replace it if it is bent.
SYMPTOM: <i>Pull-up strap fails when pull-up bolt is correctly torqued.</i>	
Error in using or reading torque wrench.	Check the recommended torque value and the setting on the torque wrench, if the torque wrench is the preset type.
Pull-up bolt was previously over-torqued, or torqued repeatedly in the past.	Replace the damaged parts and use the recommended torque.
SYMPTOM: <i>Brake lever does not operate smoothly.</i>	
Lever-arm pivots need oil.	Oil on both sides of the lever-arm pivots.
Cable-anchor socket or anchor pivots need oil.	Oil the cable-anchor socket, or the cable-anchor pivots.
Cable system or caliper is the source of the problem.	Inspect cable system and caliper if oiling the brake lever does not solve the problem.
SYMPTOM: <i>A squeak (or similar noise) comes from the brake lever when it is operated.</i>	
Cable-anchor socket or anchor pivot needs oil.	Oil the cable-anchor socket.
SYMPTOM: <i>Lever arm is bent.</i>	
Impact from crash has bent lever arm.	Replace the part, or the whole brake lever.

35 – BRAKE-CABLE SYSTEMS

ABOUT THIS CHAPTER

This chapter is about setting up and servicing the cables that operate the brakes. It covers selection of the inner wire and housing, as well as the sizing and preparation of the housings. Attaching the inner wire to the brake lever is covered in the previous chapter. Attaching the inner wires to the brakes and adjusting the tension on the inner wire is covered in the **CABLE-OPERATED RIM BRAKES** chapter (at different locations for different types of calipers).

GENERAL INFORMATION

TERMINOLOGY

Cable: The term *cable* is used to refer to the complete cable system, including the inner wire, housings, and fittings. The term *cable* is often used to refer to the inner wire as well. To avoid confusion, this book will always use *cable* to describe the whole system, and *inner wire* to describe the wire portion of the cable system.

Housing: The outer sheath that covers portions of the inner wire. It is used to guide the inner wire around bends and to connect points that move in relation to each other.

Compressionless housing: This is housing that has stiff wires embedded in it that run along the length of the housing to reduce compression. To identify this housing, look at the cut end. Many wire ends will be seen. *This housing is used exclusively on derailleur systems!*

Housing liner: A plastic sheath inside the housing that is used to reduce friction. It is almost always fixed permanently in place.

Wound housing: This type of housing, typically used on brakes, consists of a single coil wound from one end of the housing to the other. It is usually covered in a plastic sheath and often has a liner inside. To identify it, look at the cut end. It will look like the end of a coil spring. If not sure after looking at the end, strip off the plastic sheath for a few millimeters at the end. Whether it is a single coil (wound), or multi-strand (compressionless), will become clear.

Ferrule: A cap that fits on the end of the housing to improve its fit into a housing stop.

Inner wire: The wire that is attached to the brake lever, passes through housing on the way to the brake, and attaches to the brake. At times it may just be called the *wire*.

Drawn wire: Wires that have been drawn through a die to change their shape. The process flattens the individual strands of the inner wire so that the surface of the inner wire is smoother.

Inner-wire head: The barrel-shaped or mushroom-shaped bead at the end of the inner wire. It fits in a socket in the brake lever arm.

Housing stop: A socket-like fitting on the frame, brake lever, or brake. The stop is the point where the housing ends and the inner wire continues.

Adjusting barrel: A hollow screw that changes the effective length of the brake inner wire. It is inserted into the lever body. The brake inner wire goes through the adjusting barrel. The outer end of the adjusting barrel has a socket into which the cable housing is inserted.

PREREQUISITES

Whenever cables are serviced or installed, brake adjustments must be done.

INDICATIONS

Maintenance

Cables just wear out. There may be no overt symptoms, but a cable can operate sluggishly just because it is old. Cables are vital to brake performance and relatively inexpensive. It is no extravagance to regularly replace the cable system, particularly if you are adjusting a brake.

Difficult brake operation

When the lever becomes difficult to operate, and lubing the brake lever does not solve the problem, it is likely there is a cable problem.

Rusty or damaged inner wire

Inner wires fail because they get rusty, fray, become kinked, or because the wire sheath tears on a Gore-Tex cable. Replace all wires with these problems, even when the damage does not seem to be in a critical location.

Damaged and dirty housings

Housings fail because they get kinked or bent, and because the plastic outer sheath cracks. Dirt can also get inside a housing and substantially increase friction.

Housings get kinked or bent because of impact and over-extension, but they also get damaged in the same way because they are mis-sized. Kinked and bent housings should be replaced, unless the housing is too long and the damage is confined to an area that will be cut off.

Dirt gets inside housings and increases friction. There is no good way to inspect for it and there is no good way to clean it out. It could be abrasive particles embedded in the inner liner. This hidden dirt is the likely reason that a used cable system that looks fine still does not feel as good as when new. This hidden dirt is reason enough to routinely replace cable systems when adjusting brakes.

Handlebar and stem changes

When the handlebar width, stem height, and stem length are changed, the loops of housings at the brake levers need to be re-sized. If the brake levers are moved further away because of wider bars or longer stem, it usually means cable replacement.

TOOL CHOICES

The only tools required for installation of cables are appropriate tools for cutting inner wire and housing. Preferred tools are in **bold**. Tools are preferred because of a balance among: versatility, quality, and economy.

CABLE TOOLS (table 35-1)

Tool	Fits and considerations
Park CN-2	Cuts inner wires only
SunTour TA110	Cuts inner wires only
Hozan C214	Cuts inner wires only
Hozan C215	Cuts inner wires and compressionless housing
Shimano TL-CT10	Cuts inner wires and compressionless housing
VAR 990	Cuts inner wires and compressionless housing
Felco C7 Deluxe	Cuts inner wires and compressionless housing
United Bicycle Tool MS-BURR	Removes burr from filed or ground housing end
7–8" diagonal side cutter, any brand	Cuts wound housing

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into several sections. The first is **CABLE TYPES AND COMPATIBILITY**, which covers the different types of inner wires and

housings used for brake systems, and compatibility of the different types with different braking systems. The next section is **SIZING HOUSING LOOPS**, which covers how to determine the optimum length of housing loops to either brake and to brake levers of all types. The final section is **PREPARATION AND INSTALLATION OF THE CABLE SYSTEM**, which covers housing-end finishing, cable-system lubrication, and routing considerations.

Unlike other chapters in this book, there is no section on troubleshooting. This is because cable problems are covered in the **CABLE-OPERATED RIM BRAKES** chapter (page 36-44).

CABLE TYPES AND COMPATIBILITY

INNER WIRES

Inner wires differ by diameter, type of surface, and type of construction.

Inner-wire diameter

Wire diameter is important in regard to compatibility with the housing. Conventional housing has a 5mm outside diameter; wires of 1.5–1.8mm diameter will fit this size. Oversize brake-cable housing has a diameter of 6mm, and works with inner wires with a 2.0mm diameter.

There are no real advantages to the oversize-cable system, and manufacturers don't design cable systems this way any more. Some older bikes have brake-lever fittings and frame fittings that are designed for the 6.0mm housing. If this is the case, then it is best to use the oversize cables.

Inner-wire surface

Unlike indexing-derailleur systems, brake systems will work adequately no matter what the quality of the cable is. To optimize performance, however, a smooth cable surface is preferred to a rough surface. One way to ensure that the wire is smooth enough is to use *drawn inner wires*, which have the smoothest surface available. Most drawn inner wires will be marketed as such, but the appearance will identify them as well. Drawn inner wires have a more reflective surface, and the individual strands are much less obvious. When looking at drawn inner wire, instead of seeing individual strands, it just looks like there are

tiny grooves spiraling around the inner wire. Drawn inner wire also feels much smoother when pulled between the fingertips.

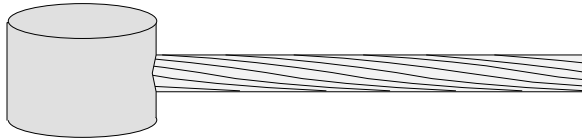
Inner-wire construction

Most inner wires today are a simple twisted wire. Several strands are laid parallel and then twisted together all at once. There is another construction, which might be called *braided*. It is not actually braided, but has that appearance. It is made by making several very small twisted-wire cables, and then twisting these together to make a larger cable. This *braided* (or *double-twisted*) inner wire is more supple than the same thickness of a simple twist. For this reason, most 2.0mm inner wires are the braided type.

INNER-WIRE HEADS

Barrel heads

The barrel-headed inner wire is used on virtually all brake levers except those found on brake levers made for drop-bars on road bikes. This type has a cylinder-shaped head that is usually slightly longer than its diameter. The wire goes into the side of the cylinder.



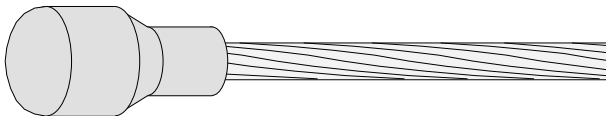
35.1 Inner wire with barrel head.

The most common barrel diameter is approximately 7.0mm. An 8.0mm-size barrel has been made, but wires with this size barrel are probably very difficult to find. The 7.0mm size can be used, instead.

The length of the barrel also varies. Even if the barrel protrudes from the socket or anchor, it is not a problem unless the barrel interferes with the lever body. Barrels that are too long can easily be filed shorter.

Mushroom heads

Mushroom heads are used almost exclusively on brake levers made for use on drop-bars for road bikes. The mushroom head typically has two diameters. The inner wire comes out the end of a narrower cylinder that with a 3.5–4.0mm diameter that mushrooms out to 6.0mm at the end.

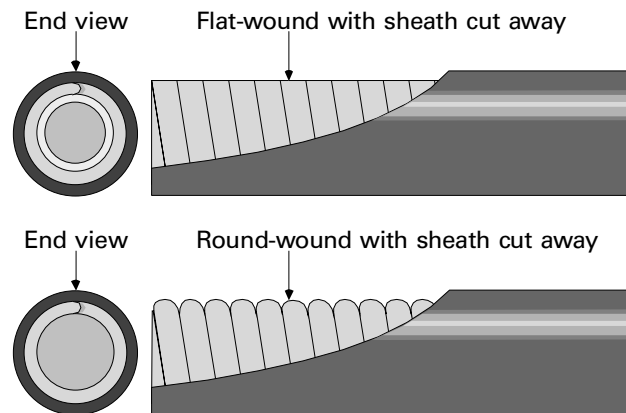


35.2 Inner wire with mushroom head.

HOUSINGS

Housing for brake systems must of be the wound variety. The compressionless variety is not designed to withstand the loads that are put on brake inner wires. *Catastrophic failure could result if compressionless housing were used on a brake system!*

Wound housings have a metal strip that is wound like a coil spring. Most wound housing has a plastic liner inside to reduce friction, but some cheap varieties are exposed metal inside. The ones without a liner generate more friction, and are more likely to rust solid, rendering the brake useless. Wound housing might be “flat wound” or “round wound.” The flat-wound variety is more common, stiffer, and stronger; flat-wound housing is made from wire that is flat.



35.3 Flat-wound and round-wound housing types.

SIZING AND ROUTING HOUSING LOOPS

SIZING HOUSING TO IMPROVE BRAKE PERFORMANCE

Sizing the housing loops is critical to good brake performance for several reasons. The shorter the housing, the less friction there will be on the inner wire (to a point). When the housing is too short, then it bends more, which increases friction and increases compression under load. The additional compression creates lost brake-lever motion. Tight bends should be avoided because they cause the coils in the housing to open more. When the brake inner wire is under load, these coils compress, which causes lost lever motion and effort.

35 – BRAKE-CABLE SYSTEMS

The housing loop at the brake lever must also be sized to permit a normal range of motion of the handlebar, or the housings will be damaged when the bar moves to its limit.

The goal, when sizing any housing loop, is to make it as short as possible without creating any abrupt bends, or limiting the handlebar's range of motion.

Most factories set up new bikes with brake lever housings that are much longer than is ideal. This may be because it allows use of the same cable sets on multiple bike sizes, or it may be because the factory anticipates that the shop may end up putting on a longer stem for the customer (requiring more cable length). Unfortunately, bikes routinely set up with housings too long train the customer's (and the mechanic's) eyes to accept something wrong as normal. Do not let any preconceptions about what looks normal prevent the decision to correctly size the housing loops.

MTB-BRAKE-LEVER HOUSING LOOPS

Normal routing

It is normal that the cable from the right lever go to the rear brake. It may be changed at customer request, but not because the shop decides that the unconventional routing is better and should be the shop standard. Anyone that has ever ridden a bike with hand brakes expects the right lever to operate the rear brake; it would be dangerous to surprise someone with a bike that had levers set up opposite from the norm.

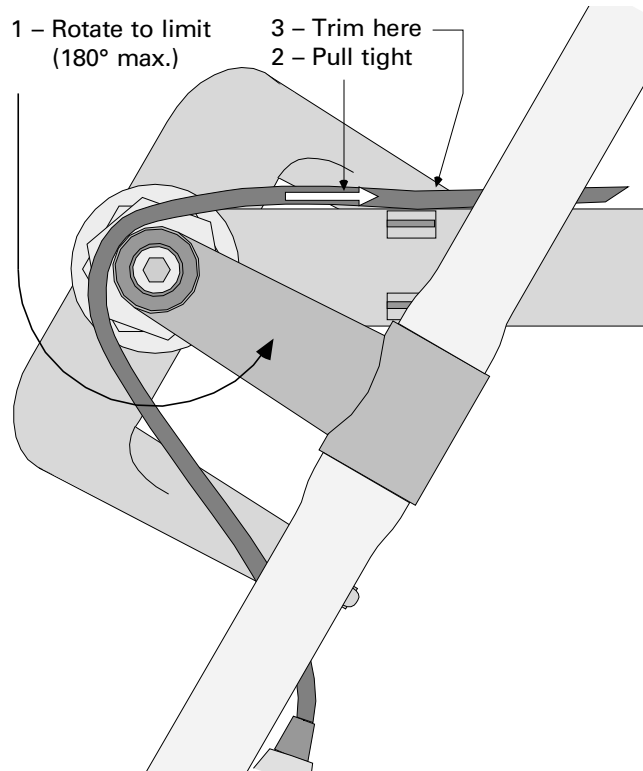
Sizing right-lever housing loop

1. [] **Slide piece of housing onto inner wire coming out of brake lever.**

There may be a housing stop for the rear-brake cable at the front end of the top tube, either centered on the top or offset to the right or left side. If the housing stop is centered on the top of the tube, then the loop from the right lever may go around either side of the stem. If the bars are narrow or the stem is short, it may be preferred to go around the left side of the stem to correct the abrupt bend. If the housing stop is on the right side of the frame, then the housing loop must pass the right side of the stem. If the housing stop is on the left side of the frame, then the housing loop must pass the left side of the stem.

2. [] **Route housing to housing stop on frame that will be used, making sure that loop does not have to deflect around derailleur cables.**

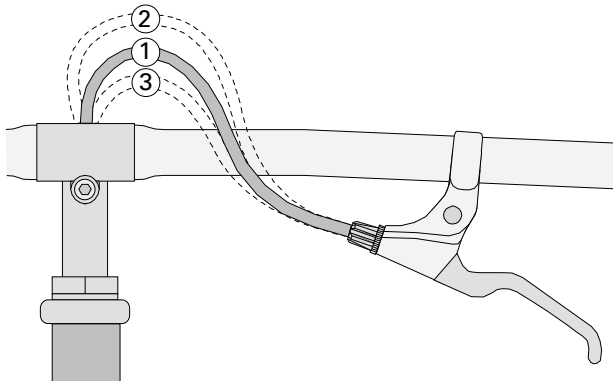
3. [] **Rotate handlebars to limit (180° max.) to side opposite the side of the stem that the housing is routed on.**
4. [] **Pull housing as far as it will go past housing stop that is on frame (without damaging housing), making sure housing remains inserted in housing stop on brake lever.**
5. [] **Mark housing at point that is even with closed end of housing stop on frame.**
6. [] **Remove housing from inner wire and cut housing at mark.**



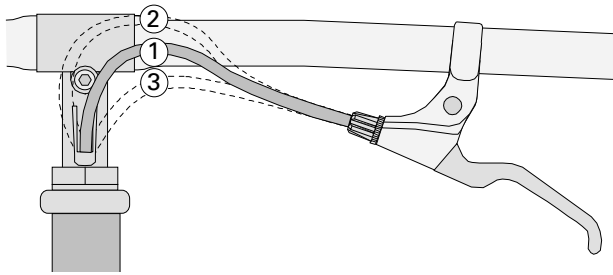
35.4 Sizing the housing loop from a right-side MTB lever.

Sizing left-lever housing loop

The loop of housing from the left lever may go to any one of locations; it may end at a stop on top of the stem, at a stop on the bottom of the stem, at a stop built into the headset, at a stop built in to a bridge that connects the two sides of the fork, or at the brake. In every case, the housing-loop length should be set as short as possible, without creating an abrupt bend where it enters the stop at either end. It should also be routed so that it does not have to deflect around anything.



35.5 When the housing length is correct (1), it enters the stop on the top of the stem in a straight line. When the housing length is too long (2) or too short (3), the housing enters the stop on top of the stem at an angle.



35.6 When the housing length is correct (1), it enters the stop on below the stem in a straight line. When the housing length is too long (2) or too short (3), the housing enters the stop below the stem at an angle.

If one end of the housing ends at a stop on a caliper arm, then the motion of the caliper arm should be considered. When sizing the housing, the caliper arm should be in a position close to its actual working position.

1. [] Slide piece of housing onto inner wire coming out of brake lever.
2. [] Find route for housing from lever to other stop (at stem, headset, bridge, or caliper) that is as direct as possible without any unnecessary deflections or avoidable abrupt bends.
3. [] If housing will be routed to stop on a caliper arm, use brake fourth-hand tool to hold pads to rim to put caliper in its working position.
4. [] With housing positioned adjacent to stop that is closer to brake, adjust housing longer and shorter until length is found that keeps abrupt bends to a minimum, where housing enters stops.
5. [] Mark housing at point that is even with closed end of housing stop.
6. [] Remove housing from inner wire and cut housing at mark.

DROP-BAR/AERO'-BRAKE-LEVER HOUSING LOOPS

Aero' brake levers that are designed to have the brake-cable housing routed along the handlebar (underneath the handlebar covering). Non-aero' levers have free loops of housing that rise several inches above the brake lever and handlebar. The housing leaves the aero' lever at its base and remains adjacent to the handlebar until it reaches the end of the handlebar covering, a few inches from the point the handlebar goes into the stem.

Normal routing

It is normal that the cable from the right lever go to the rear brake. It may be changed at customer request, but not because the shop decides that the unconventional routing is better and should be the shop standard. Anyone that has ever ridden a bike with hand brakes expects the right lever to operate the rear brake; it would be dangerous to surprise someone with a bike that had levers set up opposite from the norm.

Sizing right-lever housing loop

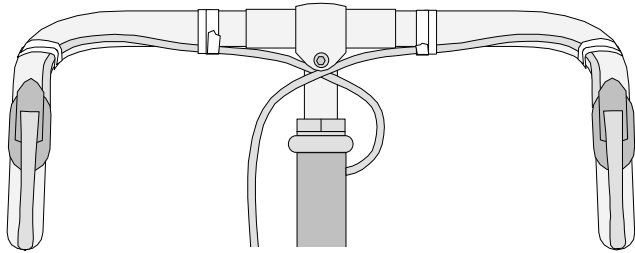
1. [] Slide piece of housing into socket on base of lever body.
2. [] Route housing so that it comes out of the base of the lever body and gradually transitions to underside of handlebar, unless a groove is provided in face of handlebar to seat housing in.
3. [] Retain housing temporarily with adhesive tape or ties to handlebar, only to point handlebar covering will end near stem.

There may be a housing stop for the rear-brake cable at the front end of the top tube either centered on the top, or offset to the right side. If the housing stop (or guide) is centered on the top of the tube, then the loop from the right lever may go around either side of the stem; usually, it is preferred to go around the left side of the stem to reduce the abruptness of the bend. However, if the housing stop is on the right side of the frame, then the housing loop must pass the right side of the stem. If the housing stop is on the left side of the frame, then the housing loop must pass the left side of the stem.

4. [] Route housing to housing stop on frame that will be used.
5. [] Rotate handlebars to limit (90° max.) to side opposite side of stem that housing is routed on.

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6. [] Pull housing as far as it will go past housing stop on frame (without damaging housing), making sure housing remains inserted in housing stop on brake lever and does not pull out of tape or tie on handlebar.
7. [] Mark housing at point that is even with closed end of housing stop on frame.
8. [] Remove housing from inner wire and cut housing at mark.



35.7 Cable routing from aero' brake levers.

Sizing left-lever housing loop

The loop of housing from the left lever may go to any number of locations. It may end at a stop on the bottom of the stem, at a stop built into the headset, at a stop built in to a bridge that connects the two sides of the fork, or at the brake. In *every* case, the housing-loop length should be set as short as possible, without creating an abrupt bend where it enters the stop or departs from the handlebar. It should also be routed so that it does not have to deflect around anything.

If one end of the housing ends at a stop on a caliper arm, then the motion of the caliper arm should be considered. When sizing the housing, the caliper arm should be in a position close to its actual working position.

1. [] Slide piece of housing into socket on base of lever body.
2. [] Route housing so that it comes out of the base of the lever body and gradually transitions to underside of handlebar, unless a groove is provided in face of handlebar to seat housing in.
3. [] Retain housing temporarily with adhesive tape or ties to handlebar (only to point handlebar covering will end near stem).
4. [] Find route for housing from handlebar to other stop (at stem, headset, bridge, or caliper) that is as direct as possible, without any unnecessary deflections or abrupt bends.
5. [] If housing will be routed to stop on a caliper arm, use brake fourth-hand tool to hold pads to rim to put caliper in its working position.
6. [] With housing positioned adjacent to stop, adjust housing longer and shorter until length is found that keeps abrupt bends to a minimum (where housing enters stops).

7. [] Mark housing at point that is even with closed end of housing stop.
8. [] Remove housing from inner wire and cut housing at mark.

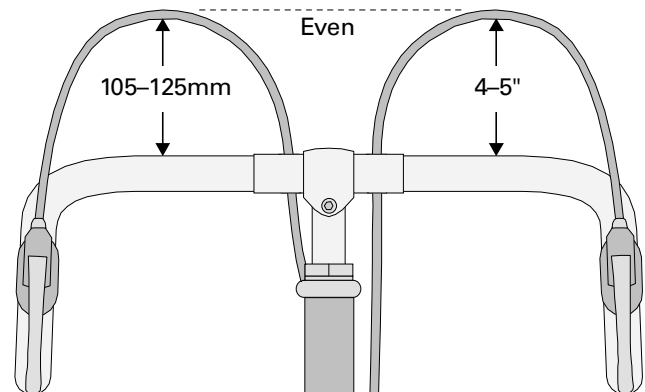
DROP-BAR/NON-AERO'-BRAKE-LEVER HOUSING LOOPS

Non-aero' brake levers are brake levers that are designed to have the brake-cable housings rise out of the top of the lever bodies and form free loops that go over the top of the handlebar on the way to the brakes.

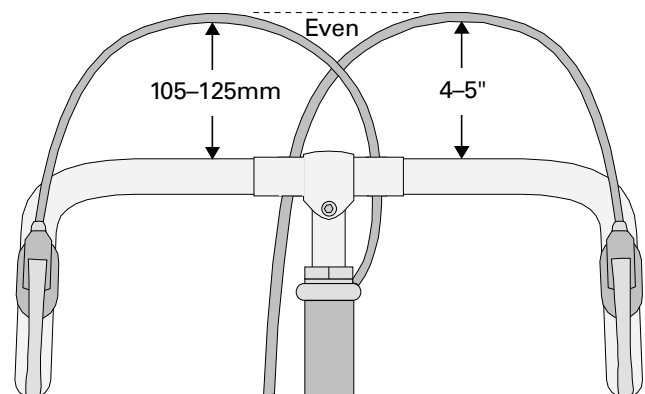
Normal routing

It is normal that the cable from the right lever go to the rear brake. It may be changed at customer request, but not because the shop decides that the unconventional routing is better and should be the shop standard. Anyone that has ever ridden a bike with hand brakes expects the right lever to operate the rear brake; it would be dangerous to surprise someone with a bike that had levers set up opposite from the norm.

The housing loops should be of equal height, and should peak at a height of 115mm (± 10 mm) above the handlebar. This is equal to a height of 4.5" ($\pm .5$ ").



35.8 Normal cable routing when the housing stop on the front brake is on the bike's left side.



35.9 Normal cable routing when the housing stop on the front brake is on the bike's right side.

Sizing right-lever housing loop

1. [] Insert ferrule into hole in top of lever body.
2. [] Insert one end of housing piece into ferrule.

There may be a housing stop (or housing guide) for the rear-brake cable at the front end of the top tube either centered on the top, or offset to the right or left side. If the housing stop (or guide) is centered on the top of the tube, then the loop from the right lever may go around either side of the stem. If the front brake has a housing stop on the right side of the bike, it may be preferred to go around the left side of the stem to make the front and rear loops appear more symmetrical. If the housing stop is on the right side of the frame, then the housing loop must go by the right side of the stem. If the housing stop is on the left side of the frame, then the housing loop must go by the left side of the stem.

Some bikes are set up with the housing loops from the brake levers routed *under* the handlebar. This decreases support for the housing, leading to an increase in housing failure; routing over the top of the handlebar is strongly recommended.

3. [] Route housing over handlebar, past correct side of stem, and to housing-stop/guide on frame.
4. [] Adjust length of loop so that it peaks 115mm (±10mm) above top of handlebar. (Make loop height equal to left-side loop, if left-side loop is in acceptable height range.)
5. [] If housing will stop at fitting on top tube, mark housing at point that is even with closed end of housing stop on frame, then cut housing at mark.
6. [] If housing will go through a tunnel guide and will not stop until it is past the seat tube, use tape to temporarily fix housing to top tube when loop height is correct. (Excess housing length will be removed when sizing loop at rear brake.)

Sizing left-lever housing loop

The loop of housing from the left lever may go to a variety of locations. It may end at a stop built into the headset, at a stop built in to a bridge that connects the two sides of the fork, or at the brake. The stop at the brake may be on the left, the right, or even at the center. In *every* case, the housing-loop length should be set at a length that makes it equal in height to the right-lever loop (unless the right-lever loop is outside the acceptable range). It should also be routed so that it does not have to deflect around anything.

If one end of the housing ends at a stop on a caliper arm, then the motion of the caliper arm should be considered. When sizing the housing, the caliper arm should be in a position close to its actual working position.

1. [] Insert ferrule into hole in top of lever body.
2. [] Insert one end of housing piece into ferrule.
3. [] If housing stop is on brake caliper, use brake fourth-hand tool to hold pads to rim so that housing stop will be in its working position.

If the housing stop for the front brake is in any of the following locations: on the left side of the brake caliper, on the headset, on the center of a bridge between the sides of the fork, or on the brake at the center, then the left-lever housing loop should come down on the left side of the stem. If the housing stop is on the right side of the brake, then the housing loop should come down on the right side of the stem.

Some bikes are set up with the housing loops from the brake levers routed *under* the handlebar. This increases housing bends, leading to an increase in housing failure; routing over the top of the handlebar is strongly recommended.

4. [] Route housing over handlebar, past correct side of stem, and to housing stop.
5. [] Adjust length of loop so that it peaks 115mm (±10mm) above top of handlebar. (Make loop height equal to right-side loop, if right-side loop is in acceptable height range.)
6. [] Mark housing at point even with closed end of housing stop, then cut housing at mark.

BMX/FREESTYLE-BRAKE-LEVER HOUSING LOOPS

Sizing and routing the right-brake-lever housing loop

The housing loop from the right brake lever goes to the top tube in most cases, but on occasion goes to a device on the stem called a rotor.

If the housing loop goes to the top tube, it should be set just long enough to allow full rotation of the handlebar, or 360° of rotation (whichever comes first). The housing should go below the handlebar and stay to the right side of the stem.

If the housing is routed to a rotor, it should be a gentle curve that is as short as possible, without creating any abrupt bends at either end.

35 – BRAKE-CABLE SYSTEMS

Sizing and routing the left-brake-lever housing loop

The housing loop from the left brake lever usually goes directly to the brake, but is sometimes routed down through the center of the stem.

If the loop of housing goes directly to the brake, the brake pads must be held to the rim while sizing the housing loop. The loop should be a gentle curve that is as short as possible, without creating any abrupt bends at either end. The housing should stay in front of the handlebar.

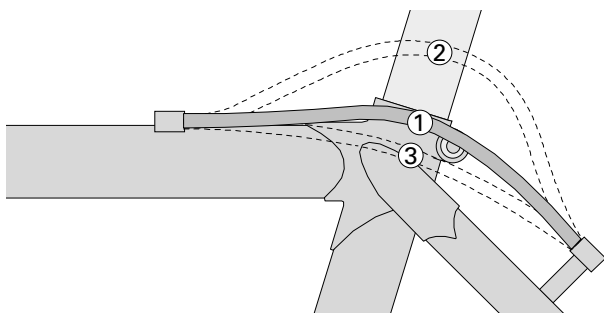
If the housing is routed into the center of the stem, the loop should be a gentle curve that is as short as possible, without creating any abrupt bends at either end. The housing should stay in front of the handlebar.

UPRIGHT-BAR BRAKE-LEVER HOUSING LOOPS

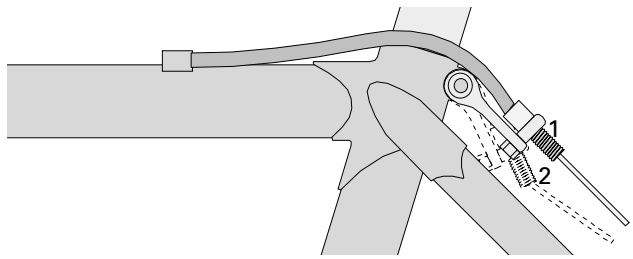
The housing loop from the right lever should be set up in the same fashion as on an MTB right lever. The housing loop for the left lever should be set up in the same fashion as a BMX/freestyle left lever that has housing routed directly to the brake.

REAR-HOUSING-STOP LOOPS

The loop can go around either side of the seat post/seat tube, except that it should be on the opposite side of any seat post quick-release lever. The length of the loop should be set to minimize abrupt bends where the housing enters the stops, and to minimize double bends. If the housing stop is a hanger mounted to the seat-post binder, the angle of the hanger might need to be adjusted. The hanger position should be set so that the inner wire will come out of the hanger parallel to the line of the hanger or any adjusting barrel on the hanger.



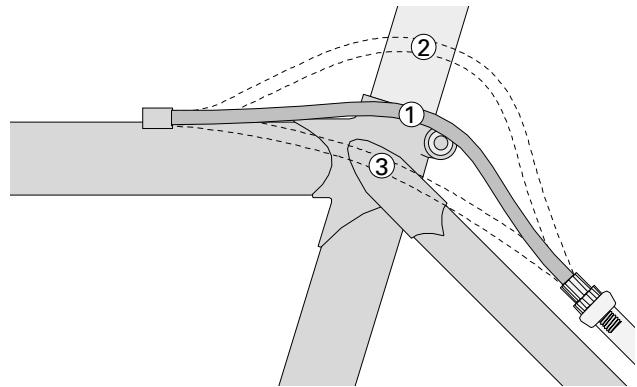
35.10 When housing is the correct length (1), it enters the stop straight. When it is too long (2) or too short (3), then it bends at the point it enters the stop..



35.11 When an adjustable cable hanger is correctly aligned (position 1), then the inner wire leaves the adjusting barrel without a bend. If the hanger is incorrectly aligned (position 2), the inner wire changes direction as soon as it exits the adjusting barrel.

REAR-CALIPER HOUSING LOOPS

The position of the housing stop on a caliper changes as the caliper opens and closes. The small amount of motion that occurs under normal operation of the caliper is not an issue; however, when the caliper is not hooked up, the housing stop will move a significant distance from its operating position. For this reason, the brake pads should always be held to the rim when sizing a loop of housing that goes to the caliper. The length of the loop should be set to minimize abrupt bends where the housing enters the stops, and to minimize double bends.



35.12 When the length of the housing loop to a rear sidepull brake is correct (1), then it enters the adjusting barrel in a straight line. If the length is too long (2), or too short (3), then the housing bends as it enters the adjusting barrel.

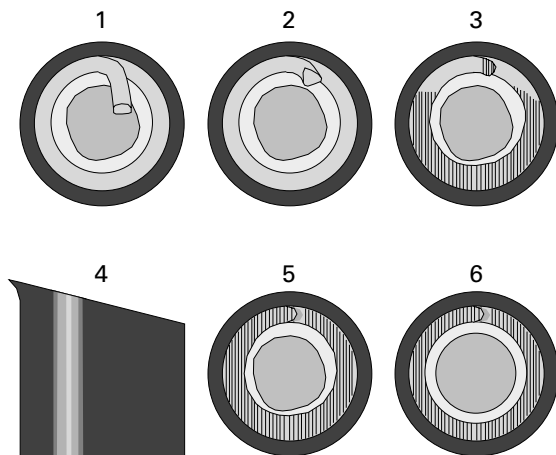
PREPARATION AND INSTALLATION OF THE CABLE SYSTEM

HOUSING-END FINISH

After cutting a piece of wound housing to length, the end must be properly finished to optimize brake performance. The fresh-finished surface should cover all 360° of the end of the housing, and the surface should be perpendicular to the axis of the housing. A hand file or grinder can be used to clean up the end of the housing. After the end has been filed or ground, then a taper reamer is used to remove any internal burr that may have been created during the filing or grinding.

When using a grinder to finish the end of the housing, a great deal of care must be used to prevent heat from building up and melting the outer plastic sheath or inner liner. Press the end of the housing very lightly against the grinding wheel to reduce heat. A useful technique to keep the housing cool is to dip the end into a water bath after every 2–3 seconds of grinding. The housing should be supported on the grinder's tool rest to keep the housing aligned to the wheel surface, and to prevent the end of the housing from being pulled out of line by the grinding wheel.

A file is slower to use, but less likely to create enough heat to melt the plastic on the housing. Care must be taken to keep the end of the housing perpendicular to the file face to prevent the finished face of the housing from ending up at the wrong angle.



35.13 1. Mangled coil: needs to be re-cut. 2. Good cut: ready for finishing. 3. Incompletely filed or ground end. 4. Filed end not perpendicular to housing axis. 5. Completely finished end ready for reaming. 6. Filed and reamed housing end.

After filing or grinding a piece of housing, the inner liner may need to be reopened, and burrs left by the filing or grinding need to be removed. A pushpin is a useful device for reopening the inner liner. A miniature taper reamer (of the type used with a rotary/Dremmel tool) is useful for removing the burr from the inside of the housing end.

INSTALLING FERRULES

It is important to use ferrules *anytime they will fit*. Fit a ferrule onto the housing and check if the ferrule will install into the housing stop or adjusting barrel. If it fits without jamming, it must be used. Dia-Compe aero' brake levers use a special ferrule that has a larger O.D. than common ferrules.

Crimping ferrules onto housing

Ferrules come from the factory crimped onto the housing so that they won't get lost in transit. Once a cable is installed on a bike, there is no advantage to having the ferrules crimped on. Crimping is a waste of time, and it complicates re-using them. Crimping ferrules is not recommended.

LUBRICATION

Any housing used for brake systems should be lined with a plastic sheath. Performance will always be improved by dripping or spraying oil into the housing before installing the cable system. Grease should not be used because it can congeal when it gets cold or old, which lowers the performance of the cable system.

Unlined housing is not recommended, but if used, the best lubricant is grease, which should be put on the inner wire.

36 – CABLE-OPERATED RIM-BRAKE CALIPERS

ABOUT THIS CHAPTER

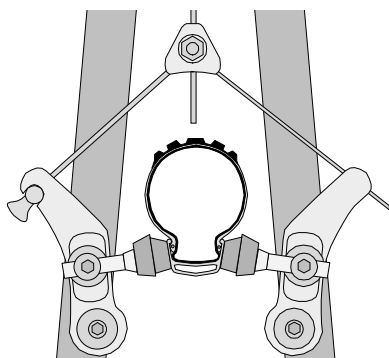
This chapter is about the mechanisms mounted near the wheel that apply pressure to the rim to control the bike's speed. This chapter does not cover brakes that are mounted at the hub, or brakes that are hydraulically operated. The brake calipers in this chapter are operated by a wire-cable system, which is covered in the earlier chapter, **BRAKE-CABLE SYSTEMS**. When working on the brake calipers covered in this chapter, it is usually necessary to work with the brake levers (covered in the earlier chapter, **BRAKE LEVERS**), and the brake-cable system, as well.

After the **GENERAL INFORMATION** section, this chapter has a section about brake-pad-alignment systems, and separate sections for several different styles of brake calipers. These sections are: **PAD-ALIGNMENT SYSTEMS**, **CANTILEVER CALIPERS**, **SIDEPULL CALIPERS**, **DUAL-PIVOT CALIPERS**, **CENTERPULL CALIPERS**, and **U-BRAKE CALIPERS**. After the sections on specific types of caliper systems, there is a section called **FINISHING** that applies to completing brake work on all types of calipers, and then the chapter ends with the section **CABLE-OPERATED RIM-BRAKE-CALIPER TROUBLESHOOTING**.

GENERAL INFORMATION

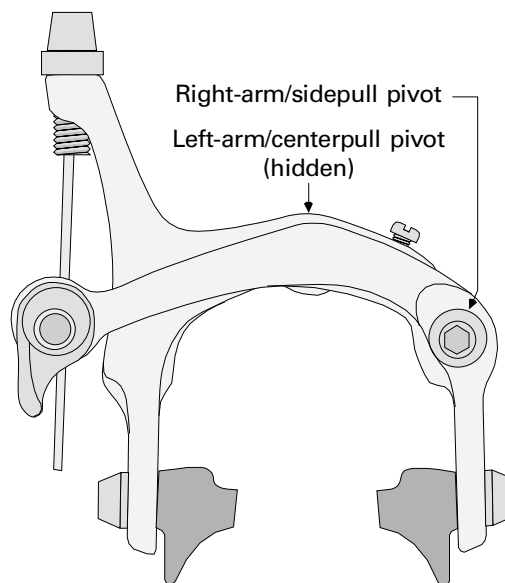
TERMINOLOGY

Cantilever caliper: A caliper system that has each caliper arm mounted to its own pivot; the pivots are fixed to the frame or fork, and are mounted below the rim.



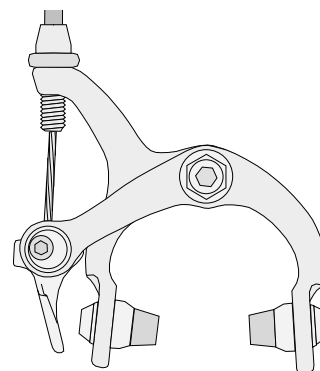
36.1 A cantilever brake caliper.

Dual-pivot caliper: A caliper system that has two pivots; the pivot for one arm is centered over the top of the rim (like a sidepull caliper), and the pivot for the other arm is above, and outward from the rim (like a centerpull caliper).



36.2 A dual-pivot caliper.

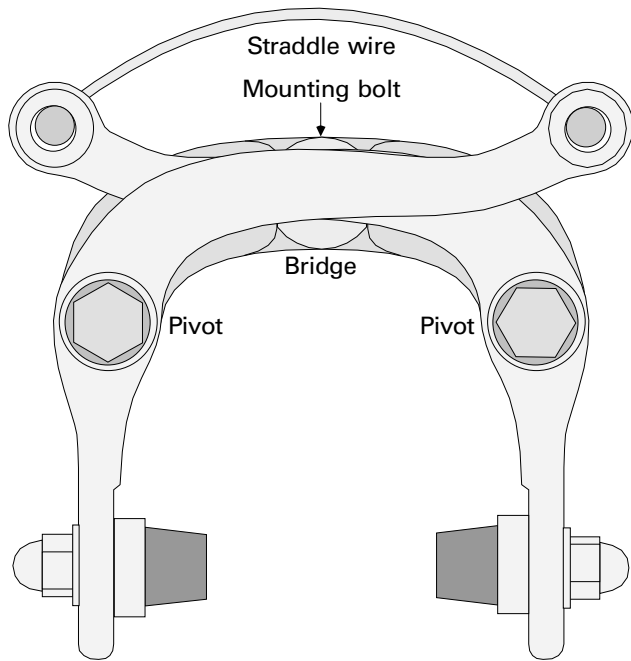
Sidepull caliper: A caliper that is distinguished by two things: the caliper arms share a common pivot (centered above the rim) that also serves as the mount for the caliper, and the cable system attaches to the caliper by means of the housing stopping at one arm and the inner wire attaching to the other arm. The sidepull caliper gets its name from the fact that the common configurations of this design rely on a cable system routed to the side of the caliper.



36.3 A typical sidepull caliper.

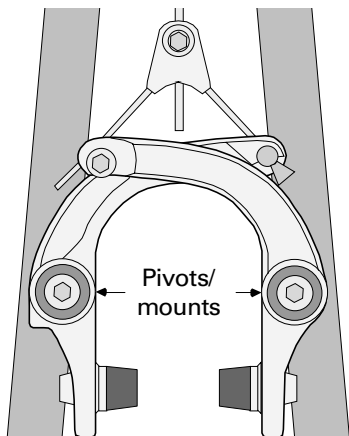
36 – CABLE-OPERATED RIM-BRAKE CALIPERS

Centerpull caliper: A caliper system that has two pivots mounted on an arch; the pivots are above and outward of the rim. The centerpull caliper gets its name from the fact that the cable system goes directly to the center of the caliper. The name is misleading, because U-brakes (and most cantilevers) have this same feature, but differ in other ways. It is the number and location of the pivots that are unique to centerpull calipers.



36.4 A typical centerpull caliper.

U-brake caliper: A caliper that is a cross between centerpull and cantilever calipers. Like a centerpull, the pivots are located above and outward of the rim. Unlike the centerpull caliper, the pivots are fixed to the frame or fork, rather than to part of an arch integral to the caliper. Unlike the cantilever caliper, the pivots are above, instead of below, the rim.



36.5 A typical U-brake.

Brake caliper: The mechanism that applies braking force to the rim. It consists of caliper arms mounted on pivots. A brake shoe is mounted on one end of the caliper arm. The cable system is attached to the other end of the caliper arm. The brake caliper can also simply be called a *caliper*.

Caliper arm: The lever arm that applies braking force to one side of the rim. The brake caliper always consists of two caliper arms that work in opposition to each other. A caliper arm can also just be called an *arm*.

Front or rear (of the brake): Any reference to the front of the brake applies to the portion that faces out from the frame or fork. This applies to both front and rear brakes. All references to the rear of the brake will mean the portion closest to the frame or fork. Again, this applies to both brakes.

Left or right (side of brake, or caliper): These references always apply to the side of the caliper, as seen when viewing the portion of the caliper that faces out from the frame or fork. It does not refer to a particular side of the bike.

Pivot bolt: A bolt that goes through the pivot hole in a caliper arm. Most typically, a pivot bolt is found in sidepull brakes, where it also serves as a mounting bolt.

Brake shoe: The assembly that holds the rubber piece that rubs on the rim.

Shoe stud: The post that connects the brake shoe to the caliper arm. It may be threaded or un-threaded.

Brake pad: The rubber piece that rubs against the rim.

Entry-end (of brake pad): The end of the pad that a point on the rim reaches first as the rim rotates through the brake pads. Traditionally, the word *back-end* would be used, but this only makes sense when the brakes are located somewhere near the top of the wheel, which is not always the case on suspension bikes.

Exit-end (of brake pad): The end of the pad that a point on the rim reaches last as the rim rotates through the brake pads. Traditionally, the word *front-end* would be used, but this only makes sense when the brakes are located somewhere near the top of the wheel, which is not always the case on suspension bikes.

Smooth-stud brake shoe: A brake shoe that has an un-threaded shoe stud. It is retained to the caliper by means of an eyebolt called a shoe-anchor bolt.

Threaded-stud brake shoe: A brake shoe that has a threaded stud. It is retained to the caliper by a nut threaded onto the stud.

Shoe anchor bolt: The shoe-anchor bolt is an eyebolt that the stud of a smooth-stud brake shoe inserts into, in order to mount the brake shoe to the caliper

arm. An eyebolt is a bolt with a hole in its head. When the shoe-anchor bolt is pulled through the caliper arm, the shoe stud is pressed against the face of the caliper arm and immobilized.

Shoe-anchor nut: The nut that threads onto the shoe-anchor bolt to pull the shoe-anchor bolt through the caliper arm to secure the brake shoe to the caliper arm.

Shoe-fixing nut/bolt: A shoe-fixing bolt is a bolt that threads directly into a brake shoe to secure it to a caliper arm. A shoe-fixing nut threads onto the stud of a threaded-stud brake shoe to secure the shoe to the caliper arm.

Alignment washers: Sloped, concave, or convex washers that permit the brake shoe to be aligned at different angles for pad toe and vertical-angle adjustment.

Straddle-wire: A cable on a cantilever, centerpull, or U-brake that goes from one side of the caliper to the other to connect the caliper arms. By means of a cable carrier, the primary wire pulls up on the straddle-wire.

Cable carrier: Connects the primary brake wire to the straddle-wire. The cable carrier contains a pinch mechanism that secures it to the primary wire.

Link wire/unit: Used instead of a straddle-wire on some cantilever brakes, the link unit connects to one caliper arm and diverts the primary wire to the other caliper arm.

Pad height: An adjustment of the brake pad that sets the face of the pad so that it contacts the rim's braking surface at the right height.

Pad toe: An adjustment of the brake pad that sets whether both ends of a pad reach the rim simultaneously, or not.

Pad tangent: An adjustment of the brake pad that sets whether both ends of the pad are the same height relative to the rim.

Pad vertical angle: An adjustment of the pad that sets whether the top and bottom edges of the pad face reach the rim's braking surface simultaneously.

Pad clearance: The clearance between the pad face and the rim.

Pad centering: The adjustment of the pad clearances on both sides of the rim to be equal.

Quick-release: A mechanism that changes the pad clearance so that the tire will clear the brake pads when the wheel is removed.

Adjusting barrel: A hollow screw that changes the effective length of the brake inner wire. It is inserted into the lever body, a caliper arm, or a hanger or stop

on the frame. The brake inner wire goes through the adjusting barrel. The outer end of the adjusting barrel has a socket into which the cable housing is inserted.

Pinch mechanism: A bolt and/or nut that secures the inner wire to a caliper arm or a cable carrier.

Braking surface: The relatively flat face of the rim that the brake pads contact.

Pivot stud: A hollow stud, smooth on the outside and threaded on the inside, that a cantilever arm or U-brake arm is mounted on. Some pivot studs are brazed or welded onto a frame; pivot studs may be threaded into a mount that is part of the frame or fork.

Spring plate: A surface with one or more holes into which the caliper-arm return spring inserts.

Pivot bushing: The bushing inside the pivot hole of the caliper arm. Some pivot bushings are fixed to the caliper arm and rotate with it. Other pivot bushings rotate independently of the caliper arm and stay fixed to the pivot stud once the caliper arm is mounted.

PREREQUISITES

Brake calipers are part of a system. To service the caliper without checking or servicing the other parts of the system could be considered negligent. This omission is also just bad service. The system consists of the brake lever, the cable system, the caliper (including pads), and the rim.

Brake lever

When servicing brake calipers, the brake should be checked for damage, proper alignment, and security. The inner wire is likely to need attachment to the brake lever. All of these items are covered in the **BRAKE LEVERS** chapter.

Brake-cable system

Attachment of the cable system to the caliper is covered in the procedures in this chapter, but cable-system replacement, sizing, and lubrication should all be done when servicing a caliper. These items are covered in the **BRAKE-CABLE SYSTEMS** chapter.

Hub adjustment

If a hub is loose, it will result in lateral motion of the rim. That affects pad clearance and pad centering. Hubs should be adjusted to eliminate visible motion of the rim. Hub adjustment is covered in the **ADJUSTABLE-CONE HUBS** chapter and the **CARTRIDGE-BEARING HUBS** chapter.

Rim true

Lateral true of the rim affects pad-clearance and pad-centering adjustments. Dish errors affect centering adjustments and pad-height adjustments on brake calipers that mount on pivot studs, such as cantilevers and U-brakes. Round errors affect setting pad height; if the rim braking surfaces have a pronounced slope, round errors create erratic brake feel. Spoke-tension errors do not affect brakes, but they lead to unstable true. For truing rims, see the **WHEEL TRUING AND REPAIR** chapter.

Wheel installation

The wheels must be properly aligned in the bike before the pads can be adjusted. The vertical position of the wheel affects pad height. The centering of the wheel in the frame or fork will affect pad-centering adjustments, and in many cases the centering of the wheel will affect pad-height adjustments.

INDICATIONS

Maintenance

Brake systems need periodic maintenance because pads wear and cable systems deteriorate. Because of safety issues, shops should encourage periodic preventive maintenance, rather than limiting service to repair of existing problems. It is a reasonable policy to require service of the entire brake system if any work is to be done on the brake system at all.

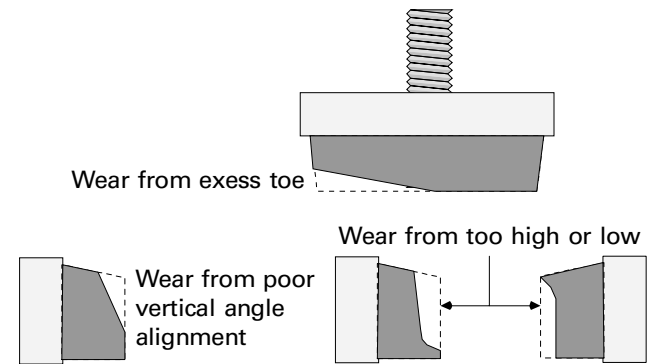
Replacing the wheel or rim

When a rim or wheel is replaced with one that is not identical, changes in the shape of the rim can cause problems with the brakes. Changes in rim width affect pad clearance, pad height, and pad vertical angle. Changes in the angle of the rim's braking surface affect the pad's vertical angle. Changes in the height of the rim's braking surface can affect pad height. When a rim or wheel is replaced with one that is not identical, count on doing extensive brake work.

Symptoms indicating need for pad replacement and alignment

It would be a good idea to replace brake pads any time any type of brake service is being performed. There are, however, some specific conditions that indicate the pads should be replaced. These include: pads worn unevenly because of excess toe, pads worn unevenly because of poor vertical-angle alignment, pads worn unevenly because of being positioned too high or low on the rim's braking surface, pad faces con-

taminated by metal fragments, pads worn so that grooves or other patterns in the face are gone, and pads worn 50% or more.



36.6 Pad wear that indicates poor pad alignment.

Symptoms indicating need for pivot adjustment or service

Some calipers have adjustable pivots, and others do not. Sidepull and dual-pivot calipers usually have adjustable pivots. Loose pivots can cause brakes to squeal and to feel grabby. Either of these symptoms should lead to inspection for free-play in the pivot adjustment if the caliper has an adjustable pivot. If the pivot adjustment is too tight, the caliper will fail to open fully when the brake lever is released. This symptom can be caused by several other factors including excess cable friction, lack of lubrication on pivot surfaces, damaged pivot studs, and weak or damaged return springs.

Symptoms indicating need for clearance or centering adjustment

Pad clearance may need adjustment because the pads are too far, or too close to the rim. When the pads are too far from the rim, the brake lever will come too close to the handlebar or grip during brake operation, and braking force will be limited. When the pads are too close to the rim, three problems occur: it is difficult to keep the pads from rubbing the rim, the rider cannot use the brake levers comfortably, and on some brakes it becomes difficult to use the release system to move the pads away from the rim for wheel removal.

On most brake types, the pads need to be centered to reduce the likelihood of the pads rubbing the rim when the brakes are not in use. On some caliper designs, notably on dual-pivot calipers, when the pads are not properly centered the brakes tend to push the rim to one side during brake operation. This increases the force needed to apply the brakes.

TOOL CHOICES

Some brake tools are virtually universal, while others are specific to certain brands and models of brakes. Table 36-1 covers all the tools for the job. The

preferred choices are in **bold**. A tool is preferred for a balance among: ease of use, quality, versatility, and economy. When more than one tool for one function is **bold**, it means that several tools are required for different configurations of parts.

BRAKE TOOLS (table 36-1)

Tool	Fits and considerations
THIRD-HAND TOOLS (for holding pads to rim)	
Park BT-1	Inexpensive, not universally effective
Park BT-4	Inexpensive, works on some cantilevers
Park BT-5	Expensive “universal” tool that is not truly universal
Pocket Pro Velcro	Velcro strap, not universally effective
United Bicycle Tool WB-BRK	A truly universal third-hand tool borrowed from the carpentry trade (called Quick Grip, also)
VAR 02	Expensive, not universally effective
VAR 939	Expensive, not universally effective
Wire-types, various manufacturers	Inexpensive consumer tools, not universally effective
FOURTH-HAND TOOLS (for pulling slack from brake inner wire, same tool used for derailleurs)	
Dia-Compe 556	Tends to let inner wire jam in tool
Hozan C356	Tends to let inner wire jam in tool
Lifu 0100	Consumer tool
Park BT-2	Least tendency for inner wire to jam in tool
VAR 233	Tends to let inner wire jam in tool
SIDEPULL-CALIPER TOOLS	
Dia-Compe 445	Set, includes: 10mm open with 8mm box, and 10mm box with 9mm box: thin wrenches for brake-pivot nuts
Dia-Compe 446	Set, includes: 13mm open with 12mm box, 10mm open with 9mm box, 8mm open with 10mm box: thin wrenches for brake-pivot nuts
Park BT-3 (pair)	Used for twisting ends of caliper arms to toe brake pads
Park CBW-6	Set (includes CBW-1 thru CBW-5) of thin 8mm, 9mm, 10mm, and 11mm wrenches for brake-pivot nuts
Park OBW-1	10mm & 13mm thin offset wrench for brake centering and pivot adjustment
Park OBW-2	11mm & 12mm thin offset wrench for brake centering and pivot adjustment
Park OBW-3	14mm thin offset wrench for brake centering and pivot adjustment, with pronged end for muscling caliper springs to adjust centering
Scura Centering Tool	Fits in the coils of a sidepull spring so that spring can be muscled
Weinmann 682/683/693	Set, includes: 9mm/10mm box, 11mm open, 8mm box with 10mm open: thin wrenches for brake nuts
Weinmann 685 & 687	4mm & 5mm sockets for hex fitting on end of pivot bolt on old Weinmann brakes (for centering)
United Bicycle Tool Langley Fifth Hand	Very useful for disengaging and engaging caliper springs
CANTILEVER-CALIPER TOOLS	
Bicycle Research BM-1	Mill for repairing pivot-stud damage and cleaning paint off pivot stud
Shimano TL-CB-10	Set of 6 tools for setting up Shimano Pro-Set type brakes with link-wires

TIME AND DIFFICULTY

Brake service (including caliper, cable system, and lever), is a 10–25 minute job of moderate difficulty. The wide range is because of the differences in types of brakes, and because it would be considered normal to include some minor lateral rim truing in many cases. This time is for a single brake, not a pair.

COMPLICATIONS

Rim-true problems

It is normal to anticipate having to touch-up the lateral true so that pads do not rub at a reasonable clearance setting. In many cases, the condition of the rim cannot be made reasonable with just a touch-up. Ideally, this should be determined at the time the repair is checked into the shop. If it is not caught at this time, the mechanic is faced with choosing between compromising the brake adjustment, giving away extensive time for rim work, or putting the job on hold until the customer authorizes the necessary rim work.

Some rim problems cannot be repaired, and compromise the brake performance to the point that it would be a mistake to complete the brake work, and then imply to the customer that everything is acceptable. If the rim has a significant flat spot, then pads that are set at the correct height will rub the tire at the flat spot. If the braking surface of the rim is distorted (bulging out or indented), then the brakes will grab whenever the damaged section moves through the brake pads. If the rim cannot be brought into a condition of true with 1mm or less lateral wobble, then brake clearance must be compromised (either by letting brakes rub or leaving them too loose). The importance of taking a good look at the wheels before selling a customer brake work cannot be over-emphasized.

Wheel-installation problems

It is very important to make sure the wheels are correctly installed before starting any brake work. For example, if cantilever pads are adjusted to a rim that is 3–4mm off-center in the fork, when the wheel is positioned correctly, the pad heights could easily be off enough to cause a pad to hit the tire or drop below the rim.

Damaged pivot studs

Cantilever pivot studs can be easily damaged in a crash, or by over-tightening the caliper-arm mounting bolt. When a pivot stud is crash-damaged, there is a chance that it may break off during use of the

brake. Furthermore, if the pivot stud is bent, it may be very difficult to correctly align the pads. When a mounting bolt is tightened too much on a caliper arm that has a bushing fixed to the arm, the pivot stud takes the load of the mounting bolt. The result can be that the end of the pivot stud can become mushroomed, and inhibit the pivoting of the caliper arm. This condition can be repaired by delicate filing, or by patient use of emery cloth, to reduce the diameter. The Bicycle Research BM-1 mill makes this repair quickly, precisely, and easily.

Mis-positioned pivot studs

Unfortunately, it is not unusual for bikes to be manufactured with poorly-positioned cantilever pivot studs. If the pivot studs are not parallel to each other and to the central plane of the wheel, then it can be difficult to correctly adjust pad toe. If the pivot studs are too low or too high, then it can be difficult to adjust the vertical angle of the pads. In both cases, a repair can be made by changing the angle of the pad face with emery cloth. The negative consequence is the reduced pad wear-life.

Mis-positioned spring plates

The spring plates are usually an integral part of the pivot stud. If the pivot studs are not rotated equally, then the spring-hole heights may not be symmetrical, making it difficult to center a cantilever brake. Holes can be enlarged with some difficulty. The only other alternative is to deliberately distort one of the springs in the brake.

Sidepull and centerpull brake reach

The reach range of a brake caliper is the range of height that the brake pads can be positioned within, measured from the center of the caliper-mounting bolt. Sidepull and centerpull brake calipers come in different reaches. If a caliper with incorrect reach is installed on the bike, it can be impossible to set the brake-pad height correctly. Minor improvement can be made by lengthening the slot into which the shoe stud is inserted.

Poor routing design at the seat cluster

On some frames, the rear brake cable is forced to make some awkward changes in direction in a very confined area. This can cause several problems. The loop of housing may end up with compound bends that increase cable friction. This may cause the brake to feel spongy, and to fail to fully release. On very small-frame bikes with cantilever brakes, this has been such a problem that the frame designers have tried to

dispense with the piece of housing in this location. The alternative is some sort of metal tube that routes the bare wire around the seat tube. These tubes also create extra friction, and sometimes forces the inner wire to approach the caliper at an odd angle. That can adversely affect brake centering.

Compatibility of levers and calipers

Not all brake calipers are compatible with all types of brake levers. If the lever pulls too little cable, then the brake pads will need to be set very close, and maximum brake force will still be limited. If the lever pulls too much cable, it is less of a problem, but the brake pads would need to have more clearance than normal so that the rider would not have to operate the brake with fingers fully extended. There is no way to determine the compatibility in advance. Inspect for the problems described above, if not using brand- and model-matched brake levers and calipers.

Fat tires with narrow rims and cantilevers

When fat tires are used with narrow rims, pads on cantilever brakes may interfere with the tire when the pad height is correct. There is no good solution that does not involve changing equipment; compromising ideal pad height is the only choice except changing the tire, rim, or brake caliper (to something other than a conventional cantilever).

Small frames and cable-carrier clearance

Small frames with conventional cantilever brakes sometimes have a clearance problem between the cable carrier (or link-unit head) and the stop for the cable housing. If the cable carrier is too close, then it may stop at the housing stop before full braking force is applied to the rim. It can appear to be acceptable when the brake is first set up, but then become a problem as the brake pads wear. If necessary, shorten the ideal straddle-wire length or the link-unit length in order to maintain at least 20mm of exposed wire between the cable-carrier/link-unit head and the housing stop.

Loose pivots on cantilevers

Cantilever brakes usually do not have an adjustment to reduce play in the pivots, but excess play can cause brakes to squeal. If a cantilever arm has a fixed pivot bushing, then the manufacturer is relying on the pivot-stud manufacturer to provide a stud with the correct dimension. If the pivot stud is loose in the bushing and causing squeal, a shim can be made out of thin steel, such as feeler-gauge blades that are under .2mm thick. When cantilevers have independent pivot bushings (rotate separately from the cali-

per arm), then the cantilever manufacturer is in control of the tolerances on both critical parts, and sloppy pivots are rarely an issue.

Damaged caliper parts

Damaged caliper arms and pivot bolts are dangerous. Bent parts should not be bent back. If the parts are available, then they should be replaced. Most often, it is necessary to replace the whole caliper.

Alignment washers and shoe studs with memory

Alignment washers and smooth shoe studs often get imprinted by the surface they press against when the brake shoe is secured. If the pad was secured when it was improperly aligned, then it may tend to seek the same improper position each time the pad is secured. Sometimes the imprinted surfaces can be cleaned up with a file or emery cloth. Sometimes rotating a washer, or switching it to the opposite side of the caliper, will solve the problem. Other times it will be necessary to replace the washers or brake shoe to solve the problem.

ABOUT THE REST OF THIS CHAPTER

The rest of this chapter is divided into the following sections:

PAD-ALIGNMENT SYSTEMS

CANTILEVER CALIPERS

SIDE-PULL CALIPERS

DUAL-PIVOT CALIPERS

CENTER-PULL CALIPERS

U-BRAKE CALIPERS

FINISHING

CABLE-OPERATED RIM-BRAKE-CALIPER TROUBLESHOOTING

Each caliper section contains sub-sections about pivot overhaul and adjustment (when appropriate), caliper installation, cable attachment, pad alignment, and clearance and centering adjustments. Each of these sections may be further subdivided into further sub-sections that cover specifics for a variety of brakes. This means that to complete a section (on cantilever brakes for example), it will be necessary to skip over several sub-sections that apply only to brakes of another type. This is necessary because of the recent proliferation of brake-caliper designs.

PAD-ALIGNMENT SYSTEMS

There are four systems for aligning brake pads. Many of these apply to several types of brake calipers. Rather than repeating the same alignment technique for several systems, each is described in detail in this section, before description of the various brake-caliper types. In the procedure for a specific caliper type, you will be asked to identify the pad-alignment system. It is assumed that you will already be familiar with the different systems, or that you will refer back to this section to determine the correct method of pad alignment.

The simplest alignment system is a plain threaded-stud pad in a slot in the caliper arm. With this system, the stud is always perpendicular to the mounting surface on the caliper arm. For obvious reasons, this system is called **simple threaded-stud-pad alignment**. A variation on this system relies on a set of concave and convex washers between the caliper arm and the shoe, and between the caliper arm and the mounting nut. These washers permit the stud to be moved away from a perpendicular position to the mounting face of the caliper arm, so that more alignments can be done. This system is called **threaded-stud/curved-washer pad alignment**.

There are two pad-alignment systems in which the shoe stud is smooth, instead of threaded. One smooth-stud system features a curved washer between the shoe stud and face on the caliper arm. This system is called **smooth-stud/curved-washer pad alignment**. The other of these systems features a sloped washer between the shoe stud and the caliper arm face. This system is called **smooth-stud/sloped-washer pad alignment**.

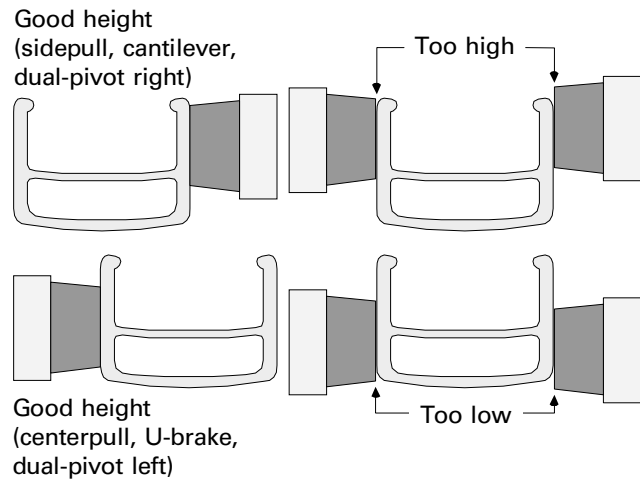
SIMPLE THREADED-STUD-PAD ALIGNMENT

This type of pad-alignment system is found on dual-pivot calipers, sidepull calipers, and centerpull calipers. A threaded stud on the brake shoe fits in a slot in the caliper arm. Height and tangent of the pad are fully adjustable, but no adjustments for toe or vertical angle are built into the system.

Height adjustment

1. [] Loosen mounting nut/bolt.

2. [] Slide shoe stud up/down in slot until desired height setting is achieved.

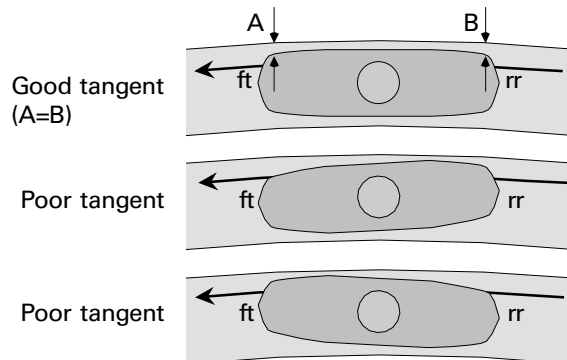


36.7 Proper pad height varies with the type of brake.

3. [] Gently secure mounting nut/bolt.

Tangent alignment

4. [] View brake pad from side of bike, then move viewpoint up or down until top corners of brake shoe are even with top edge of rim.
5. [] Twist brake shoe around axis of shoe stud until front and back corners of pad are simultaneously even with top edge of rim.



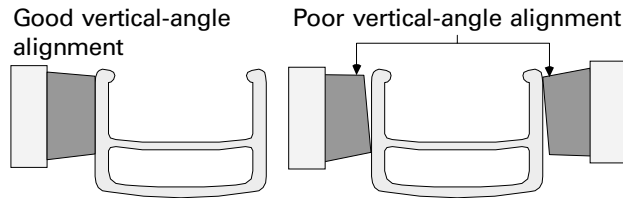
36.8 When pad tangent alignment is correct, the upper front and rear corners of the pad are equidistant from the top of the rim.

6. [] Check that height adjustment is still correct, then stabilize shoe with fingers or adjustable wrench while tightening mounting nut to 50–60in-lbs (17–20lbs@3').

Vertical-angle alignment

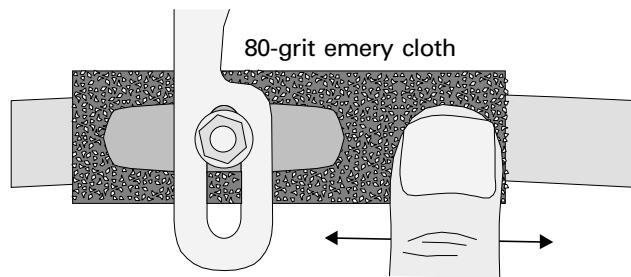
There is no easy adjustment for vertical-angle alignment. The vertical angles of the faces on different brake pads vary. One type of pad may match the angle of the rim's braking surface closely, while another may not. If possible, change pads to get a closer vertical-

angle alignment between the pad face and rim. The following procedure should be considered a good option if the vertical-angle alignment is close, but the procedure should not be ignored even if there is a big angle difference. When there is a big difference in the angles, pad wear will be rapid and the clearance adjustment will be lost quickly.



36.9 The vertical angle of the pad face should closely match the vertical angle of the rim's braking surface.

7. [] Place strip of 80-grit emery cloth between rim and brake pad (grit toward pad face).
8. [] Squeeze pads against rim with third-hand tool.
9. [] Rotate wheel and emery cloth back and forth through brake pads until vertical angle of pad face matches angle of rim face.



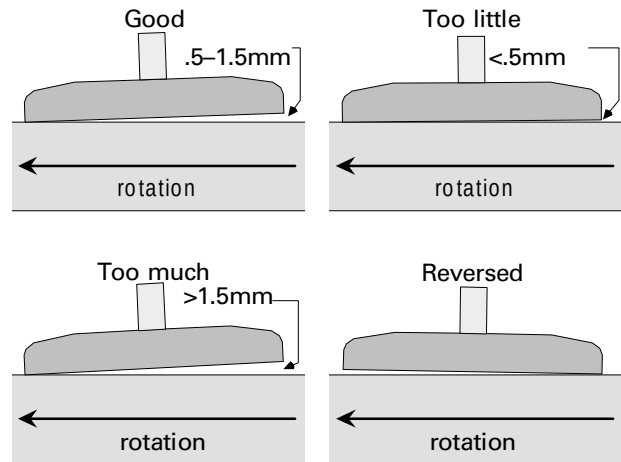
36.10 With the aligned pad pressed against the emery cloth, move the emery cloth and rim back and forth until the pad has been sanded to match the rim's vertical angle.

Toe alignment

Brake pads need toe to reduce squeal, particularly when the pads are new. When a pad is properly toed, the exit-end of the pad should reach the rim before the entry-end of the pad (see figure 36.11). If both brakes were at the 12:00 position on the wheel, toe could be described as having the front ends of the brake pads reach the rim before the rear ends. If pads have broken in properly to the rim, no toe should be needed, unless the pads squeal on a test ride.

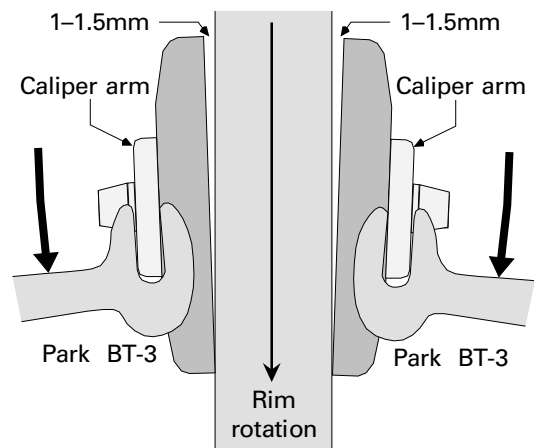
Because simple threaded-stud shoes have no means for adjusting toe, some rather crude means must be used to make this alignment. The most common method is to twist the caliper arms to align the pads. This method is suitable in most cases, but when the calipers are too strong or too finely finished, the preferred method is to modify the face of the pad by holding it against a

spinning grinding wheel. The following procedure covers the arm-twisting method only (see figure 36.12). When twisting arms, it is important to not twist the pivot bolt or mounting bolt of the caliper. To prevent this, both caliper arms should be worked with at once. If one needs to be twisted and not the other, then support one with the tool while bending the other. If both need twisting, twist both at once.



36.11 Properly-toed pads should clear the rim by .5–1.5mm at the entry end of the pad when the exit end just touches the rim.

10. [] Place Park BT-3 on each caliper arm, above or below pad (whichever is most convenient).
11. [] Apply twisting load to arm(s) until desired amount of clearance is achieved at rim entry-end of brake pad(s).



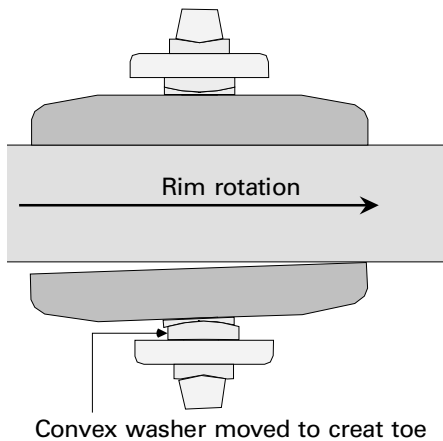
36.12 Using Park BT-3 tools to twist the caliper arms to adjust toe.

THREADED-STUD/CURVED-WASHER PAD ALIGNMENT

This type of pad-alignment system is primarily found on cantilever brakes and U-brakes. It is also found on upgrade pad sets that can be used with any caliper that comes with a simple threaded-stud pad-alignment system. A threaded-stud on the brake shoe fits in a slot in the caliper arm. Height and tangent of the pad are fully adjustable (in the same way as the simple threaded-stud system), but alignment washers between the shoe and the caliper arm permit simultaneous alignment of the toe and vertical angle of the pad face.

Toe alignment

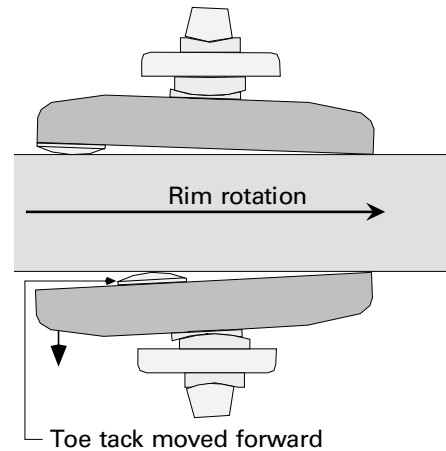
Brake pads need toe to reduce squeal, particularly when the pads are new. When a pad is properly toed, the exit-end of the pad should reach the rim before the entry-end of the pad. If both brakes were at the 12:00 position on the wheel, toe could be described as having the front ends of the brake pads reach the rim before the rear ends reach the rim. If pads have broken in properly to the rim, no toe should be needed, unless the pads squeal on a test ride.



36.13 When the convex washer is moved forward or backward, the end of the pad moves in or out.

The curved washer between the inside face of the caliper arm and the brake shoe enables toe adjustment. When this washer is pushed one way, the forward end of the pad moves in. When the washer is pushed the other way, the forward end of the pad moves out. Some mechanics find it easiest to manipulate the washer to align the pad. For other mechanics, the easiest approach is to manipulate the pad in order to position the washer. If the mounting nuts are loose and the cable is adjusted so that the caliper arms are pressing the pads against the rim, the pads will automatically align to have no toe. To adjust pad toe, a spacer can be

put between the entry-end of the pad and the rim to space it further out. A #4 (1/2") thumb tack pressed into the face of the entry-end of the pad makes a good spacer. With this thumb tack (henceforth called *toe-tack*) in place, toe adjustment is semi-automatic. Moving the toe-tack closer to the exit-end of the brake pad increases the amount of toe. Manipulation of the washer may be necessary to finesse the alignment.

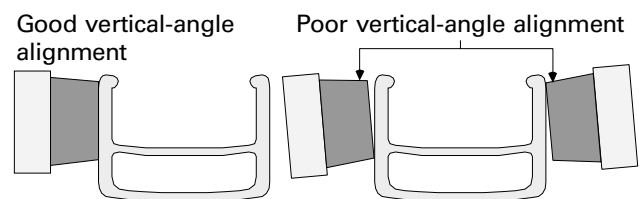


36.14 Toe tacks can be moved toward the exit-end of the pad to increase the toe.

1. [] Complete ATTACH CABLE TO CALIPER procedure for the type of cable system being used.
2. [] Check that toe-tack and exit-end of brake pad are both contacting rim simultaneously, and manipulate curved washer between arm and shoe to improve toe as necessary.

Vertical-angle alignment

Vertical-angle alignment can also be affected by changing the position of the curved washer against the inside face of the caliper arm. When this washer is pushed in one direction, the pad face angles down. When the washer is pushed in the other direction, the pad face angles up. Some mechanics find it easier to manipulate the washer to align the pad. Other mechanics, find the easier approach is to manipulate the pad to position the washer. The procedure for setting the toe usually also sets the vertical-angle alignment, but it may need additional fine tuning.



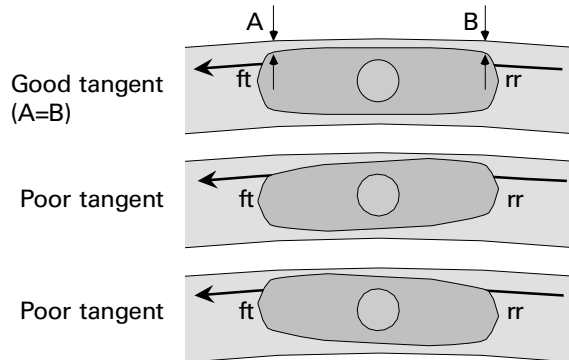
36.15 The vertical angle of the pad face should closely match the vertical angle of the rim's braking surface.

When manipulating the washer or pad to improve the vertical angle of the pad face, it is not unusual for the height of the pad to end up too high or too low. The height is adjusted later, so do not compromise the vertical-angle alignment at this time in order to maintain acceptable height.

3. [] Inspect at either end of brake pad to see if vertical angle of pad face is parallel to vertical angle of rim face, then manipulate washer between caliper arm and shoe up or down to fine-tune alignment.

Tangent alignment

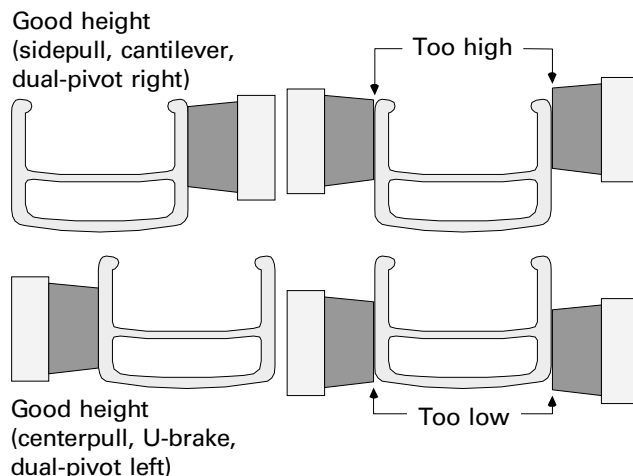
4. [] View brake pad from side of bike and move viewpoint up or down, until top corners of brake shoe are even with top edge of rim.
5. [] Twist brake shoe around axis of shoe stud, until front and back corners of pad are simultaneously even with top edge of rim.



36.16 When pad tangent alignment is correct, the upper front and rear corners of the pad are equidistant from the top of the rim.

Height adjustment

6. [] Slide shoe stud up/down in slot until desired height setting is achieved. If acceptable height cannot be achieved, compromise vertical angle just enough to enable setting of height.

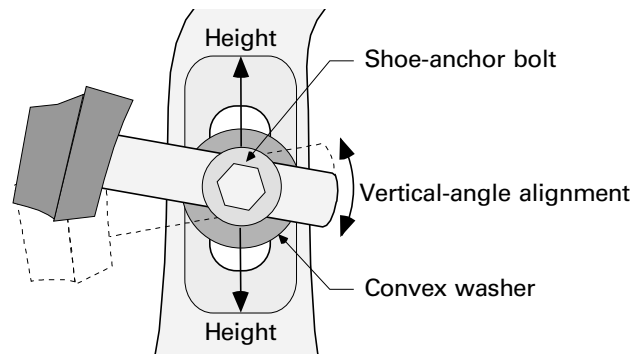


36.17 Proper pad height varies with the type of brake.

7. [] Gently secure mounting nut/bolt.
8. [] Stabilize shoe with fingers or adjustable wrench while tightening mounting nut to 50–60in-lbs (17–20lbs@3').
9. [] Check that all alignments were maintained during securing of mounting nut.

SMOOTH-STUD/CURVED-WASHER PAD ALIGNMENT

This type of alignment system is found on most Shimano cantilevers, many other cantilevers, and some U-brakes. The front of the caliper arm has a curved face against which an oppositely-curved washer is nestled. The shoe stud is inserted through a hole in a shoe-anchor bolt. The stud of the shoe-anchor bolt is inserted through the curved washer and the slot in the face of the caliper arm. Like other pad-alignment systems, height is adjusted by moving the bolt up and down in the slot (see figure 36.18, below). Tangent is aligned by rotating the shoe about the axis of its stud. Toe is adjusted by means of moving the curved washer in the face of the caliper arm (see figure 36.19, page 36-12), which enables the end of the shoe anchor to twist in or out (relative to the rim). Vertical angle of the pad is adjusted by rotating the shoe-anchor bolt about its axis (see figure 36.21, page 36-12).



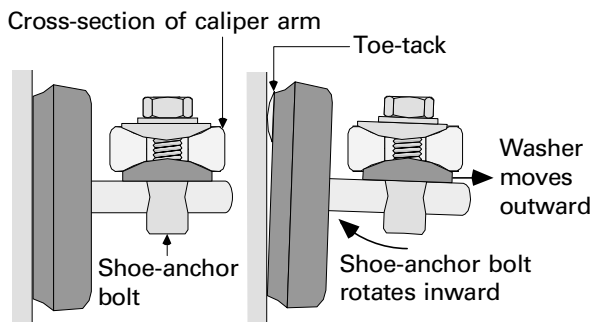
36.18 Height is adjusted by moving the shoe-anchor bolt up or down in the slot. Vertical-angle alignment is done by rotating the shoe-anchor bolt around its axis.

Toe alignment

Brake pads need toe in order to reduce squeal. This is particularly true when the pads are new. When a pad is properly toed, the exit-end of the pad should reach the rim before the entry-end of the pad. If both brakes were at the 12:00 position on the wheel, toe could be described as having the front ends of the brake pads reach the rim before the rear ends reach the rim. If pads have broken in properly to the rim, no toe should be needed, unless the pads squeal on a test ride.

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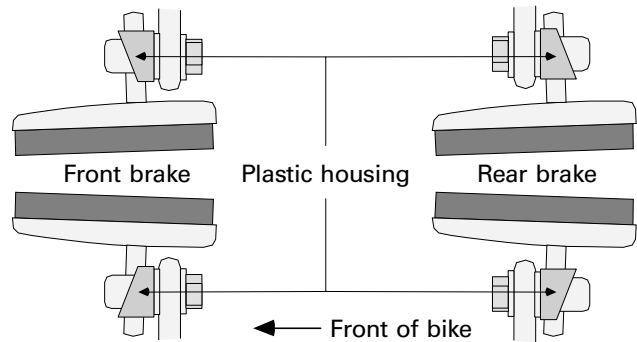
The curved washer between the face of the caliper arm and the shoe-anchor bolt enables toe adjustment, by allowing the head of the shoe-anchor bolt to pivot toward or away from the rim. When the head of the shoe-anchor bolt pivot moves out from the rim, the exit-end of the pad moves in. Conversely, when the head of the shoe anchor bolt pivot moves in toward the rim, the exit-end of the pad moves out. Some mechanics find it easier to align the pad by manipulating the shoe anchor. For other mechanics, the easier approach is to position the shoe-anchor bolt by manipulating the pad. If the shoe-anchor nut is loose and the shoe stud is pushed to press the pad against the rim, the pads will automatically align to have no toe. To adjust pad toe, a spacer can be put between the entry-end of the pad and the rim to space it further out. A #4 (1/2") thumb tack pressed into the face of the entry-end of the pad makes a good spacer. With this thumb tack (henceforth called *toe-tack*) in place, toe adjustment is almost automatic. Moving the toe-tack closer to the exit-end of the brake pad increases the amount of toe. Manipulation of the washer may be necessary to finesse the alignment.



36.19 When a toe-tack is put between the entry end of the pad and the rim, it causes the head of the shoe-anchor bolt to rotate toward the rim and the convex washer to twist and move outward.

Some Shimano calipers have an automatic-toeing system called *Easy-Set*. With the Easy-Set system, there is no need to use toe-tacks, or any other system that creates toe alignment before the shoe-anchor nut is tightened. This system, instead, relies on a special washer between the shoe stud and the curved washer to automatically create toe. The washer sits inside a plastic housing that fits flat against the curved washer. It appears flat but has a distinctly sloped face that faces out from the brake caliper. The washer is designed to collapse on one side, but not on the other. The side of the washer that collapses is in the lower portion of the plastic housing. When the low side of the plastic housing is on the rim-side of the shoe-anchor bolt, the end of the pad

that is in front of the face of the caliper arm moves closer to the rim. When the low side of the plastic housing is on the non-rim-side of the shoe-anchor bolt, the end of the pad that is in back of the face of the caliper arm moves closer to the rim. Use the figure 36.20 as a guide to positioning the plastic housings.

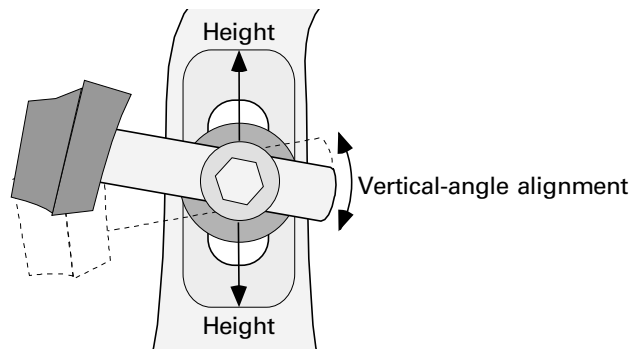


36.20 The plastic housings reverse orientation on front and rear brakes.

1. [] **Complete ATTACH CABLE TO CALIPER procedure for the type of cable system being used.**
2. [] **Push in on shoe stud to press pad against rim, then check that toe-tack and exit-end of brake pad are both contacting rim simultaneously; manipulate shoe-anchor-bolt head in or out to improve toe as necessary.**

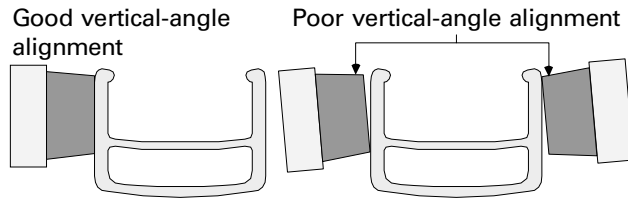
Vertical-angle alignment

Vertical-angle adjustment is also enabled by changing the position of the shoe-anchor bolt, but in this case it is done by rotating the shoe-anchor bolt around its axis. When the bolt is rotated in one direction, the pad face angles down and when it is rotated in the other, the pad face angles up. Some mechanics find it easier to align the pad by manipulating the bolt. For other mechanics, the easiest approach is to manipulate the pad in order to position the bolt. If done properly, the procedure for setting the toe usually also sets the vertical-angle alignment. If it does, it may still need fine tuning.



36.21 Rotate the shoe-anchor bolt around its axis to change the vertical-angle alignment.

When rotating the shoe-anchor bolt to improve the vertical angle of the pad face, it is not unusual for the pad to end up too high or too low. The height is adjusted later, so do not compromise the vertical-angle alignment at this time.

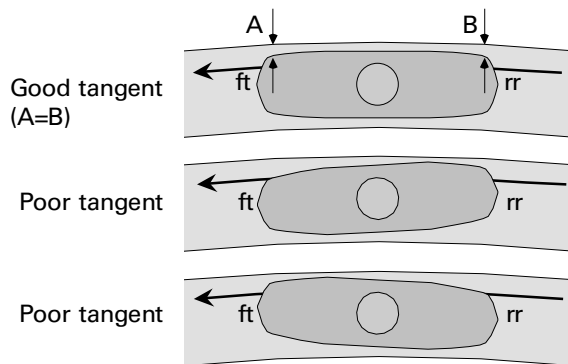


36.22 The vertical angle of the pad face should closely match the vertical angle of the rim's braking surface.

3. [] Inspect at both ends of brake pad to see if vertical angle of pad face is parallel to vertical angle of rim face, then rotate shoe anchor bolt around its axis to fine-tune alignment.

Tangent alignment

4. [] View brake pad from side of bike and move viewpoint up or down until top corners of brake shoe are even with top edge of rim.

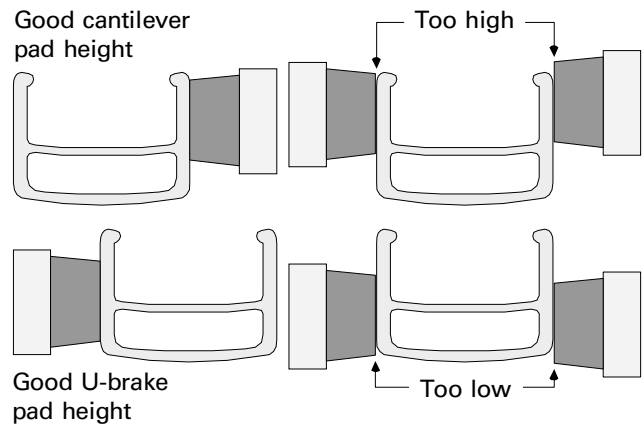


36.23 When pad tangent alignment is correct, the upper front and rear corners of the pad are equidistant from the top of the rim.

5. [] Twist brake shoe around axis of shoe stud until front and back corners of pad are simultaneously even with top edge of rim.

Height adjustment

6. [] Slide shoe stud up/down in slot until desired height setting is achieved. If acceptable height cannot be achieved, compromise vertical angle just enough to enable setting of height (see figure 36.24).



36.24 Correct pad height varies depending on the type of brake caliper.

7. [] Stabilize shoe-anchor bolt with Allen wrench and tighten shoe-anchor nut to 70–80in-lbs (23–27lbs@3").
8. [] Check that all alignments were maintained during securing of shoe anchor nut.

SMOOTH-STUD/SLOPED-WASHER PAD ALIGNMENT

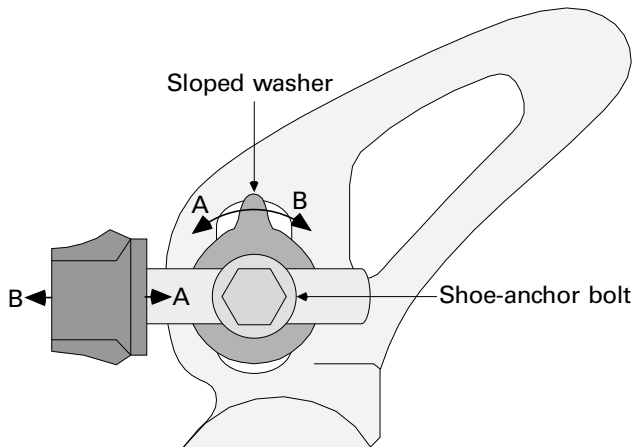
This type of alignment system is commonly found on older Shimano cantilevers and on many after-market cantilevers. The front of the caliper arm has a flat face. The shoe stud is inserted through a hole in a shoe-anchor bolt. The stud of the shoe-anchor bolt is inserted through the sloped washer and through the slot in the face of the caliper arm. The sloped washer has a tab at its perimeter. Like some other pad-alignment systems, height is adjusted by moving the shoe anchor bolt up and down in the slot, and tangent is aligned by rotating the shoe about the axis of its stud. Toe is adjusted by moving the tab on the sloped-washer between the 10:00 and 2:00 position. That enables the end of the shoe anchor to twist in or out (relative to the rim). Vertical angle of the pad is adjusted by rotating the shoe anchor bolt around its axis. (See figure 36.25, page 36-14.)

Toe alignment

Brake pads need toe in order to reduce squeal. This is particularly true when the pads are new. When a pad is properly toed, the exit-end of the pad should reach the rim before the entry-end of the pad. If both brakes were at the 12:00 position on the wheel, toe could be described as having the front ends of the brake pads reach the rim before the rear ends reach the rim. If pads have broken in properly to the rim, no toe should be needed, unless the pads squeal on a test ride.

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The sloped-washer between the face of the caliper arm and the shoe-anchor bolt enables toe adjustment, by allowing the head of the shoe-anchor bolt to pivot toward or away from the rim. When the head of the shoe-anchor bolt pivots out from the rim, the exit-end of the pad moves in. Conversely, when the head of the shoe-anchor bolt pivots in toward the rim, the exit-end of the pad moves out. The only way to align the toe is to rotate the sloped washer.

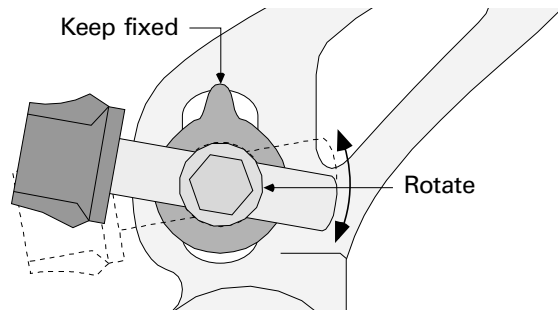


36.25 When the tab on the sloped washer is rotated back and forth, the end of the pad moves in or out.

1. [] **Complete ATTACH CABLE TO CALIPER procedure** for the type of cable system being used.
2. [] **Push on end of shoe stud to move pad to rim, then check that toe-tack and exit-end of brake pad are both contacting rim simultaneously; manipulate sloped-washer tab in or out to improve toe as necessary.**

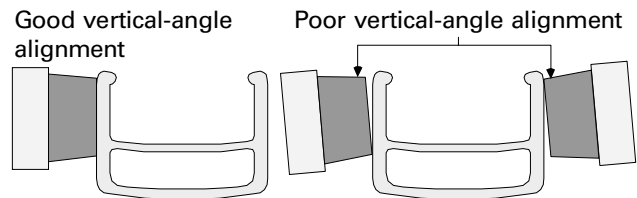
Vertical-angle alignment

Vertical-angle alignment is also enabled by changing the position of the shoe-anchor bolt, but in this case it is done by rotating the shoe-anchor bolt around its axis. When the bolt is rotated in one direction, the pad face angles down and when it is rotated in the other, the pad face angles up. Rotating the shoe-anchor bolt changes the effective position of the sloped washer; it is likely the toe will need fine-tuning if the shoe-anchor bolt needs rotation to adjust the vertical-angle alignment.



36.26 The vertical-angle alignment is adjusted by rotating the shoe-anchor bolt around its axis.

When rotating the shoe-anchor bolt to improve the vertical angle of the pad face, it is not unusual for the pad to end up too high or too low. The height is adjusted later, so do not compromise the vertical-angle alignment at this time.

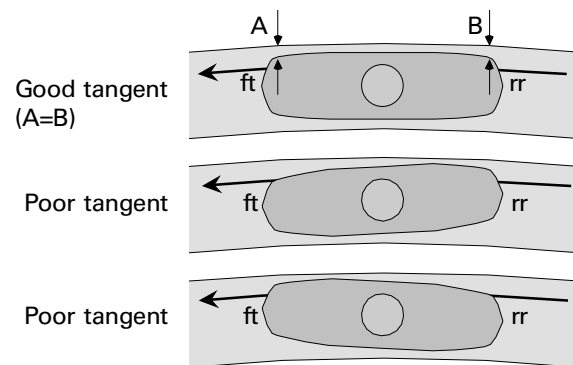


36.27 The vertical angle of the pad face should closely match the vertical angle of the rim's braking surface.

3. [] **Inspect at either end of brake pad to see if the vertical angle of the pad face is parallel to the vertical angle of the rim face, then rotate shoe-anchor bolt around its axis to fine-tune alignment.**

Tangent alignment

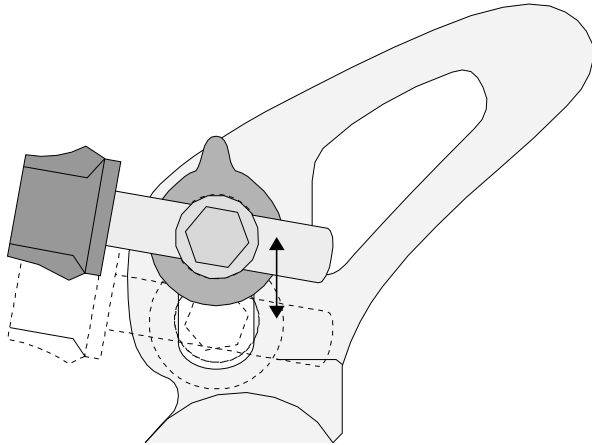
4. [] **View brake pad from side of bike and move viewpoint up or down until top corners of brake shoe are even with top edge of rim.**
5. [] **Twist brake shoe around axis of shoe stud until front and back corners of pad are simultaneously even with top edge of rim.**



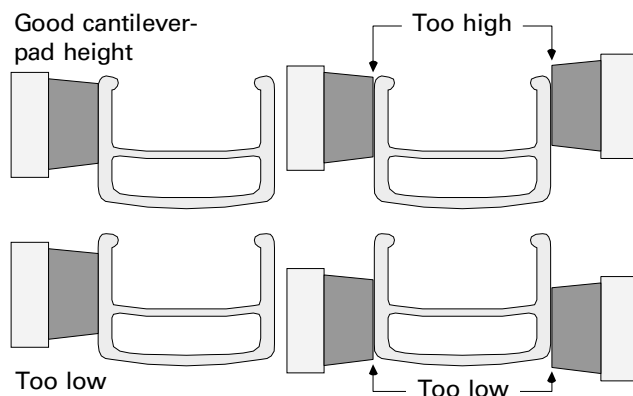
36.28 When pad tangent alignment is correct, the upper front and rear corners of the pad are equidistant from the top of the rim.

Height adjustment

6. [] Slide shoe stud up/down in slot until desired height setting is achieved. If acceptable height cannot be achieved, compromise vertical angle just enough to enable setting of height.



36.29 To adjust pad height, move the shoe-anchor bolt up and down in the slot in the caliper arm.



36.30 Correct cantilever brake-pad height.

7. [] Stabilize shoe-anchor bolt with Allen wrench and tighten shoe anchor nut to 70–80in-lbs (23–27lbs@3').
8. [] Check that all alignments were maintained during securing of shoe-anchor nut.

CANTILEVER CALIPERS

This section covers cantilevers equipped with several different cable systems, including straddle-wire systems, link-wire systems (such as Shimano Pro-Set models), link-unit systems (such as Shimano M-system brakes), and transverse-wire systems (such as Shimano V-brakes). Several different pad-alignment

systems are found on cantilever brakes; the following procedure defines the alignment tolerances, but it is expected that you will refer back to **PAD-ALIGNMENT SYSTEMS** for the alignment procedure.

CALIPER-ARM INSTALLATION

If working on a bike with the caliper arms already installed, it is still a good idea to remove and reinstall them using the following procedure. *Pivot cleaning, pivot greasing, pivot-stud inspection, and spring greasing are very important and should not be taken for granted!*

When installing caliper arms, it is a good idea to check the pads for proper orientation. Usually, a left-rear caliper arm and a right-front caliper arm are interchangeable, except that the pads might be facing in the wrong direction were you to switch the arms from one end of the bike to the other.

Brake pads often have distinctly different top and bottom sides. If the pad is curved over its length, it should be clear which is the top. Obviously, the curve of the pad should match the curve of the rim. Pads that are not curved may, nonetheless, still have distinct top and bottom sides. Usually, if there is a manufacturer's name on only one side of the pad, that would be the top side. If it is not clear which side of the pad should face up, then determine whether there is a front or back end (front or back of bike), whether the pad should face in any direction in regard to the rim's rotation (exit-end or entry-end), or whether there are any other indications that a pad is a left or right pad.

Some pads are specifically designed to work only on the front or back of the bike. This is often done so that a longer pad can be used. Longer pads often come with the stud off-center. The shorter end of the pad always faces the frame or fork, so that the pad will clear the frame or fork when the brakes are released.

It is not unusual for a pad to be specifically designed for its orientation to the rim's rotation. If the shoe is open at one end so that the pad rubber can be slid in or out, then the open end *must* be the entry-end, and the closed end would consequently be the exit-end. This orientation prevents the pad from sliding out of the shoe. When a manufacturer marks a pad with the word *forward*, the end that is *forward* would be the exit-end of the pad.

Some pads are marked for left and right usage. Shimano has done this for years, putting an L or R directly on the pad. Usually, however, it is unlikely that a pad will be marked this way. A combination of other markings may, in effect, make a pad a left or right pad. If a pad were marked for the front of the

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bike, curved so that it had a specific top side, and marked with an arrow or the word *forward* (for direction of rim rotation), then it could *only* go on one side of the front brake to meet all these criteria.

1. [] **Check for any indications of: which side of each brake pad is top side, which end of each pad should point to direction rim rotates, whether pads are specific to front or rear of bike, and for any markings that indicate pads are specific to left or right side of the bike.**

The next step suggests installing toe-tacks in the face of the brake shoes. Toe-tacks are simply #4 thumb tacks. Placing toe tacks in the pad face is a convenient way to set the toe adjustment. The amount of toe can be controlled by how deep the toe-tack is pressed in, and by how far the toe-tack is installed from the entry-end of the brake pad. Rubber bands wrapped around the entry-end of the pad are alternative method for creating toe. Brake pads that are well broken-in to the rim, and brake pads on Shimano V-brakes, may not need any toe; if this is the case, the next step should be skipped.

2. [] **Install toe-tacks in face of entry-end of pad so that they do not extend beyond pad face.**

Before preparing to install the caliper arms on the pivot studs, it is a good idea to test fit the caliper arms on the pivot studs. If the fit is difficult, it could be caused by several things. Paint or rust on a pivot stud can make it a tight fit; these conditions can easily be repaired by using some medium-grit emery cloth on the pivot stud. Pivot studs could be mushroomed on the end, if caliper-mounting bolts have been over-tightened. This mushrooming damage is harder to repair with emery cloth. A Bicycle Research BM1 is a simple and effective tool that will repair mushrooming, as well as remove paint with ease.

If the bike is used, it is a good idea to inspect the pivot studs for bends or cracks at the base. It is *not* a good idea to bend pivot studs back into alignment. Cracked studs are a safety and liability risk that no one should take. If the pivot stud is not replaceable, it may still be possible to repair it without brazing. Some types of brazed-on pivot studs can be repaired with a replacement retained by a bolt that attaches to the original pivot-stud base.

3. [] **Grease outside of pivot studs.**
4. [] **Grease outside of any bushings to be installed over pivot studs.**

It is very critical that the caliper arms be well-secured, but the design of pivot studs prevents using high torques on the mounting bolts (mushrooming of the pivot stud may occur). The solution to this is to use Loctite #242 to retain the mounting bolt securely

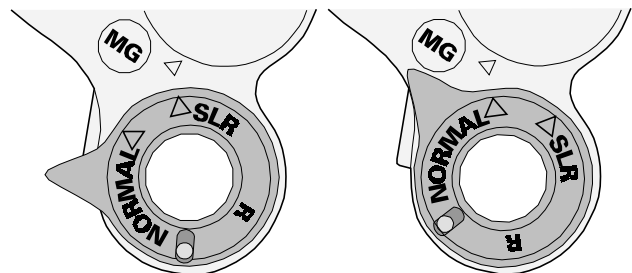
without relying on high torque. The Loctite should be put inside the pivot stud, *not* on the mounting bolt threads; Loctite on the bolt threads has a tendency to back out of the pivot-stud hole and get into the space between the pivot stud and the caliper arm. The factory often puts dry Loctite on the mounting bolt that is good for several installations. If the bolt can be threaded in by hand, then fresh Loctite is needed.

5. [] **Use Loctite 242 inside pivot-stud threads unless mounting bolts have dry factory Loctite in good condition (or nylon insert) on threads.**
6. [] **Grease any coil springs that will be enclosed inside caliper arms.**

There are springs specific to the left and right caliper arms. When a spring is on the correct side, it will always coil tighter as the caliper arm moves the pad closer to the rim, and uncoil as the pad moves away from the rim. Over the years, Shimano has remained very consistent and used a silver spring in the right caliper arm, and a gold spring in the left caliper arm (left and right when facing front of caliper, not in regard to side of bike).

Coil springs often have one leg that fits into a hole in the spring-mounting plate at the base of the pivot stud, and another leg that goes in a hole in the caliper arm. When a spring has legs of different length, the longer leg almost always fits into the spring-mounting plate at the base of the pivot stud.

Certain vintages of Shimano brakes had multiple holes inside the caliper arm into which the spring leg installs. This was done to offer the option of setting up the brake with a soft (SLR) feel, or firmer (NORMAL) feel. After putting the spring into one of the holes, a dustcap is placed over the spring. The triangular indicator on the caliper arm points either to the SLR or NORMAL notation on the dustcap, depending into which hole in the caliper arm the spring was installed. These SLR/NORMAL-marked dustcaps were also marked for left and right side of the brake with an L or R. Particularly as the brakes are getting older, it is a good idea to select the spring hole that sets the brake at the NORMAL setting.



36.31 Shimano SLR and NORMAL spring and dustcap orientations.

7. [] Select spring for each side so that spring will coil tighter as brake pad moves in towards rim, and install spring in caliper.
8. [] Put any dustcaps or spring-adjusting nuts (if any) on backside of caliper, and any removable bushings (greased) inside of caliper hole.
9. [] Slide caliper assembly onto pivot stud. If there are multiple spring holes in spring-mounting plate, make sure springs go in middle holes.
10. [] If caliper is Dia-Compe 984 or similar (with spring-tension-adjusting nut on front of caliper), install nut on face of caliper.
11. [] Install, but do not tighten, mounting bolts.

All caliper arms have a bushing that fits between the pivot stud and the caliper arm to act as a bearing. In some cases, the bushing is a fixed and permanent part of the caliper arm. In other cases, the bushings is either removable or can be rotated in the caliper arm. If a caliper arm has a fixed bushing, the head of the mounting bolt presses against the end of the pivot stud. In these cases, low torque is needed to prevent mushrooming the pivot stud. If the caliper arm has an independent bushing (removable or free-rotating), then the head of the mounting bolt presses against the bushing. In these cases, the bushing can take higher torque than the pivot stud, and the bushing needs higher torque to prevent it from turning. Inspect the caliper arm to determine whether it has a fixed, or independent, bushing.

Some caliper arms have a nut (or plate) that is installed in front of or behind the caliper arm, to which the spring is attached. This is seen on some Dia-Compe and SunTour brakes. This feature is usually found on one caliper arm. This spring-tension-adjusting nut (or plate) will stay at the position it is set when the mounting bolt is secured. When securing the mounting bolt in the next step, position the spring tension nut so that the positions of the caliper arms on each side of the wheel are symmetrical.

12. [] **Fixed-bushing caliper(s):** Secure to 25in-lbs (8lbs@3").

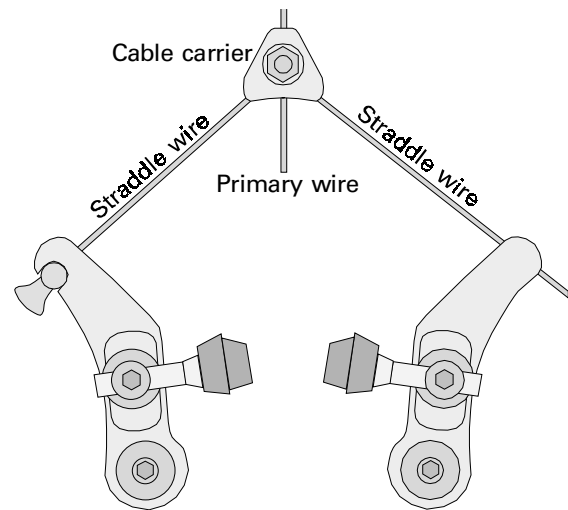
Independent-bushing caliper(s): Secure to 50–60in-lbs (17–20lbs@3").

If the brake uses a link-wire or link-unit cable-attachment system, the brake pads can interfere with getting the cable-attachment system set up properly. For this reason, if the brake has one of these cable systems, the next step requires positioning the pads so that they will miss the rim when the caliper arms move in. On the other hand, brakes with straddle-wires or transverse wires require that the pads are in a normal position in order to attach the cable system to the caliper arms. The pads should be set up close to their final position, but precision adjustment is done later.

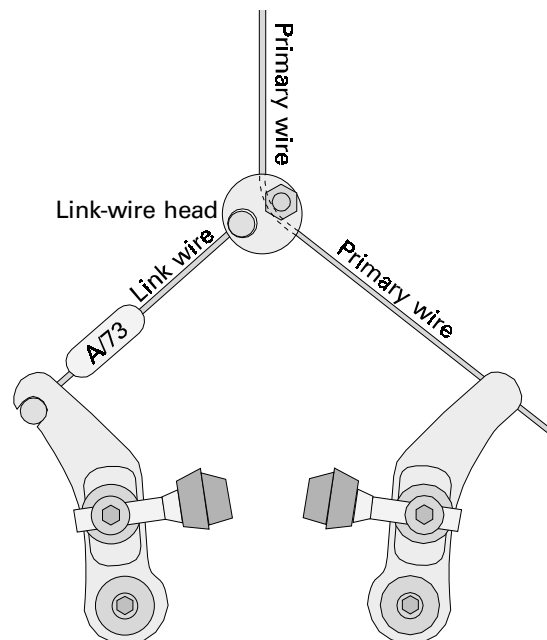
13. [] **Link-wire and Link-unit systems:** Position pads so that they will go below rim when caliper arms move in.
Straddle-wire systems and Shimano V-brake: Position pads on caliper to approximately correct height, tangent, and toe. Leave nuts/bolts just tight enough to keep shoe in place.

ATTACH CABLE TO CALIPER

At this point, determine whether the brake system uses a straddle-wire, a link-wire, a link-unit, or a transverse cable. Once this is determined, use the appropriate following section for attaching the cable system to the calipers.

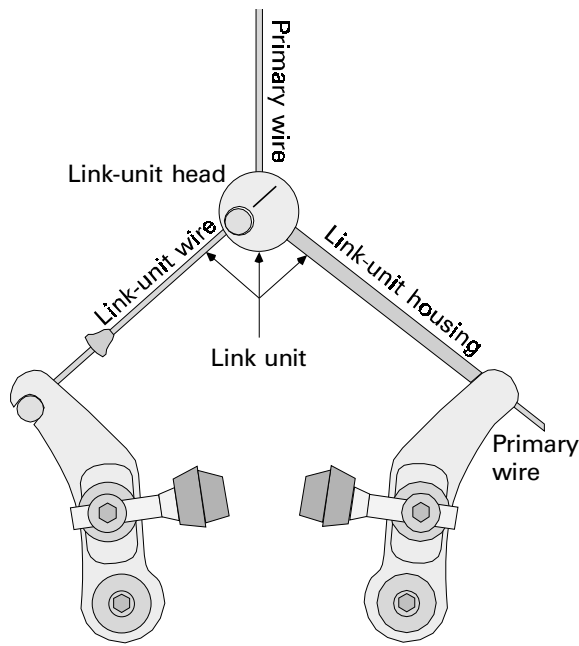


36.32 A cantilever with a straddle-wire.

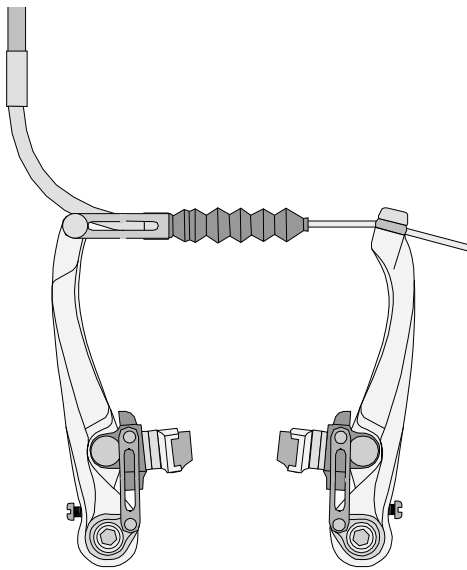


36.33 A cantilever with a link-wire.

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36.34 A cantilever with a link-unit.



36.35 A Shimano V-brake with a transverse wire.

Straddle-wire systems

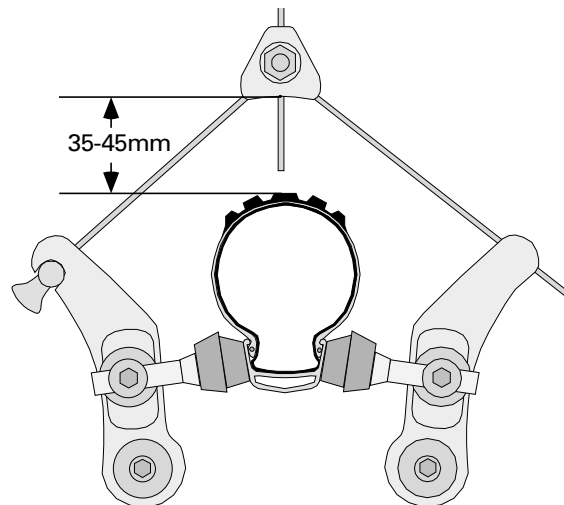
Straddle-wire systems are found on older Shimano cantilever brakes, and almost all current cantilever brakes made by companies other than Shimano. Newer Shimano cantilevers use link-wires, link-units, or transverse wires. It is not unusual to find Shimano cantilevers that were designed with link-wires or link-units converted to a straddle-wire setup.

1. [] Install brake lever and cable system, if not already installed.
2. [] Set cable-system adjusting barrel to 3 full turns out from fully-in position.

The cable carrier should be installed on the primary wire so that the name and the nut both face out from the frame or fork, and so that the trough the straddle-wire sits in is on the side of the cable carrier that faces the frame or fork. The purpose of this is threefold: it creates access so that the nut can be tightened with a torque wrench, it creates clearance so that the cable carrier does not interfere with the headset cup, and it is aesthetically correct.

Traditional cable carriers with a simple pinch mechanism are being replaced by carriers made out of extruded aluminum in all types of fanciful shapes. These are most often used to replace link-unit and link-wire systems, on the premise that the link-unit or link-wire system is too troublesome to learn to set up properly. Most of these fancier cable carriers attach to the wires by means of set screws, rather than by a pinch mechanism. A pinch mechanism works by squeezing the wire between two flat surfaces; pinch mechanisms flatten and distort the wires, but do not break strands. Set screws work by *biting* into the wire; they are designed to do this biting on solid metal surfaces, not wires. *Set screws cause wires to fray; cable carriers that use set screws to secure the wire should not be used!*

3. [] Lubricate threads of pinch mechanism on cable carrier.
4. [] Slide cable carrier over primary wire so that nut faces out from frame or fork.
5. [] Position cable carrier on primary wire so bottom edge of cable carrier clears tire tread by 35–45mm, or to just clear reflector bracket.



36.36 Position the cable carrier on the primary wire so that it clears the tire tread by 35–45mm.

6. [] Hold cable-carrier bolt with wrench, then torque nut to 50–70in-lbs (17–23lbs@3").
7. [] Hold pads to rim with third-hand tool.

8. [] Thread straddle cable through cable carrier and caliper-arm pinch mechanism, then hook straddle-wire bead into other caliper arm.
9. [] Use fourth-hand tool on end of straddle wire to pull slack out of straddle-wire and inner wire.
10. [] Torque caliper-arm pinch to 50–70in-lbs (17–23lbs@3").
11. [] Remove third-hand tool. *Both brake pads should be rubbing the rim at this time!*

Link-wire systems

Link-wire systems are found on a series of Shimano cantilever models that were called Pro-Set cantilevers. The link-wire replaces the straddle wire and cable carrier. The straddle-wire/cable-carrier system is prone to several problems that Shimano helped to solve with the link-wire system (see figure 36.33, page 36-17).

Brake performance is closely tied to the geometry of the cable-attachment system. Since straddle wires have adjustable length, there is no good way for the manufacturer to ensure the brake system would be set up with optimum performance. The link-wire systems solves this problem because the link-wire has a fixed length.

The fact that cable carriers can float back and forth on the straddle-wire creates problems with creating a stable pad-centering adjustment. The fixed nature of the link-wire also solves this problem.

Shimano's original attempts at using a link-wire did not rely on using their Pro-Set tools to set up the link wire. Mechanics found setup to be very problematical. After a short period, Shimano introduced their Pro-Set tools for setting up link-wire systems. The Pro-Set tools make clearance and centering adjustments semi-automatic, if properly used. If the Pro-Set tools are not used, setting up a brake with a link wire can be problematic.

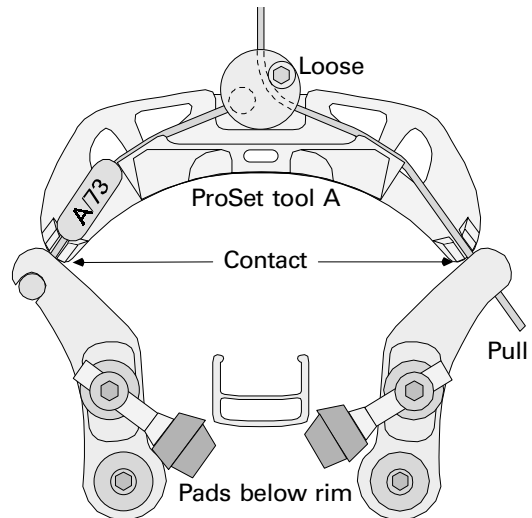
Link-wires come in a variety of sizes that are marked with a letter, or a letter/number combination. The letters are A, B, C, D, E, and S. The A and B sizes are most commonly seen. When replacing a link-wire, try to match the existing size. If a longer link-wire is used, watch out for the link wire head getting too close to the housing stop. A clearance of 20mm is required between the link-wire head and the housing stop.

1. [] Install brake lever and cable system, if not already installed.
2. [] Set cable-system adjusting barrel to 3 full turns out from fully in position.

There are two ends to the link-wire. One end is simply a lead cylinder that is called the bead; the other end has another bead that is trapped between two plates. The primary wire is routed through these two plates, as well. The two plates are called the link-wire head. There is a pinch bolt and nut through the link-wire head that fixes the head to the primary wire.

3. [] Lubricate threads of pinch mechanism on link-wire head.
4. [] Slide link-wire head over primary wire so that aluminum side faces out from frame or fork, when bead of link wire points to caliper arm that has socket for link-wire bead.
5. [] Oil threads of pinch bolt on caliper arm.
6. [] Thread primary wire under pinch plate on caliper arm.
7. [] Hook link-wire bead into socket on other caliper arm.

Shimano Pro-Set tools are marked with the same letter codes as the link-wires. There is also a number on the tool. The number corresponds to the length of the exposed wire in the link-wire (from the edge of the bead to where the wire enters the head). The number is useful if the marking cannot be found on the link-wire. It is also useful if the link-wire is a non-Shimano imitation (which is likely to be mis-marked).



36.37 A link-wire set-up, with a Pro-Set tool in place.

8. [] Select Shimano Pro-Set tool that has matching letter to letter that appears on link wire; install tool so that link wire head is nestled in cradle at center of tool, and so that primary wire and link wire are in slots at ends of tool.
9. [] Use fourth-hand tool to pull slack out of primary wire until both caliper arms are against ends of Pro-Set tool; make sure that tool is properly seated on wires and link-unit head. (Rotate pads down if pads touch rim before Pro-Set tool seats against caliper arms.)
10. [] Torque caliper-arm pinch to 50–70in-lbs (17–23lbs@3").
11. [] Hold head of bolt in link-unit with wrench and torque nut to 35–45in-lbs (12–15lbs@3").
12. [] *Do not* remove Pro-Set tool at this time.
13. [] Position pad faces against rim and snug shoe-anchor nuts.

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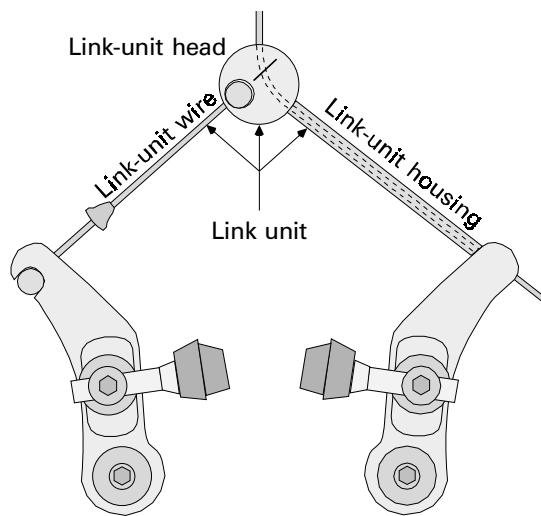
14. [] Hold shoes to rim with third-hand tool.
15. [] Loosen shoe-anchor nuts.
16. [] Move calipers/Pro-Set tool assembly to one side or other until equal amounts of shoe stud protrude from each shoe-anchor bolt, then gently secure one shoe-anchor nut.

NOTE: Side with loose shoe-anchor nut will be first side to adjust pad alignment on.

17. [] Remove third-hand tool, but **do not remove Pro-Set tool** at this time.

Link-unit systems

Shimano invented the link-unit system to replace the link-wire system. Link-units are used on a Shimano brakes called M-system brakes. The link-unit serves all the purposes and functions of the link-wire system, but does not require the use of Pro-Set tools to set it up. A link-unit consists of a link-wire, a link-wire head, and a piece of housing attached to the head that goes to the caliper arm with the pinch mechanism. The piece of housing fixes the distance of the head from the right caliper arm and eliminates the need for the Pro-Set tool.

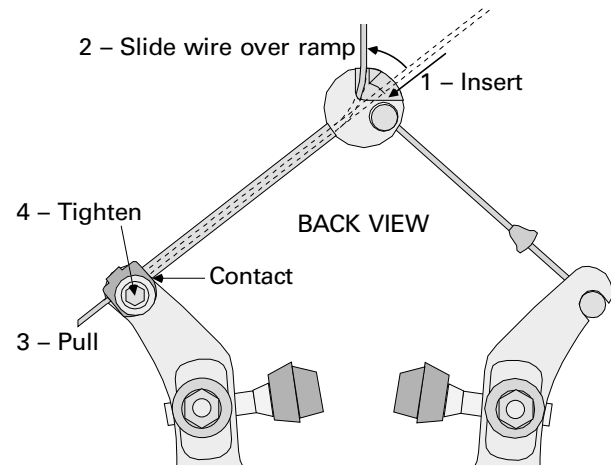


36.38 A link-unit system.

1. [] Install brake lever and cable system, if not already installed.
2. [] Set cable-system adjusting barrel to 3 full turns out from fully-in position.

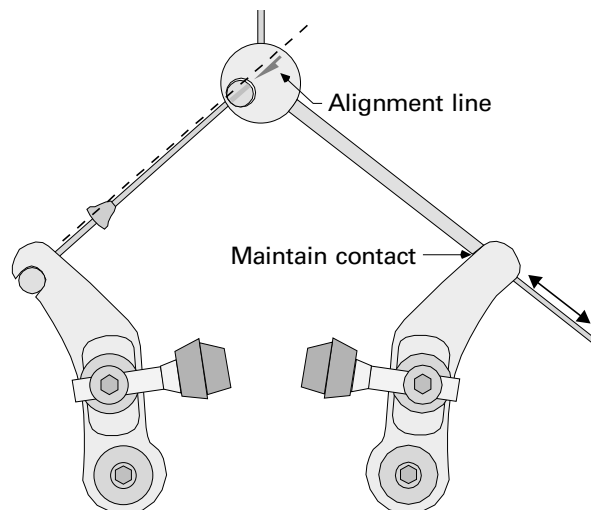
Link-units come in a variety of sizes. They may be marked with letters A, B, C, or D. The A and B sizes are the most common. When replacing a link-unit, try to match the existing size. If a longer link-unit is used, watch out for the link-unit head end up too close to the housing stop. A clearance of at least 20mm is required between the link-unit head and the housing stop.

3. [] Lubricate threads of pinch mechanism on caliper arm.
4. [] Thread primary wire through link-unit head and then through link-unit housing.
5. [] Move primary wire over ramp and into working slot in link-unit head.



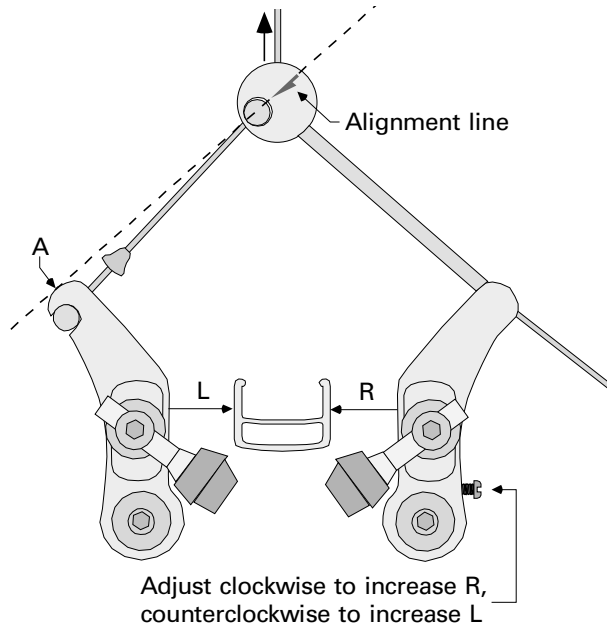
36.39 Installing the primary wire into the link-unit.

6. [] Hook lead bead on link-unit into caliper arm.
7. [] Insert primary wire through pinch mechanism on right caliper arm, then tighten pinch bolt just enough so that cable can still slide through pinch mechanism.
8. [] Push on link-unit head until link-unit housing stops against caliper arm.
9. [] Move primary wire through link-unit housing with fourth-hand tool, to align alignment line in link-unit head so that groove is aligned to link-unit wire. (Use straight edge to extend alignment line to make alignment easier to see.)



36.40 Use a fourth hand on the primary wire to align the alignment line with the link-unit wire.

10. [] Torque caliper-arm pinch to 50–70in-lbs (17–23lbs@3").
11. [] Use cable-adjusting barrel to raise link-unit head up until alignment line points to position A in figure 36.41. (Use straight edge to extend alignment line to make alignment easier to sight.)



36.41 Use adjusting barrel to move link-unit head up until alignment line points to A.

12. [] Use adjusting screw in side of right caliper arm to center arms to rim to < 1mm difference. Measure from each caliper to rim as shown in figure 36.41.

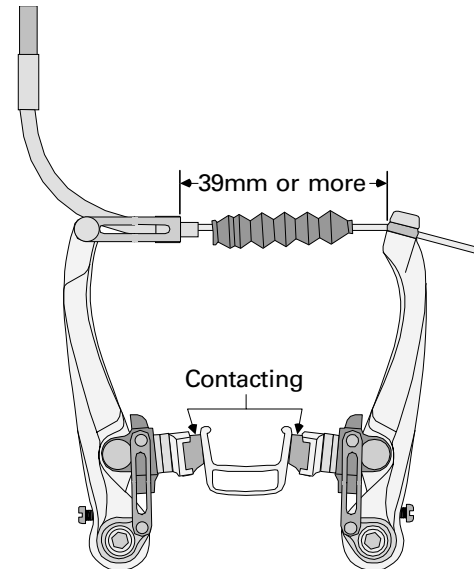
Shimano V-brake (transverse wire)

The Shimano V-brake system differs in appearance from a cantilever, but acts in essentially the same fashion. It is simpler to set up than most cantilever brakes, because the primary wire attaches directly to the caliper arms, much like a sidepull brake.

1. [] Install brake lever and cable system, if not already installed.
2. [] Set cable-system adjusting barrel to 3 full turns out from fully-in position.
3. [] Lubricate threads of pinch mechanism on right caliper arm.
4. [] Hold pads to rim with third-hand tool.

It is possible to set up a Shimano V-brake so that the ends of the caliper arms actually end up touching under certain conditions. That, of course, makes the application of additional brake force impossible. To ensure that this does not happen, Shimano provides washers that can be moved to different locations to compensate for different combinations of rim and

pivot-stud width. The washers are the same concave types used for pad alignments. There is one 6mm-thick concave washer, and another that is 3mm. They can be switched back and forth between their positions inward and outward of the caliper arm to change the distance between the ends of the caliper arm when the pads meet the rim. See figure 36.42, and try switching the washers if the dimension is less than 39mm.



36.42 If the dimension shown is less than 39mm, switch the positions of the 3m and 6mm concave washers in the pad-mounting hardware.

5. [] Measure from end of bracket that holds cable-guide tube, to edge of pinch-bolt head.
6. [] If dimension in previous step is < 39mm, re-install pads with 6mm concave washers between caliper arm and brake shoe, and 3mm concave washers between caliper arm and mounting nut.
7. [] Insert cable-guide tube into bracket in left arm.
8. [] Insert inner wire through cable-guide tube and through pinch mechanism.
9. [] Pull slack wire through pinch mechanism until pads are against rim, then torque pinch bolt to 50–70in-lbs (17–23lbs@3").

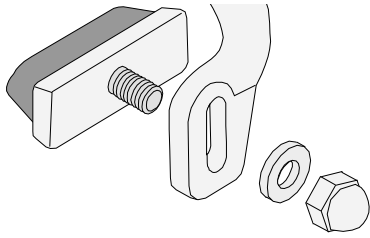
PAD-ALIGNMENT PREPARATION

1. [] Loosen shoe-mounting bolts/nuts just enough so that shoe alignment can be manipulated with your fingers (except link-wire and link-unit brakes; this step is already done).

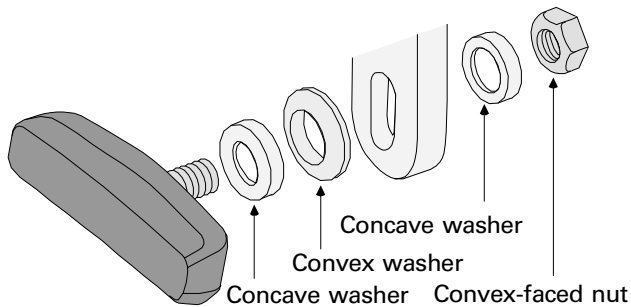
Determine the type of pad-alignment system used on the calipers. Use the procedures in the earlier section for **SIMPLE THREADED-STUD-PAD ALIGNMENT** (page 36-8), **THREADED-STUD/CURVED-WASHER PAD ALIGNMENT** (page

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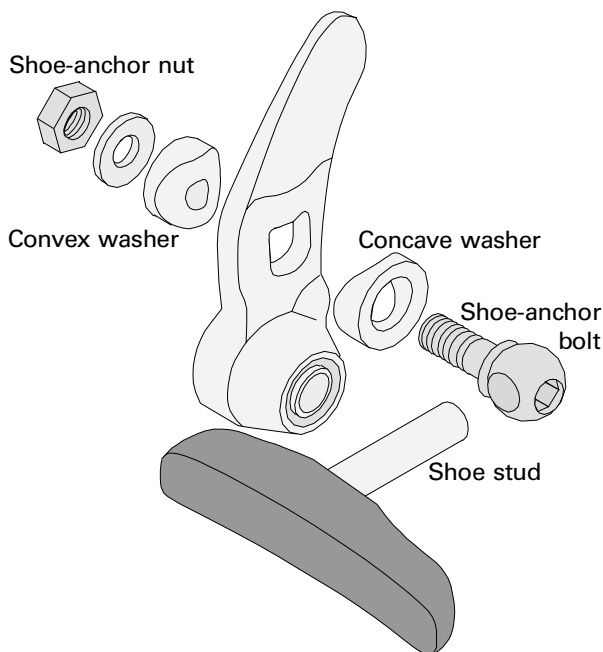
36-10), **SMOOTH-STUD/CURVED-WASHER PAD ALIGNMENT** (page 36-11), or **SMOOTH-STUD/SLOPED-WASHER PAD ALIGNMENT** (page 36-14) Align the pads to the tolerances described in step 2.



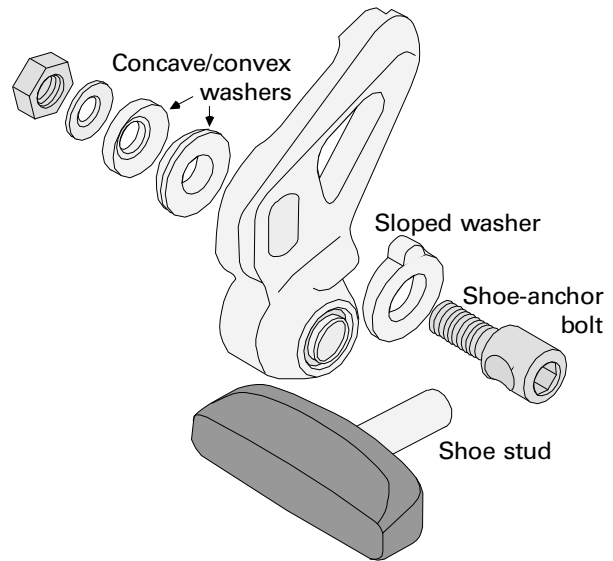
36.43 A simple threaded-stud-pad alignment design.



36.44 A threaded-stud/curved-washer pad-alignment design.

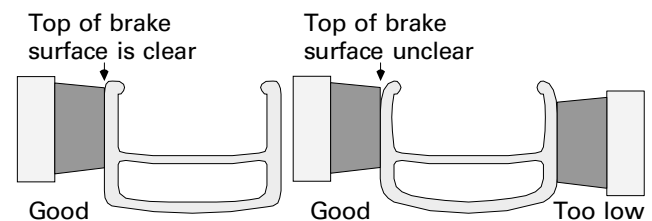


36.45 A smooth-stud/curved-washer pad-alignment design.



36.46 A smooth-stud/sloped washer pad-alignment design.

Proper-pad height is a very critical to the correct installation of cantilever brakes. The nature of a typical cantilever arm causes the pads to arc significantly downward as the pads move in toward the rim. The inward motion that results from compression after the pads contact the rim causes even more downward motion. Over time, pad wear has an even greater affect on the height of the pad when it reaches the rim. For these reasons, it is critical to set the pads as high on the rim as is safe, when setting up cantilever brakes. Normally, this highest setting would place the top edge of the pad even with the top edge of the braking surface on the rim. Unfortunately, the braking surface is not always clearly delineated. If the braking surface gradually transitions to the “top” of the rim, the correct height is somewhat subjective. Certainly, the top edge of the pad should not be more than 1mm below the top edge of the rim. Figure 36.47 shows good cantilever-pad height on a rim with a clearly delineated braking surface, and on a rim with a gradual transition from the top of the braking surface to the top of the rim. After setting pad height to the ideal position, it is important to check whether the pads interfere with the tire after the brakes are released. This cannot be checked until the brake setup is completed.



36.47 Correct cantilever-pad height.

2. [] **Determine what pad-alignment system to use by looking at way shoes are mounted to caliper arm, then use appropriate pad-alignment-system procedure to achieve following tolerances (in order indicated by pad-alignment-system procedure):**

Pad toe: entry-end of pad clears rim by .5–1.5mm when exit-end touches rim.

Vertical angle: vertical angle of pad face is parallel to vertical angle of rim face.

Pad tangent: top corners of pad are equidistant from top edge of rim.

Pad height: top edge of pad face is even with top edge of rim's braking surface (unless interference with tire occurs when caliper is released).

Smooth-stud engagement: Position shoes so that both contact rim and amount of shoe stud protruding past anchor bolts is equal on both sides.

CLEARANCE ADJUSTMENT

1. [] **Remove Pro-Set tool from link-wire system, if applicable.**

The brake system is ready to be stressed. To stress the system, squeeze the lever 10 times, as hard as it would be squeezed in a panic stop. This stressing procedure performs several functions: it seats wire beads into their sockets fully, it seats housing ends into the stops fully, it double-checks that pinch mechanisms are adequately secure, it confirms that pads are adequately secure, and it tests for defective wire beads that could pop off under high load.

2. [] **Stress cable system by pulling on lever equivalent of 10 hard panic stops.**
3. [] **Inspect for pads that have lost alignment and wires that have slipped through pinch mechanisms.**

Before going to the next step, which leads directly to setting the pad clearance, it is important to understand the parameters for pad clearance. There are two parameters: when the pads *first* reach the rim, the lever should have at least 25mm of clearance to the grip, and when the pads are held to the rim by hand, it should be relatively effortless to release the cable system from the caliper.

The 25mm clearance between the lever and the grip is the rule that determines that the brakes are safely set up. If there is not enough lever travel left after the pads first reach the rim, then the potential braking force will be compromised. The 25mm toler-

ance is adequate for virtually all brakes, but for some low-performance equipment you might exercise discretion and set a larger clearance.

Second, the cables system should release effortlessly. It is common for mechanics to set brake-pad clearance tighter than necessary. There is a belief that it makes the brakes “feel better,” and that it is a hallmark of a meticulous mechanic. These misdirected goals should be avoided. Instead, adhere to this second parameter. The primary convenience feature that is established by following this guideline is that it will be easy for the rider to release the brakes when wheel removal is required. The common mechanic's error is to check the cable-system release with the benefit of a mechanic's strong fingers. The procedure recommends handicapping yourself by using any finger combination *not including* your thumb, to simulate a rider with more typical finger strength. Another is that the brake lever will travel a reasonable amount before engaging the pads to the rim. When the lever does not travel far before pad engagement, riders with short fingers have to operate the brake levers with fingers that are uncomfortably extended. The additional pad clearance that is created by this parameter makes it more convenient for the rider to install the wheel without the rim rubbing the pads. You (the mechanic) will appreciate the extra pad clearance established when this rule is followed. Extra pad clearance makes the pad-centering adjustment easier.

4. [] **Go to step 5 of *Straddle-wire systems* (page 36-23), *Link-wire systems* (page 36-24), *Link-unit systems* (page 36-24), or *Shimano V-brake* (page 36-25), as appropriate.**

Straddle-wire systems

5. [] **Pull on brake lever *just* until pads touch rim and check if clearance between lever and grip is < 25mm.**
6. [] **If lever clears grip by < 25mm in previous step, turn cable-adjusting barrel out (up to 5 full turns out from fully-in) to tighten cable, then check lever clearance again. (If clearance is still < 25mm after turning adjusting barrel out to 5-turn limit, turn adjusting barrel in 2 full turns, then pull approximately 2–3mm of straddle-wire through caliper-arm pinch mechanism; check lever clearance again.)**
7. [] **Hold pads to rim with one hand and pull straddle-wire bead out of socket in caliper arm *using any combination of fingers not including your thumb*.**

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8. [] If straddle-wire bead is too difficult to remove, turn adjusting barrel in 1 full turn and check again. Repeat adjustment if straddle-wire removal remains difficult. (If straddle-wire removal is still difficult after adjusting barrel is fully-in, release 2–3mm of straddle-wire through caliper-arm pinch mechanism, secure pinch mechanism, then check straddle-wire removal again.)
9. [] Unhook straddle-wire, remove toe-tacks, then rehook straddle-wire.

Link-wire systems

5. [] Pull on brake lever *just* until pads touch rim and check if clearance between lever and grip is < 25mm.

In the next step, if the adjusting barrel needs to be turned out more than a total of five full turns to correct the condition of the lever getting too close to the grip, several things may have gone wrong in the setup of the brake. It is possible that the primary wire has slipped through the pinch mechanism, the housing ends were never fully seated in the stops, or that the pads were not set to contact the rim when the pad alignment was done with the Pro-Set tool in place. All of these problems require that you start over at **ATTACH CABLE TO CALIPER** (page 36-17).

6. [] If lever clears grip by < 25mm in previous step, turn cable-adjusting barrel out (up to 5 full turns out from fully-in) to tighten cable, then check lever clearance again. (If clearance is still < 25mm after turning adjusting barrel out to 5-turn limit, return to **ATTACH CABLE TO CALIPER** and start over.)
7. [] Hold pads to rim with one hand and pull link-wire bead out of socket in caliper arm *using any combination of fingers not including your thumb*.

If, in the next step, the adjusting barrel cannot be turned in far enough to create easy cable-system release, several things may have gone wrong in the setup of the brake. It is possible that the adjusting barrel was not out three full turns before attaching the cable to the caliper, the Pro-Set tool was not properly installed, the Pro-Set tool was removed before the pads were adjusted, or that too much tension was put on the wire by the fourth-hand tool. All of these problems are best solved by starting over again at **ATTACH CABLE TO CALIPER** (page 36-17).

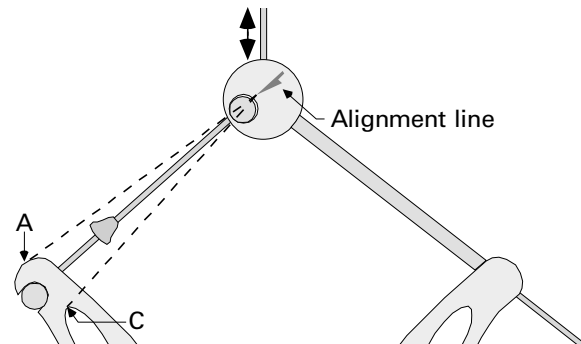
8. [] If link-wire wire bead is too difficult to remove, turn adjusting barrel in 1 full turn and check again. Repeat adjustment if link-wire-bead removal remains difficult. (If link-wire-bead removal is still difficult after turning adjusting barrel fully-in, return to **ATTACH CABLE TO CALIPER** and start over.)

9. [] Unhook link-wire bead, remove toe-tacks, then re-hook link-wire bead.

Link-unit systems

There is a line on the face of the link-unit head that is supposed to come close to lining up with the link-wire when the brake is all set up. Establishing this alignment ensures that the cable geometry will offer maximum brake performance.

5. [] Check if alignment line in link-unit head falls between A and C in figure 36.48.



36.48 After stressing the cable system, the alignment line in the link-unit head should point between points A and C.

6. [] If alignment line failed to point between points A and C as in figure 36-48, move inner wire through pinch mechanism on caliper arm to improve alignment.
7. [] Pull on brake lever *just* until pads touch rim and check if clearance between lever and grip is < 25mm.

In the next step, if the adjusting barrel must be turned out more than 5 full turns (or if the alignment line would end up pointing above point A) to prevent the lever from coming closer than 25mm to the grip when the pads contact the rim, several things may have gone wrong in the setup of the brake. It is possible that the primary wire has slipped through the pinch mechanism, the housing ends were not fully seated in the stops, or that the pads were set to contact the rim when the alignment line was pointing *above* point A. All of these problems require that you start over at **ATTACH CABLE TO CALIPER** (page 36-17).

8. [] If lever clears grip by < 25mm in previous step, turn cable-adjusting barrel out (up to 5 full turns out from fully-in, or until alignment line points no higher than point A) to tighten cable, then check lever clearance again. (If clearance is still < 25mm after turning adjusting barrel out to limit, return to **ATTACH CABLE TO CALIPER** and start over.)

9. [] Hold pads to rim with one hand and pull link-wire bead out of socket in caliper arm *using any combination of fingers not including your thumb*.

If, in the next step, the adjusting barrel cannot be turned in far enough (or the alignment line must point below point C) to create easy cable-system release, several things may have gone wrong in the setup of the brake. It is possible that the adjusting barrel was not out three full turns before attaching the cable to the caliper or that the pads were set to contact the rim when the alignment line was pointing *below* point A. All of these problems are best solved by starting over again at **ATTACH CABLE TO CALIPER** (page 36-17).

10. [] If link-unit wire bead is too difficult to remove, turn adjusting barrel in 1 full turn and check again. Repeat adjustment if link-unit wire-bead removal remains difficult, but do not adjust until alignment line points below point C as in figure 36.48. (If link-unit wire-bead removal is still difficult after turning adjusting barrel in to limit, return to **ATTACH CABLE TO CALIPER** and start over.)
11. [] Unhook link-unit wire bead, remove toe-tacks, then rehook link-unit wire bead.

Shimano V-brake (transverse wire)

5. [] Pull on brake lever *just* until pads touch rim and check if clearance between lever and grip is < 25mm.
6. [] If lever clears grip by < 25mm in previous step, turn cable-adjusting barrel out (up to 5 full turns out from fully-in) to tighten cable, then check lever clearance again. (If clearance is still < 25mm after turning adjusting barrel out to 5-turn limit, turn adjusting barrel in 2 full turns, then pull approximately 2–3mm of wire through caliper-arm pinch mechanism; check lever clearance again.)
7. [] Hold pads to rim with one hand and pull cable-guide tube out of bracket on left caliper arm.
8. [] If cable-guide tube is too difficult to remove, turn adjusting barrel in 1 full turn and check again. Repeat adjustment if cable-guide-tube removal remains difficult. (If cable-guide-tube removal is still difficult after adjusting barrel is fully-in, release 2–3mm of wire through caliper-arm pinch mechanism, secure pinch mechanism, then check cable-guide-tube removal again.)

PAD CENTERING

Caliper with spring-tension-adjusting nut

Spring-tension-adjusting nuts are usually found on the back side of the left caliper arm, but may be found on the faces of both caliper arms. The caliper-mounting bolt should be loosened to adjust the spring-tension-adjusting nut(s). A cone wrench works well on spring-tension-adjusting nuts located on the back side of the caliper.

1. [] Operate brake several times, then check whether pads clear rim equally.
2. [] If caliper has a cable-carrier/straddle-wire-cable-attachment system, try sliding carrier toward side with too much pad clearance; operate brake and see if centering improves and cable carrier holds its position.
3. [] Loosen caliper-mounting bolt on caliper arm that has spring-tension-adjusting nut on front or back face of caliper arm.
4. [] Rotate spring-tension-adjusting nut either way until pad centering is acceptable.
5. [] Holding spring-tension-adjusting nut stationary, torque caliper-arm-mounting bolt to 50–60in-lbs (17–20lbs@3").
6. [] Operate brake and check whether further adjustment is needed.

Caliper with spring-tension-adjusting screw

Spring-tension-adjusting screws adjust the position of a spring-mounting plate located inside the caliper arm (where it cannot be seen). The spring-tension-adjusting screw might be a recessed Allen screw or an exposed Phillips screw. The spring-tension-adjusting screw is usually located on the right caliper arm on the outside edge above the arm pivot and below the shoe mount. Turning the screw into the caliper arm always increases spring tension and clearance on the side where the screw is found. Turning the screw out of the caliper arm always decreases spring tension and clearance on the side where the screw is found.

1. [] Operate brake several times, then check whether pads clear equally.
2. [] If caliper has a cable-carrier/straddle-wire-cable-attachment system, try sliding carrier toward side with too much pad clearance; operate brake and see if centering improves and cable carrier holds its position.
3. [] Tighten spring-tension-adjusting screw to increase clearance of pad attached to caliper arm that has spring-tension-adjusting screw, or loosen spring-tension-adjusting screw to decrease clearance of pad attached to caliper arm that has spring-tension-adjusting screw.

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4. [] Operate brake and check whether pad clearance is uniform on both sides. If not, repeat adjustment of spring-tension-adjusting screw.

Changing shoe-stud engagement

When setting up brakes with smooth-stud brake shoes, the objective is to have the same amount of shoe stud protruding out past both anchor bolts. If the centering methods described above do not get the pads equally centered, check whether the shoe studs are protruding evenly. If not, the shoe alignments should be redone. Be certain to set the shoe studs equally.

If the shoe-stud engagements are equal, the cable system is set up properly, and the brakes still cannot be centered, there are usually other problems with the brakes. These problems could be sticky caliper-arm pivots, damaged springs, mis-installed springs, or simply that the wheel is poorly centered between the pivot studs. If any of these problems are found, they should be addressed. If there is still a problem equalizing pad clearance, then shoe-stud engagement in the shoe anchor bolts can be deliberately *offset* to improve pad-clearance symmetry.

FINISHING

See the section called **FINISHING** (page 36-43) for cable finish, rim cleaning, and test-ride procedures.

SIDEPULL CALIPERS

This section contains the following sub-sections, which may all be used, or can be used in part:

DOUBLE-NUT PIVOT SERVICE

SAFETY-PIVOT SERVICE

CALIPER ATTACHMENT AND LUBRICATION

PAD ADJUSTMENT

CABLE ATTACHMENT AND CLEARANCE ADJUSTMENT

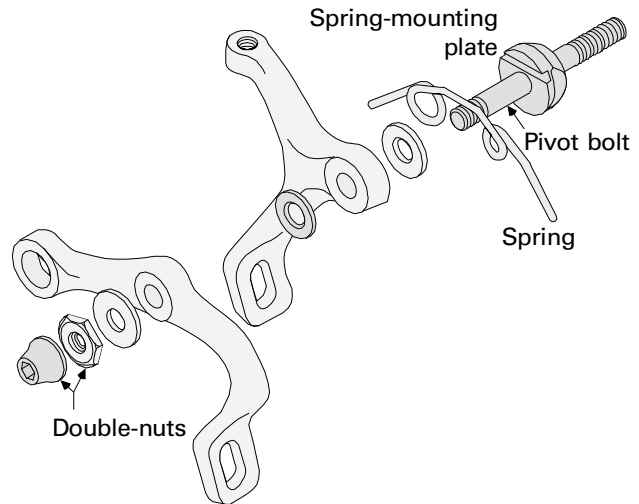
CENTERING ADJUSTMENT

Even if the brake caliper is not being disassembled as part of the brake service, it is nonetheless a good idea to readjust the pivots. Loose pivots cause brake squeal and “grabby” feeling brakes. It is important to remember that loose pivot-adjusting nuts on a double-nut-type pivot *can cause the brake to come apart!*

The **PAD ADJUSTMENT** section provides alignment tolerances only. You must refer back to the earlier section, **PAD-ALIGNMENT SYSTEMS**, to use the procedure for aligning the pads. (Page numbers are provided in the procedure when needed.)

DOUBLE-NUT-PIVOT SERVICE

The double-nut-pivot type of sidepull caliper is characterized by two nuts that are locked to each other on the face of the caliper. These nuts are used to adjust the pivot. The other common type of pivot design is the safety-pivot type, which has a bolt head on the front of the pivot, instead of the two nuts.



36.49 Blow-up of a typical double-nut-pivot assembly.

Disassembly

1. [] Grasp back end of pivot/mounting bolt in soft jaws of bench vise.
2. [] Disconnect springs from caliper arms by popping them out of their mounts with screwdriver, or Langley fifth-hand tool.
3. [] Hold inner nut stationary while turning outer nut counterclockwise, until removed.
4. [] Remove inner nut.
5. [] Remove front washer(s) and note orientation(s).
6. [] Remove front caliper arm, and look for washers stuck on back side of arm.
7. [] Remove any washers between front and back caliper arms. Shimano Dura-Ace caliper #BR7400 may have central washer that is sandwich of plastic washer (contains 14-2mm ball bearings) between two metal washers. Be careful when separating washers so that balls do not drop out.
8. [] Remove back caliper arm and look for washer stuck on backside of arm. Note orientation of washer.
9. [] Remove any washer left on pivot bolt and note its orientation.
10. [] Note orientation of spring and remove it from slot in spring-mounting plate.

If you are disassembling front and rear calipers at the same time, it is critical that you do not mix up the arms. They may be different lengths, or they may have been twisted to create the pad-toe adjustment. When caliper arms have been twisted for toe adjustment, the direction of twist on the front is opposite of that used on rear calipers. Use a scribe to mark the back face of each caliper arm. A single scribe mark can be used to indicate a front caliper arm, and a double scribe mark can indicate a rear caliper arm.

11. [] If disassembling front and rear brakes, mark front and rear arms with different marks.

Brake pads that have broken-in to the rim should always be reinstalled at their original locations and orientations, even if there were no original orientation guidelines on the pads. A convenient way to mark pads is to use the corner edge of a file to put a groove in the *back* and *bottom* edge of the pad. This location for the groove is well hidden from view when the pad is on the bike and has no effect on braking quality. By putting the groove on the back *and* bottom edge, there is no way the pad can be installed incorrectly. See figure 36.53 (page 36-29) for clarification as to where the pads should be marked. Once again, one mark can be used to signify front brake, and two marks to signify rear brake.

12. [] Remove brake pads for replacement or cleaning. Note front and back ends of pads, and mark pads so that they will not be switched between front and back of bike.

Cleaning and inspection

- 13. [] Clean all parts in solvent.
- 14. [] Inspect pivot bolt for bends.
- 15. [] Inspect caliper arms for bends.
- 16. [] Inspect pivot bolt and adjusting nuts for damaged threads.
- 17. [] Inspect adjusting nuts for damaged flats.
- 18. [] Inspect spring for stiffness (should be too stiff to remove or install without tools, except when lever has return spring).

Assembly and lubrication

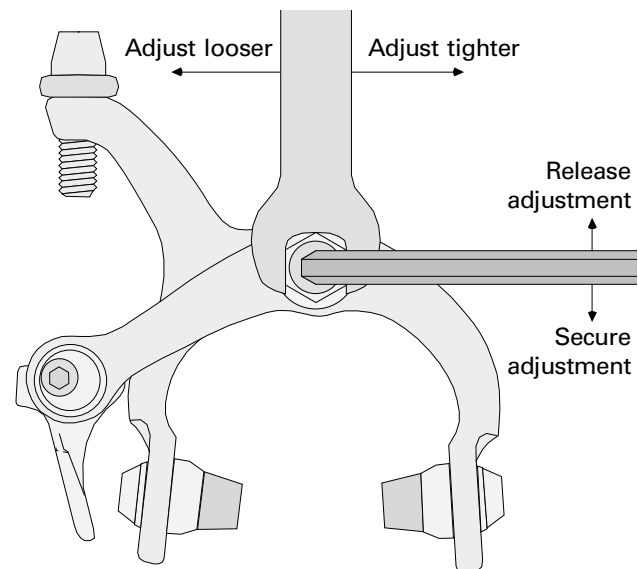
- 19. [] Grasp pivot bolt by mounting end in soft jaws of vise.
- 20. [] Lubricate pivot and threads in front of spring-mounting plate only.

In the next step, the spring is put into the spring-mounting plate. Be careful, it is easy to install the spring incorrectly. The spring should be oriented so that coils protrude back from mounting point and the coils are beside the mounting plate (not above or below). Most calipers are designed so that the slot in the spring-mounting plate should be above the pivot bolt. If, however, mounting the spring above the pivot bolt causes the coils to rise above the caliper arms, then the slot in the spring-mounting plate belongs below the pivot bolt.

- 21. [] Place spring in spring-mounting plate.
- 22. [] Place back washer in its correct orientation on pivot.
- 23. [] Oil front and back of rear caliper arm at pivot.
- 24. [] Place rear caliper arm on pivot, but do not engage spring.
- 25. [] Place middle washer(s) on pivot. (Oil bearings in Shimano Dura-Ace #BR-7400 middle washer.)
- 26. [] Oil front and back of front caliper arm at pivot.
- 27. [] Place front caliper arm on pivot, making sure that cable-pinch-mechanism end of arm is below housing stop end of rear caliper arm. Do not engage spring ends at this time.
- 28. [] Place front washer(s) on pivot in correct orientation.
- 29. [] Thread on two front nuts.
- 30. [] Engage spring ends to posts on back face of caliper arms, and lubricate points at which they bear against arms. Additional oil may be needed in coils themselves, between coils and spring-mounting plate, and between spring and rear caliper arm.
- 31. [] If shoes have been removed, oil mounting threads and mount shoes securely.
- 32. [] Additional oiling should be done on pinch-mechanism threads, cable-adjusting-barrel threads, and quick-release-mechanism pivots.

Pivot adjustment

Adjustment can be accomplished with the brake still mounted on the bike, as long as it is secure. The adjustment can also be done with the mounting bolt secure in a vise with soft jaws.



36.51 Proper setup for adjusting the pivot on a double-nut-type pivot. The adjustment can be done with the caliper on the bike, or mounted in the vise.

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- 33. [] If brake was not just oiled, oil front and back of each caliper arm at pivot and at points at which spring ends bear against caliper arms.
- 34. [] If brake adjusting nuts are still locked together, hold inner one stationary and break loose outer nut.
- 35. [] Turn inner nut clockwise until it bears against caliper arms, then turn it counterclockwise 90°.
- 36. [] Holding inner nut stationary, tighten outer nut to torque of 50–70in-lbs (13–18lbs@4").
- 37. [] Grasp bottoms of caliper arms and jerk them vigorously forward and back to check for any knocking sensation that indicates adjustment is too loose.

For the proper directions to turn the inner nut and outer nut for adjusting and securing the pivot adjustment, see figure 36.51 (page 36-27).

- 38. [] To tighten adjustment, hold inner nut stationary while breaking loose outer nut, then turn inner nut 10° clockwise (about 3/4" at end of 4.5" wrench), and hold it at this position while re-securing outer nut.

In the next step, it is important to eliminate all play from the pivot adjustment. Loose pivot adjustments cause grabby brakes and squealing brakes.

- 39. [] Check for knocking again, and repeat adjustment as many times as necessary to eliminate knocking that indicates pivot adjustment is loose.

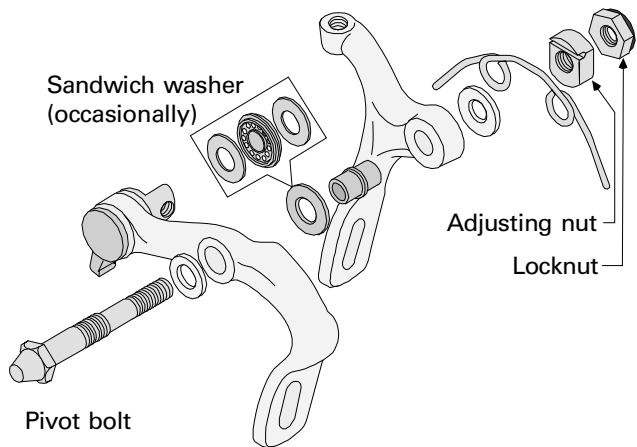
In the next step, the pivot adjustment is checked for excessive tightness. It can appear that the adjustment is too tight because the spring is too soft. The spring should be stiff enough so that it cannot be removed or installed comfortably by hand (unless lever has return spring). Soft springs should be replaced. Soft springs can be stiffened, if necessary, by bending the ends further away from each other. Use a pair of Langley fifth-hand brake tools (or pliers on each end of spring) to spread the spring ends further apart.

- 40. [] To check for too-tight pivot adjustment, squeeze caliper arms together about 1/2", then release them slowly. If they do not open all way by themselves, adjustment may be too tight, or spring too soft. Check spring before loosening adjustment.
- 41. [] To loosen adjustment, hold inner nut stationary while breaking loose outer nut, then turn inner nut 10° counterclockwise (about 3/4" at end of 4.5" wrench), and hold it at this position while re-securing outer nut. Repeat adjustment until knocking is detected, then return to last setting.

SAFETY-PIVOT SERVICE

Disassembly

The safety-pivot type of sidepull caliper is distinguished by the fact that the pivot bolt has a head on the front of the caliper, unlike the double-nut type which has two nuts threaded onto the pivot bolt at the front of the caliper. The adjustment nut and locknut are located between the caliper and the mounting point on the frame or fork. On some models, there is no adjustment locknut and the adjustment must be done with the caliper mounted on the bike (the mounting nut serves as the adjustment locknut).



36.52 Blow-up of a safety-pivot-design sidepull caliper.

- 1. [] Remove brake from bike.
- 2. [] Disengage spring. With many models, spring needs to be rotated up for wrench access to adjusting nut (nut closest to caliper).

The adjustment locknut (outer nut) on some models of Shimano brakes is a 12-point nut that is fit only by a 13mm or 14mm box-end wrench. In the next step, the end of the pivot bolt is grasped in the vise; the box-end wrench needs to be placed over the end of the pivot bolt first.

- 3. [] Mount pivot bolt in soft jaws of vise.
- 4. [] Facing caliper from its back, hold inner nut stationary with cone wrench, then turn outer nut counterclockwise to break it loose.
- 5. [] With caliper in hand (not in vise), hold nuts and arms stationary while turning pivot-bolt head counterclockwise to unthread it from nuts. Note order and orientation of each nut as it comes off.

In the next step, a simple washer may be found between the caliper arms. There may also be a more complex thrust washer with bearings. The thrust washer is a sandwich with a plastic retainer contain-

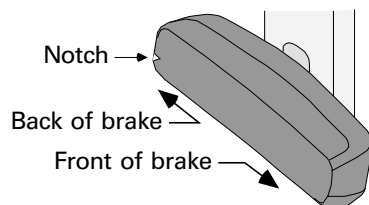
ing 14 tiny 2mm bearings. Because the bearings are easily lost, be careful when separating the metal washer from either face of the plastic retainer.

6. [] **Remove caliper arms and washers, noting order and orientation of each.**

If you are disassembling front and rear calipers at the same time, it is critical that you do not mix up the arms. They may be different lengths, or they may have been twisted to create the pad-toe adjustment. When caliper arms have been twisted for toe adjustment, the direction of twist on the front is opposite of that used on rear calipers. Use a scribe to mark the back face of each caliper arm. A single scribe mark can be used to indicate a front caliper arm, and a double scribe mark can indicate a rear caliper arm.

7. [] **If disassembling front and rear brakes, mark front and rear arms with different marks.**

Brake pads that have broken-in to the rim should always be reinstalled at their original locations and orientations, even if there were no original orientation guidelines on the pads. A convenient way to mark pads is to use the corner edge of a file to put a groove in the *back* and *bottom* edge of the pad. This location for the groove is well hidden from view when the pad is on the bike and has no effect on braking quality. By putting the groove on the back *and* bottom edge, there is no way the pad can be installed incorrectly. See figure 36.53 for clarification as to where the pads should be marked. Once again, one mark can be used to signify front brake, and two marks to signify rear brake.



36.53 Notch the back-bottom edge of the pad. Use one notch for front-brake pads, or two notches for rear-brake pads.

8. [] **Remove brake pads for replacement or cleaning. Note front and back ends of pads, and mark pads so that they will not be switched between front and back of bike.**

Cleaning and inspection

9. [] **Clean all parts in solvent.**
 10. [] **Inspect pivot bolt for bends.**
 11. [] **Inspect caliper arms for bends.**
 12. [] **Inspect pivot bolt and adjusting nuts for damaged threads.**
 13. [] **Inspect adjusting nuts for damaged flats.**

14. [] **Inspect spring for stiffness (should be too stiff to remove or install without tools except when lever has return spring).**

Assembly and lubrication

15. [] **Oil pivot area of pivot bolt.**
 16. [] **Oil threads for adjusting nut(s).**
 17. [] **Install front washer on pivot.**
 18. [] **Oil front and rear face of front caliper arm at pivot point.**
 19. [] **Install front caliper arm on pivot.**
 20. [] **Install middle washer(s) and bushing (if any). Oil bearings in Shimano sandwich washer with bearings.**
 21. [] **Oil front and rear face of rear caliper arm at pivot point.**
 22. [] **Install rear caliper arm on pivot.**
 23. [] **Install rear washer.**

In the next step, the spring is put into the spring-mounting plate. Be careful, it is easy to install the spring in incorrectly. The spring should be oriented so that coils protrude back from mounting point and the coils are beside the mounting plate (not above or below). Most calipers are designed so that the slot in the spring-mounting plate should be above the pivot bolt. If, however, mounting the spring above the pivot bolt causes the coils to rise above the caliper arms, then the slot in the spring-mounting plate belongs below the pivot bolt.

24. [] **Thread on spring-mounting plate in correct orientation, until it is just close enough to caliper to allow installation of spring. Then install spring.**
 25. [] **Thread pivot bolt rest of way into spring-mounting plate.**
 26. [] **Install outer nut.**

Pivot adjustment

The pivot adjustment on a safety-pivot caliper has to be done with the caliper removed from the bike.

27. [] **Mount pivot bolt in soft jaws of vise.**
 28. [] **Flip spring up out of way if it prevents access to inner nut with wrench from above.**
 29. [] **If brake was not just oiled, oil front and back of each caliper arm, and points at which spring ends bear against caliper arms.**

In the next step, make the adjustment while viewing the caliper from its back face.

30. [] **If brake adjusting nuts are still locked together, hold inner nut (spring-mounting plate) stationary while turning outer nut counterclockwise.**
 31. [] **Turn inner nut clockwise until it bears against caliper arms. Then turn it counterclockwise 90°.**
 32. [] **Holding inner nut stationary, tighten outer nut to torque of 50–70in-lbs (13–18lbs@4").**

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33. [] Grasp bottoms of caliper arms and jerk them vigorously forward and back to check for any knocking sensation that indicates adjustment is too loose.

34. [] To tighten adjustment, hold inner nut stationary while breaking loose outer nut, then turn inner nut 10° clockwise (about 3/4" at end of 4.5" wrench), and hold it at this position while re-securing outer nut.

In the next step, it is important to eliminate all play from the pivot adjustment. Loose pivot adjustments cause grabby brakes and squealing brakes.

35. [] Check for knocking again and repeat adjustment as many times as necessary to eliminate knocking that indicates pivot adjustment is loose.

In the next step, the pivot adjustment is checked for excessive tightness. It can appear that the adjustment is too tight because the spring is too soft. The spring should be stiff enough so that it cannot be removed or installed comfortably by hand (unless lever has return spring). Soft springs should be replaced. Soft springs can be stiffened, if necessary, by bending the ends further away from each other. Use a pair of Langley fifth-hand brake tools (or pliers on each end of spring) to spread the spring ends further apart.

36. [] To check for too-tight pivot adjustment, squeeze caliper arms together about 1/2", then release them slowly. If they do not open all way by themselves, adjustment may be too tight, or spring too soft. Check spring before loosening adjustment.

37. [] To loosen adjustment, hold inner nut stationary while breaking loose outer nut, then turn inner nut 10° counterclockwise (about 3/4" at end of 4.5" wrench), and hold it at this position while re-securing outer nut. Repeat adjustment until knocking is detected, then return to last setting.

CALIPER ATTACHMENT AND LUBRICATION

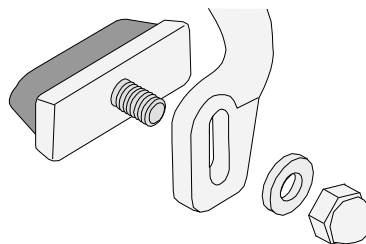
1. [] Make sure radiused washer is between brake and mounting surface if mounting surface is curved.
2. [] Treat mounting-nut threads with Loctite 242, unless mounting nut has nylon insert.
3. [] Put caliper-mounting stud in mounting hole and thread nut on end of mounting stud (use flat washer under hex nut that seats against flat surface; use radiused washer under hex nut that seats against curved surface).
4. [] Holding pads firmly to rim, torque mounting nut to 70–85in-lbs (23–28lbs@3").

5. [] Oil: between pivot-bolt head (or double nuts) and face of front caliper arm, between caliper arms at pivot, at backside of back caliper arm at pivot, where springs push against posts on back side of caliper arms, pinch-mechanism threads, shoe-mounting threads, and adjusting-barrel threads.

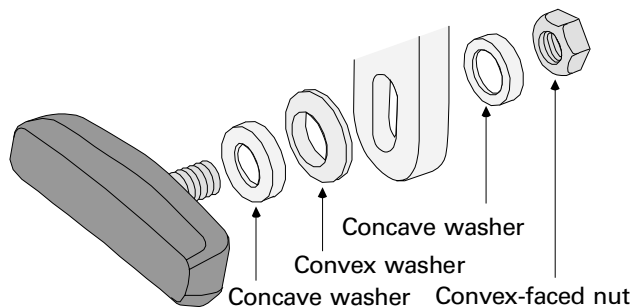
PAD ADJUSTMENTS

1. [] Check each pad for directional arrows and/or right/left indications; make sure pads will be installed with arrows pointing in the direction of rim rotation, and any pad marked with "R" is mounted on right side of bike and any marked with "L" is on left side of bike.

Determine what type of pad-alignment system is on the calipers. Use the procedures in the earlier section for **SIMPLE THREADED-STUD-PAD ALIGNMENT** (page 36-8), or **THREADED-STUD/CURVED-WASHER PAD ALIGNMENT** (page 36-10). Align the pads to the tolerances described in step 2.



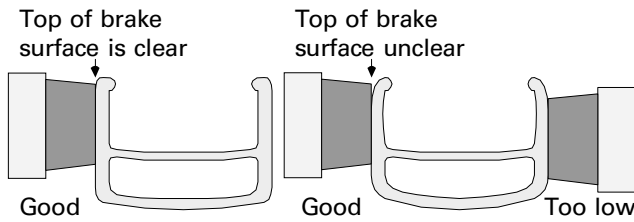
36.54 A simple threaded-stud pad-alignment design.



36.55 A threaded-stud/curved-washer pad-alignment design.

Sidepull-caliper pads move down as they move in. So that the pads do not end up too low, they should be set so that the top edge of the pad is even with the top edge of the rim's braking surface. Complicating pad height setting is the fact that the top edge of the braking surface is not always distinct. Sometimes the rim just begins to curve inward gradually, and the braking surface just "fades" away. In this case, consider the edge of the braking surface to be the point of transi-

tion where the surface of the rim changes from facing towards the pad to facing more up. In no case should the top edge of the left pad be more than 1mm below the absolute top of the rim.



36.56 Correct sidepull caliper-pad height.

2. [] Determine what pad-alignment system to use by looking at way shoes are mounted to caliper arm, then use appropriate pad-alignment-system procedure to achieve following tolerances (in order indicated by pad-alignment-system procedure):

Pad toe: entry-end of pad clears rim by .5–1.5mm when exit-end touches rim.

Vertical angle: vertical angle of pad face is parallel to vertical angle of rim face.

Pad tangent: top corners of pad are equidistant from top edge of rim.

Pad height: top edge of pad face is even with top edge of rim's braking surface.

CABLE ATTACHMENT AND CLEARANCE ADJUSTMENT

1. [] Install brake lever and cable system, if not already installed.
2. [] Lubricate threads of pinch mechanism on caliper arm and threads of cable-adjusting barrel on other caliper arm, if not already done.
3. [] Set cable-system adjusting barrel to 3 full turns out from fully-in position.
4. [] Hold pads to rim with third-hand tool.

Many sidepull calipers come equipped with quick release (Q.R.) mechanism. This mechanism is usually a lever that can be flipped up or down to change the pad clearance in order to facilitate wheel removal. The cable-pinch mechanism is usually attached to the Q.R. mechanism. When the Q.R. mechanism is operated, it should be possible to see the pinch mechanism moving closer to and further from the cable-housing stop. When the two are closer together, the Q.R. mechanism is in the released position and when the two are farther apart, the Q.R. mechanism is in the non-released (brake operational) position. The brake should be setup with the Q.R. mechanism in the non-released position.

5. [] Make sure Q.R. mechanism lever is in non-released position.
6. [] Thread inner wire through cable-adjusting barrel and cable-pinch mechanism.
7. [] Draw slack out of cable with fourth-hand tool.
8. [] Secure pinch bolt to torque of 50–70in-lbs (17–23lbs@3").
9. [] Stress cable system by pulling against lever 10 times with maximum force that would be used during a panic stop.
10. [] Set up stack of feeler gauges to equal 3mm (or use 3mm Allen wrench) to check clearance at exit-end of one brake pad when other pad is held to rim.
11. [] If clearance is >3mm, draw more wire through pinch mechanism.
12. [] When clearance is <3mm, turn down cable-adjusting barrel(s) until clearance is 3mm.
13. [] If clearance is still <3mm when adjusting barrel is fully down, let 2–3mm more cable through pinch mechanism and check clearance again.

CENTERING ADJUSTMENT

Double-nut-caliper pad centering

NOTE: In steps 1 and 2, references to clockwise and counterclockwise are as seen when viewing the brake from its front.

1. [] If right pad is closer to rim, rotate inner nut (on front of brake) and mounting nut simultaneously counterclockwise the same amount, to rotate pivot assembly.
2. [] If left pad is closer to rim, rotate outer nut (on front of brake) and mounting nut simultaneously clockwise the same amount, to rotate pivot assembly.
3. [] Operate brake with lever to check result of adjustment.
4. [] Repeat adjustment in either direction as necessary.

Safety-pivot caliper pad centering

1. [] With one wrench on pivot-bolt head and another wrench on mounting nut, rotate both wrenches simultaneously clockwise to move left pad away from rim, or simultaneously counterclockwise to move right pad away from rim (viewed from front of brake).
2. [] Operate brake with lever to check result of adjustment.
3. [] Repeat adjustment in either direction as necessary.

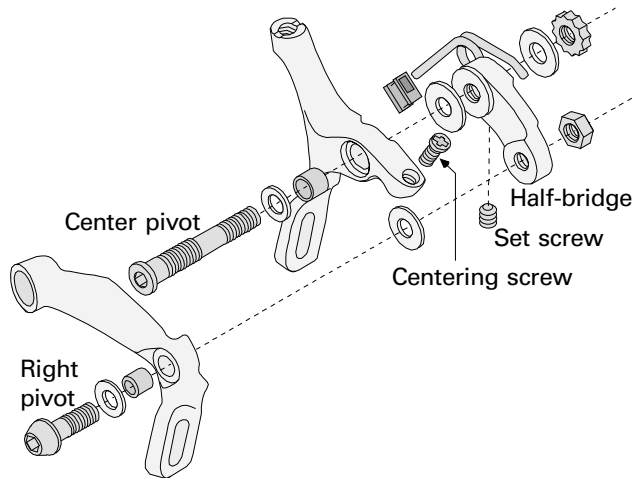
FINISHING

See the section called **FINISHING** (page 36-43) for cable finish, rim cleaning, and test-ride procedures.

DUAL-PIVOT CALIPERS

The dual-pivot brake is unique, with one caliper arm operating like a sidepull-caliper arm, and the other operating like a centerpull-caliper arm.

All references to the brake in this section will be the same, regardless of the brake's position on the bike. Simply put, the right arm is on the right as viewed from the face of the brake. "Front" is the face of the brake, and "rear" is the backside of the brake, or the part that faces the frame or fork.



36.57 Blow-up of a Shimano dual-pivot caliper.

The caliper consists of three main pieces and two pivots. Refer to the accompanying illustration.

- The right caliper arm is the most forward piece. It is the one that operates like a centerpull arm, arcing on a pivot that is outward of the rim.
- The left caliper arm is the middle piece of the brake. It is the one that operates like a sidepull-caliper arm, arcing on a pivot that is centered over the rim.
- The remaining piece, closest to the frame or fork, is similar to the bridge of a centerpull caliper. Due to this similarity, it is called the half-bridge.
- At the center of the brake, there is a bolt that serves to mount the brake to the bicycle and also as a pivot bolt for the left arm. It will be called the center pivot. With the other parts that make up the pivot assembly, it is called the center-pivot assembly.
- The right caliper arm is mounted to the half-bridge. The bolt that holds these together is referred to as the right-pivot bolt. With the accompanying parts, it is called the right-pivot assembly.

- One more unique part is found on top of the extreme right end of the left caliper arm. It is a screw that can fit a Phillips or standard screwdriver. It is used to center the caliper arms, and is called the centering screw.

NOTE: If adjusting brakes only, and no pivot adjustment is necessary, go to **MOUNTING CALIPER TO FRAME** (page 36-35).

This section contains the following sub-sections, which may all be used, or can be used in part:

DISASSEMBLING THE CALIPER

ASSEMBLING THE CALIPER

MOUNTING CALIPER TO FRAME

INSTALLING AND ADJUSTING PADS

CABLE ATTACHMENT, CLEARANCE, AND CENTERING ADJUSTMENTS

If the brake caliper is not being disassembled as part of the brake service, it is still a good idea to use the part of the **ASSEMBLING THE CALIPER** section regarding pivot adjustment (page 36-33). Loose pivots can cause the brakes to squeal and feel grabby.

The **PAD ADJUSTMENT** section provides alignment tolerances only. You will need to refer back to the earlier section, **PAD-ALIGNMENT SYSTEMS**, to use the procedure for aligning the pads (page number provided in the procedure when needed).

DISASSEMBLING THE CALIPER

1. [] Remove caliper assembly from bike.
2. [] Use Langley fifth hand (or pliers) to disengage spring, then remove rectangular sleeve on the springs (Shimano non-Dura-Ace only).
3. [] Remove brake shoes, note and mark right/left and front/back orientations as necessary.
4. [] If intending to disassemble or adjust center pivot only, face brake and push down and in on right arm to expose center pivot-bolt head (Shimano only).

NOTE: Shimano and Campagnolo dual-pivot calipers differ primarily in regard to the design of the right pivot. Use steps 5–8 only for the type of caliper being serviced.

Disassembling Shimano right pivot

5. [] Hold pivot bolt stationary with 4mm Allen wrench.
6. [] Turn 10mm nut on back side of half-bridge counterclockwise (facing back) to break nut loose and remove nut.
7. [] Turn pivot bolt counterclockwise (facing front) to remove bolt.
8. [] Disassemble pivot assembly and observe sequence of parts.

NOTE: Go to *Disassembling center-pivot assembly* now.

Disassembling Campagnolo right pivot

NOTE: There is a set screw in one of the faces of the hex nut on the back of the right-pivot assembly that will destroy the threads on the pivot stud, if not loosened before turning the hex nut.

5. [] Loosen set screw in wrench flat of rearmost nut on right-pivot assembly.
6. [] Hold square nut stationary and unthread hex nut on back side of right-pivot assembly.
7. [] Unthread square nut from backside of right-pivot assembly.
8. [] Disassemble pivot assembly and observe sequence of parts.

Disassembling center-pivot assembly

NOTE: There is a set screw in the half bridge (or the nut on the back of the center-pivot assembly) that will destroy the threads on the pivot stud if not loosened before turning the center pivot.

9. [] Loosen set screw on bottom of half-bridge immediately below center-pivot bolt with 2mm hex wrench (set screw is on rearmost nut of center-pivot assembly on Dura-Ace and Campagnolo models).
10. [] Place wrench on nut on back side of half-bridge (12-point nuts require box-end wrench), and then secure threaded end of the center-pivot bolt in soft jaws in vise. (Place assembly in vise so that you can easily face assembly's back side.)
11. [] Holding half-bridge stationary, turn nut counterclockwise to break it loose.
12. [] Remove assembly from vise.
13. [] Thread off nut.
14. [] Slip off large thin washer.
15. [] Remove spring from groove in back face of half-bridge, being sure to observe how unique end of spring fits in groove so that spring cannot pull straight out.
16. [] Thread center-pivot bolt counterclockwise out front of assembly, being careful to not let assembly fall apart.
17. [] With bolt out, disassemble center-pivot assembly and observe sequence of parts.
18. [] From face of left caliper arm, remove small washer.
19. [] From inside hole in left caliper arm, remove plastic bushing (except Campagnolo).

Depending on the model, there may be a simple washer, or a sandwich-washer, between the left caliper arm and the half-bridge. Be careful when separat-

ing the caliper arm and half-bridge because the sandwich washer has twelve 2mm bearings trapped in holes in the plastic washer which are easily lost.

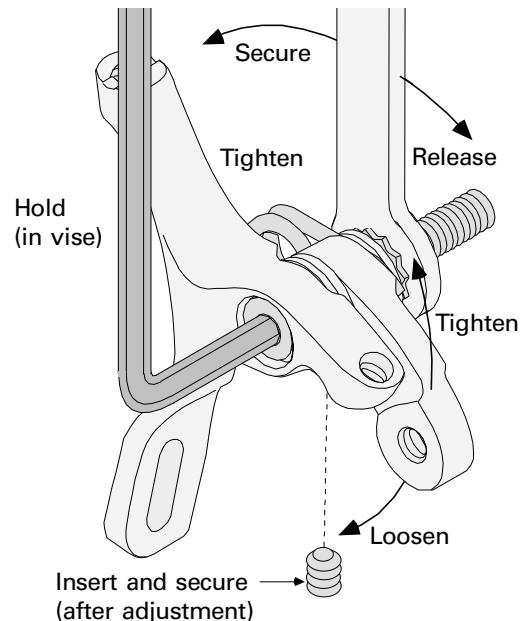
20. [] From between left caliper arm and half-bridge, remove washer or sandwich-washer assembly.

ASSEMBLING THE CALIPER

21. [] Lubricate washer or sandwich-washer that goes between left arm and half-bridge, and place it between these two pieces.
22. [] Lubricate small washer that goes on face of left arm, and place it on face of left arm.
23. [] Lubricate larger diameter threads of center-pivot bolt. Slip bolt into face of left caliper arm and thread it fully into half-bridge.
24. [] Place spring and large washer onto back of center-pivot assembly.
25. [] Thread nut onto center-pivot bolt (Shimano: make sure subtly concave face is against large washer).

Adjust center-pivot assembly

Even if the caliper has not been disassembled, it is a good idea to adjust the pivots to eliminate any free play. Such play can cause brakes to squeal and feel grabby. The Shimano center-pivot assembly can be adjusted without disassembling the right-pivot assembly. With the mounting bolt held in soft jaws of a vise, by pushing down and in on the right-pivot assembly, the head of the center-pivot bolt becomes exposed. The Campagnolo center-pivot assembly is only accessible after disassembling the right-pivot assembly.



36.58 Adjusting the center-pivot assembly.

36 – CABLE-OPERATED RIM-BRAKE CALIPERS

26. [] Place wrench on nut.
27. [] Grasp threaded-end of center pivot firmly in soft jaws of vise with assembly positioned so that you are facing its back side.
28. [] Turn half-bridge clockwise until it bottoms out, then counterclockwise about 60°.
29. [] Holding half-bridge stationary with your fingers, turn nut clockwise to tighten it against half-bridge to a torque of 60–70in-lbs (20–23lbs@3").
30. [] Jerk in and out on end of left caliper arm to check for free play or knock.
31. If knock is felt:
 - [] Hold half-bridge stationary.
 - [] Break nut loose (counterclockwise).
 - [] Turn half-bridge clockwise so that its end moves 5–10mm.
 - [] Hold half-bridge stationary and secure nut.
 - [] Check for knock again. Repeat step 31 as many times as necessary until no knock is felt.
32. If no knock is felt, check that left caliper arm is pivoting freely without excessive drag. If excessive drag is felt:
 - [] Hold half-bridge stationary.
 - [] Break nut loose (counterclockwise).
 - [] Turn half-bridge counterclockwise so that its end moves 5–10mm.
 - [] Hold half-bridge stationary and secure nut.
 - [] Check for excessive drag again. Repeat step 32 as many times as necessary until knock is felt, then return to last setting.
33. [] *Shimano non-Dura-Ace only*: Slip spring sleeve onto spring.
34. [] Engage spring in its notch on back side of left caliper arm.

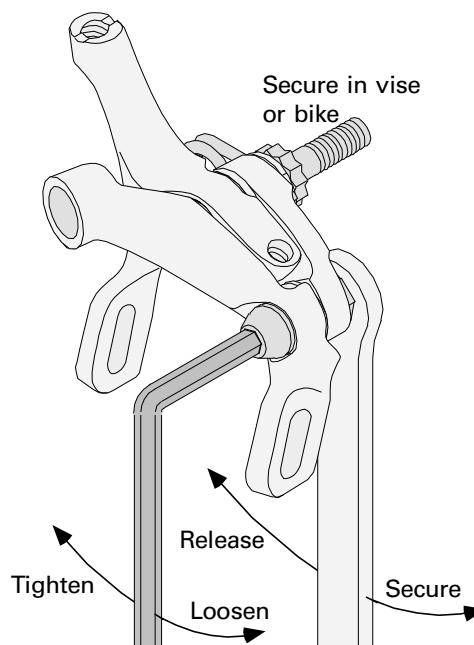
On Shimano non-Dura-Ace calipers, the sleeve on the spring can be flip-flopped two ways to adjust spring tension. On Shimano Dura-Ace and Campagnolo models, there is a threaded adjustment for changing spring tension. The tighter setting is for excess cable friction that results from long or unusual routings.

35. [] Secure set screw in half-bridge (or locknut on backside of half-bridge) with 2mm Allen wrench.

NOTE: Go to *Assembling and adjusting Campagnolo right pivot*, if brake being serviced is a Campagnolo model.

Assemble and adjust Shimano right pivot

Even if the caliper has not been disassembled, it is a good idea to adjust the pivots to eliminate any free play. Such play can cause brakes to squeal or feel grabby. The Shimano right-pivot assembly can be adjusted without removing the caliper from the bike.



36.59 Adjusting a Shimano right-pivot assembly.

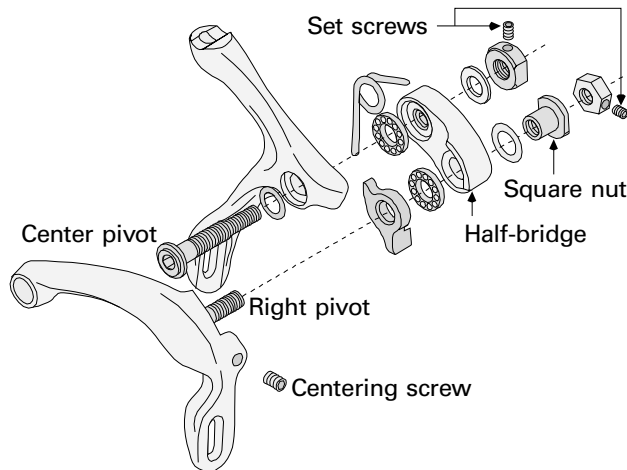
36. [] Lubricate both sides of both washers, inside and outside of bushing, and threads of right-pivot bolt.
37. [] Sandwich large washer between back of right caliper arm and front of right end of half-bridge.
38. [] Put small washer on face of right caliper arm.
39. [] Put right-pivot bolt through right caliper arm and thread it fully into half-bridge.
40. [] Thread on, but do not secure, 10mm nut on back side of half-bridge.
41. [] Mount brake securely to frame or fork.
42. [] Turn right-pivot bolt clockwise (facing brake) until it bottoms out, then back it off 90°.
43. [] Hold right-pivot bolt stationary while securing 10mm nut to torque of 50–70in-lbs (17–23lbs@3").
44. [] Jerk in and out on end of right caliper arm and check for free play or knock.
45. If knock is felt:
 - [] Hold bolt stationary.
 - [] Break loose 10mm nut.
 - [] Turn bolt clockwise (1/2" at end of 3" Allen wrench
 - [] Hold bolt stationary and secure 10mm nut.
 - [] Check for knock again. Repeat step 45 as many times as necessary until no knock is felt.

46. [] If no knock is felt, check that right caliper arm is pivoting freely without excessive drag. If excessive drag is felt:
- [] Hold bolt stationary.
 - [] Break loose 10mm nut.
 - [] Turn bolt counterclockwise (1/2" at end of 3" Allen wrench).
 - [] Hold bolt stationary and secure 10mm nut again.
 - [] Check for excessive drag again. Repeat step 46 as many times as necessary until knock is felt, then return to last setting.

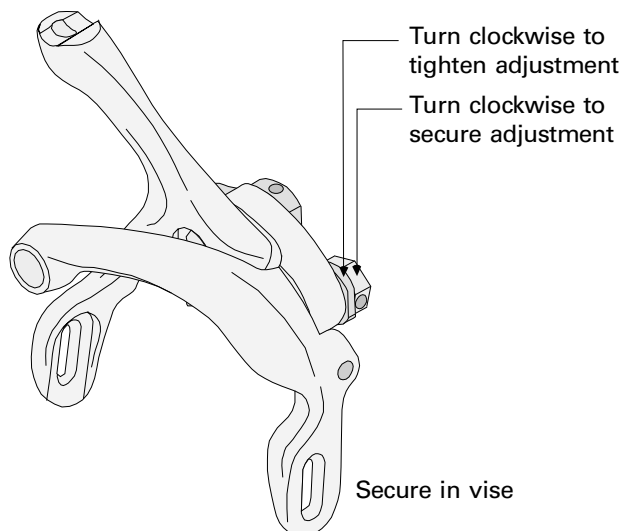
NOTE: Go to MOUNTING CALIPER TO FRAME.

Assemble and adjust Campagnolo right pivot

Even if the caliper has not been disassembled, it is a good idea to adjust the pivots to eliminate any free play. Such play can cause brakes to squeal or feel grabby. The Campagnolo right-pivot assembly can be adjusted without removing the caliper from the bike.



36.60 Blow-up of a Campagnolo dual-pivot assembly.



36.61 Adjusting a Campagnolo right-pivot assembly.

36. [] Lubricate sandwich-washer, then assemble centering cam and washer onto pivot stud in back face of right arm.
37. [] Place half-bridge over right-arm pivot stud.
38. [] Put small washer on back face of half-bridge.
39. [] Grease square-head sleeve nut, then thread onto pivot stud so that sleeve goes inside hole in half-bridge.
40. [] Thread nut onto right-arm pivot stud, but do not secure.
41. [] Grasp bottom end of right caliper arm in soft jaws in vise, with back face of brake up.
42. [] Turn square nut clockwise until bottomed, then back of approximately 90°.
43. [] Hold square nut stationary and secure hex nut to torque of 50–70in-lbs (17–23lbs@3").
44. [] Jerk in and out on end of right caliper arm and check for free play or knock.
45. If knock is felt:
- [] Hold square nut stationary.
 - [] Break loose hex nut.
 - [] Turn square nut clockwise (1/2" at end of 3" wrench).
 - [] Hold square nut stationary and secure hex nut again.
 - [] Check for knock again. Repeat step 45 as many times as necessary until no knock is felt, then secure 2mm Allen set screw in wrench flat on hex nut.
46. [] If no knock is felt, check that right caliper arm is pivoting freely, without excessive drag. If excessive drag is felt:
- [] Hold square nut stationary.
 - [] Break loose hex nut.
 - [] Turn square nut counterclockwise (1/2" at end of 3" wrench).
 - [] Hold square nut stationary and secure hex nut again.
 - [] Check for excessive again. Repeat step 46 as many times as necessary until knock is felt, then return to last setting and secure 2mm Allen set screw in wrench flat on hex nut.

MOUNTING CALIPER TO FRAME

1. [] Treat mounting-nut threads with Loctite 242, unless mounting nut is hex-nut variety with nylon insert for thread locking (leave untreated).
2. [] Install mounting stud on back of caliper into hole in frame or fork, then thread mounting nut onto mounting stud.
3. [] Install brake pads so that they will strike rim at normal position. This is not final pad adjustment.

36 – CABLE-OPERATED RIM-BRAKE CALIPERS

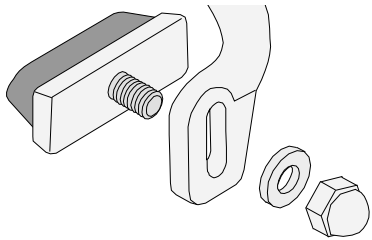
Shimano and Campagnolo dual-pivot brakes have centering screws that must be used to make an adjustment in either direction. The screws are located in different places. For Shimano, look for a Phillips screw on top of the left caliper arm at its rightmost end. For Campagnolo, look for a recessed Allen set screw in the outward face of the right caliper arm, just below the right pivot.

4. [] **Shimano:** Adjust centering screw so that bottom edge of its head is even with the top of hole in left caliper arm that screw goes into.
Campagnolo: Adjust centering screw so that it is in one full turn out from flush with face of right caliper arm.
5. Hold caliper so that pads are equidistant from rim, then secure mounting nut to torque of 70–85in-lbs (23–28lbs@3").

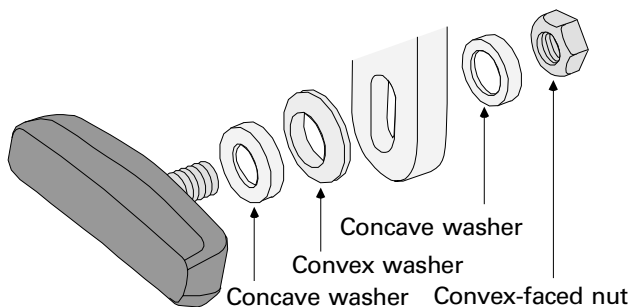
INSTALLING AND ADJUSTING PADS

1. [] Check each pad for directional arrows and/or right/left indications; make sure pads will be installed with arrows pointing in the direction of rim rotation, and any pad marked with "R" is mounted on right side of bike and any marked with "L" is on left side of bike.

Determine what sort of pad-alignment system is on the calipers. Use the procedures in the earlier section for **SIMPLE THREADED-STUD-PAD ALIGNMENT** (page 36-8), or **THREADED-STUD/CURVED-WASHER PAD ALIGNMENT** (page 36-10). Align the pads to the tolerances described in the next step.

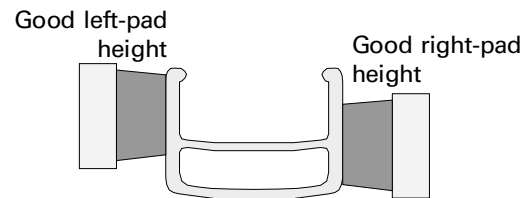


36.62 A simple threaded-stud pad-alignment design.



36.63 A threaded-stud/curved-washer pad-alignment design.

Pad height is a very different with dual-pivot brakes. The right pad swings up as it moves in, and the left pad swings down as it moves in. Consequently, the right-pad height needs to be set so that its bottom edge is even with the bottom edge of the rim's braking surface, and the left-pad height needs to be set so that its top edge is even with the top edge of the rim's braking surface. Although it looks unusual, dual-pivot pad heights are correct when the heights are not even. Complicating pad-height setting further, is the fact that the bottom and top edges of the braking surface are not always distinct; sometimes the rim just begins to curve inward gradually, and the braking surface just "fades" away. In this case, consider the edge of the braking surface to be the point of transition where the surface of the rim changes from facing towards the pad to facing more up or down. In no case should the top edge of the left pad be more than 1mm below the absolute top of the rim, and in no case should the bottom edge of the right pad extend below the rim.



36.64 Correct dual-pivot pad height.

2. [] Determine what pad-alignment system to use by looking at way shoes are mounted to caliper arm, then use appropriate pad-alignment-system procedure to achieve following tolerances (in order indicated by pad-alignment-system procedure):

Pad toe: entry-end of pad clears rim by .5–1.0mm when exit-end touches rim.

Vertical angle: vertical angle of pad face is parallel to vertical angle of rim face.

Pad tangent: top corners of pad are equidistant from top edge of rim.

Right-pad height: bottom edge of pad face is even with bottom edge of rim's braking surface.

Left-pad height: top edge of pad face is even with top edge of rim's braking surface.

CABLE ATTACHMENT, CLEARANCE, AND CENTERING ADJUSTMENTS

Cable attachment

1. [] Install brake lever and cable system, if not already installed.
2. [] Lubricate threads of pinch mechanism on right caliper arm, and threads of cable-adjusting barrel on left caliper arm.
3. [] Set cable-system adjusting barrel to 3 full turns out from fully-in position.
4. [] Hold pads to rim with third-hand tool.
5. [] Make sure Q.R. mechanism lever is fully down.
6. [] Thread inner wire through cable-adjusting barrel and cable-pinch mechanism.
7. [] Draw slack out of cable with fourth-hand tool.
8. [] Secure pinch bolt to torque of 50–70in-lbs (17–21lbs@3").
9. [] Stress cable system by pulling against lever 10 times with maximum force that would be used during a panic stop.

Adjust pad centering

The purpose of the centering adjustment is to ensure that the pads reach the rim simultaneously. The centering adjustment is not primarily designed to ensure that the pads end up equally clear of the rim when released, as a sidepull or cantilever does. When the centering is set so that the pads reach the rim simultaneously, they will also end up clearing the rim almost evenly. If not set in this way, then the first pad to reach the rim will push the rim to the side until the other pad meets the rim. This then requires higher braking effort.

10. [] Operate brake and observe whether brake tends to push rim to one side, or one pad reaches rim before other. If either condition exists, centering adjustment is needed.
11. [] Turn centering screw clockwise to move the brake's right pad (as seen when facing brake) away from rim and left pad toward rim.
12. [] Turn centering screw counterclockwise to move brake's right pad (as seen when facing brake) toward rim and left pad away from rim.

Fine tune brake-pad clearance

When released, each pad should clear the rim by at least 1mm and a maximum of 2mm. The clearances need not be precisely identical. Use feeler gauges to check clearance at the point the pad(s) is closest to the rim.

13. [] Move cable-adjusting barrel in to increase clearance, or out to reduce clearance until each pad clears rim by 1–2mm.

14. [] Move inner wire through pinch mechanism to change clearance if adjusting barrel cannot move down far enough, or if adjusting barrel must be moved up >4mm from bottomed, to make clearance tight enough.

FINISHING

See the section called *FINISHING* (page 36-43) for cable finish, rim cleaning, and test-ride procedures.

CENTERPULL CALIPERS

CALIPER MOUNTING

1. [] Install radius washer between caliper and frame, wherever frame/fork mounting surface is not flat. Reflector bracket may serve this function in some cases.
2. [] Install radius bushing between frame/fork and mounting nut, if surface is not flat.

The mounting nut should be the type with a nylon insert so that it cannot work loose. If no such nut is available, use Loctite #222 or #242 on the threads.

3. [] Install flat washer under mounting nut.

The brake should be mounted loosely enough so that it can be centered by hand, but secure enough that it will not shift on its own. A nylon insert or Loctite on the threads, and not high torque, ensures that brake will not work loose.

4. [] Secure nut to torque of 12–36in-lbs (4–12lbs@3").

LUBRICATION

1. [] Oil arm pivots at front and back of each arm.
2. [] Oil spring ends where they bear against caliper-arm posts and bridge posts.
3. [] Oil sockets in caliper arm for straddle wire end(s) and pinch mechanism (if any).
4. [] Oil threads of any pinch mechanism on straddle wire or primary wire.
5. [] Oil threads of adjusting barrel at end of cable housing.
6. [] On many Weinmann and Dia-Compe brakes, there is tab on back side of front caliper arm that rides in slot in face of rear caliper arm so that arms always move in unison. Oil tab.

PIVOT ADJUSTMENT

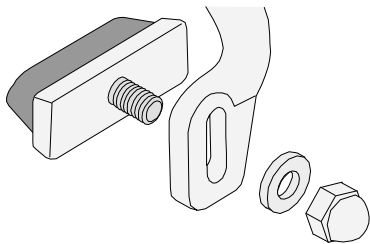
Most centerpull pivots are not adjustable. Non-adjustable pivots are characterized by the lack of a locknut on the back end of the pivot bolt, or by a locknut mounted in a recess in the back side of the brake-arm bridge. The pivot is usually a bushing that is longer than the hole in the caliper arm. When the pivot bolt is tightened, it seats against the bushing, but not the caliper arm. The bolt should be checked for proper security on all new bikes and during all repair situations. The bushing parts may be replaced, when available, to reduce free play in the pivots, but this is rarely done.

Adjustable pivots are found on some models, including the old Shimano Tourney centerpull. When the pivot is adjustable, there will be a fully accessible locknut for each pivot bolt on the back side of the brake-arm bridge. Hold the pivot bolt stationary, then turn the locknut counterclockwise (as viewed from the back of the caliper) to release the pivot bolt. The pivot bolt may now be turned clockwise to reduce play, or counterclockwise to reduce binding. After changing the adjustment, hold the pivot bolt stationary and secure the locknut.

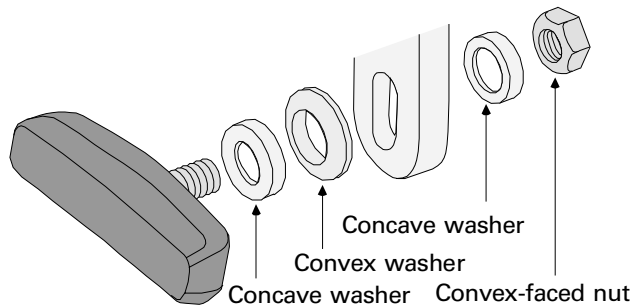
PAD INSTALLATION AND ALIGNMENTS

1. [] Rock caliper bridge side-to-side until pads are equidistant from rim.
2. [] Check each pad for directional arrows and/or right/left indications; make sure pads will be installed with arrows pointing in the direction of rim rotation, and any pad marked with "R" is mounted on right side of bike and any marked with "L" is on left side of bike.

Determine what type of pad-alignment system is on the calipers. Use the procedures outlined in the earlier section for **SIMPLE THREADED-STUD-PAD ALIGNMENT** (page 36-8), or **THREADED-STUD/CURVED-WASHER PAD ALIGNMENT** (page 36-10). Align the pads to the tolerances described in the next step.

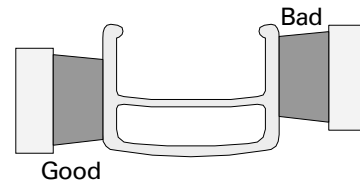


36.65 A simple threaded-stud pad-alignment design.



36.66 A threaded-stud/curved-washer pad-alignment design.

Pads on centerpull calipers swing up as they move in; set the pad height so that the bottom edge of the pad is even with the bottom edge of the rim's braking surface.



36.67 Correct centerpull pad height.

3. [] Determine what pad-alignment system to use by looking at way shoes are mounted to caliper arm, then use appropriate pad-alignment-system procedure to achieve following tolerances (in order indicated by pad-alignment-system procedure):

Pad toe: entry-end of pad clears rim by .5–1.5mm when exit-end touches rim.

Vertical angle: vertical angle of pad face is parallel to vertical angle of rim face.

Pad tangent: top corners of pad are equidistant from top edge of rim.

Pad height: bottom edge of pad face is even with bottom edge of rim's braking surface.

CABLE ATTACHMENT, CLEARANCE ADJUSTMENT, AND CENTERING

1. [] Set cable-adjusting barrels so that they are turned 3–4 turns out from fully-in.
2. [] Hook cable carrier onto straddle wire (name side of carrier should face out).
3. [] Thread primary wire through pinch bolt. If pinch bolt is in carrier correctly, primary wire should be on same side of cable carrier as straddle wire.
4. [] Hold pads to rim with third-hand tool.

5. [] Check that wire end is properly seated in lever, and that housing ends are fully seated in their stops and adjusting barrels.
6. [] Use fourth-hand tool to simultaneously tighten straddle wire and primary wire by bracing fourth-hand on bottom side of cable carrier, then pulling primary wire through pinch bolt.
7. [] Secure pinch nut enough to hold cable temporarily, then remove fourth-hand tool.
8. [] Use an open-end 8mm, 9mm or 10mm wrench to hold pinch bolt while tightening nut to torque of 50–70in-lbs (17–23lbs@3"), then remove third-hand tool.
9. [] Stretch cable system by squeezing lever firmly at least 10 times. If cable seems to slip, loosen cable pinch and repeat from step 4.
10. [] Check pad clearance by pushing one pad to rim while measuring gap between other pad and rim at closest point.
11. [] Use cable-adjusting barrel to adjust clearance so that gap at one pad (when other touches rim) is 2–3m. If clearance cannot be achieved when adjusting barrel is turned all the way in, or out more than 5 full turns, then cable must be reset in cable-carrier pinch mechanism.
12. [] Center pads by rocking caliper bridge to one side or other by hand. Loosen mounting nut if necessary.

FINISHING

See the section called **FINISHING** (page 36-43) for cable finish, rim cleaning, and test-ride procedures.

U-BRAKE CALIPERS

U-brake calipers are similar to centerpull brakes, but the pivot studs are an integral part of the frame, rather than simply a part of a caliper bridge which is bolted to the frame. The fact that the pivot studs are part the frame makes U-brakes appear similar to cantilever brakes, but the dimensions and locations of the pivot studs in relation to the rim are completely different. Because of those differences, U-brakes are a completely different brake system than cantilever brakes.

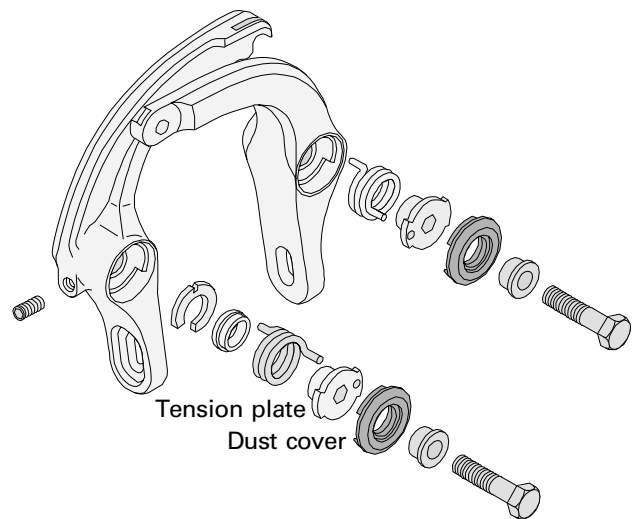
Another variety of brakes, called Rollercam brakes, fits on the same pivot studs as U-brakes. Rollercam brakes have been discontinued, and never were as popular as U-brakes. Parts availability is limited. Service instructions for Rollercam brakes are not included in this book. It is strongly recommended to replace problematic Rollercam brakes with U-brakes.

REMOVAL AND DISASSEMBLY

1. [] Disconnect cables.
2. [] Turn mounting bolt(s) counterclockwise (spring tension will be lost) to remove. (On Dia-Compe #AD-990/992, mounting bolts are Allen bolts, not large nuts with 13mm pair of flats and 19mm hex.)
3. Caliper arms should pull off studs once mounting bolts are removed.

Disassembling of Shimano-type U-brake

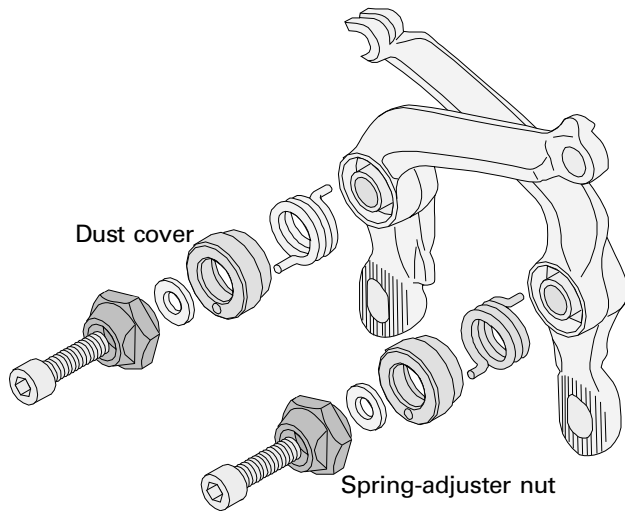
It is not necessary to disassemble these brakes for adequate cleaning and lubrication. *It is recommended to leave Shimano U-brakes assembled, except to replace damaged parts!*



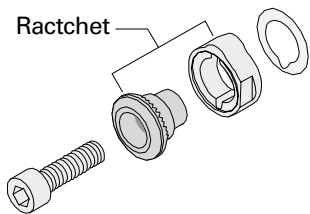
36.68 Blow-up of a Shimano U-brake.

1. [] Remove plastic dustcap or "shark's tooth."
2. [] Put an Allen wrench of appropriate size in spring-tension plate.
3. [] For inner arm (no pinch bolt), turn Allen wrench small amount clockwise while pressing in. Then pull out with wrench and let tension plate unwind (counterclockwise). Tension plate should pull out after spring tension is released.
3. [] For outer arm (with pinch bolt), turn Allen wrench small amount counterclockwise while pressing in. Then pull out with wrench and let tension plate unwind (clockwise). Tension plate should pull out after spring tension is released.
4. [] Pull spring(s) out and observe which end of each spring was in caliper arm, and which color spring was in each arm.

Disassembly of Dia-Compe AD-990/992 type



36.69 Blow-up of Dia-Compe AD-990 U-brake.



36.70 Dia-Compe AD-992 spring-tension mechanism.

1. [] Pull off large spring-tension nut or ratchet.
2. [] Remove plastic dust cover.
3. [] Pull out spring, observing which color spring comes from which arm.

ASSEMBLING CALIPER ARMS

All models of U-Brakes fit the same pivot studs as Rollercam brakes, but not the same pivot studs as cantilevers. The pivot stud should be 9mm outside diameter and 16.5mm long. It may be a female or male thread. A conversion kit may be needed if the pivot stud is male.

1. [] Fit caliper arm(s) onto pivot stud(s) and check whether they are good fit.
2. [] If they are tight going on, pivot stud may be rusted, covered with paint, or swollen at tip if mounting bolt was over-tightened. In any case, reduce diameter with an emery cloth.
3. [] If pivot stud is short, it will not protrude past end of brass bushing in caliper arm when arm is slipped all way on. File or grind back end of bushing in arm to shorten it.
4. [] Remove caliper arm after checking fit.
5. [] Grease outside of pivot stud(s).
6. [] Add Loctite 222 or 242 to female threads (in pivot stud or mounting nut).

Assembling Shimano-type U-brake

1. [] Grease springs.
2. [] Install gold spring in arm without pinch bolt. Long end should be pointing out, and should be winding in clockwise direction.
3. [] Install silver spring in arm with pinch bolt. Long end should be pointing out, and should be winding in counterclockwise direction.
4. [] Install tension plates with Allen fitting face out, with end of spring in hole in plate.
5. [] Plate on gold spring should be wound clockwise about 60°, until tab on perimeter of plate is past stop inside arm. Then, press in firmly on tension plate with Allen wrench to seat it in arm.
6. [] Plate on silver spring should be wound counterclockwise about 60°, until tab on perimeter of plate is past stop inside arm. Then, press in firmly on tension plate with Allen wrench to seat it in arm.
7. [] Place dustcap(s) over tension plate so protruding spring will engage slot in back of dustcap, and so two notches in back perimeter of dustcap line up with stop tabs inside arm(s).

INSTALLATION OF CALIPER ARMS

Dia-Compe AD-990/992 type

1. [] Install arm without pinch bolt first, then other arm.
2. [] Grease springs.
3. [] Install gold spring in pinch-bolt arm and silver spring in arm without pinch bolt.
4. [] Install dust covers.
5. [] Install spring-adjuster nuts.
6. [] *Model AD-992 only:* install right and left ratchets. Then install and secure mounting bolts. *Model AD-990 only:* install, but do not secure, mounting bolts.

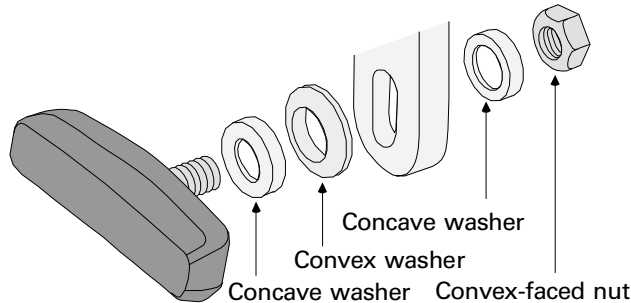
Shimano type

1. [] Install arm without pinch bolt first, and then other arm.
2. [] Thread in, but do not secure, mounting bolts/nuts.
3. [] Hold caliper arms in their fully-open position, while securing mounting bolts/nuts to torque of 50–60in-lbs (17–20lbs@3").

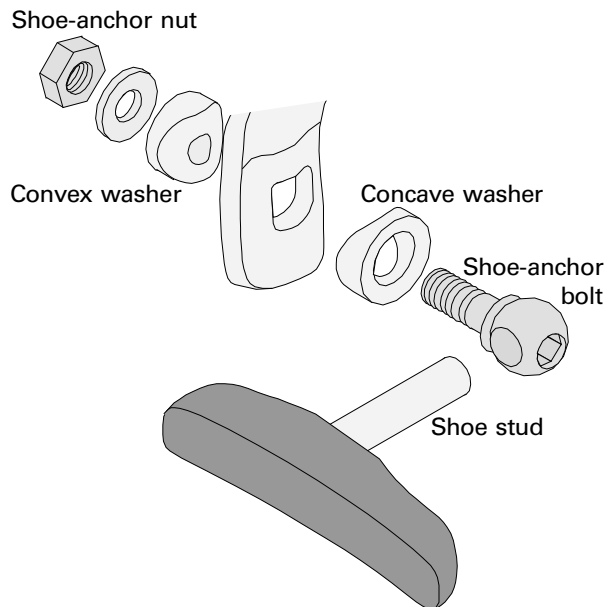
PAD INSTALLATION AND ADJUSTMENT

1. [] Loosen shoe-mounting bolts/nuts just enough so that shoe alignment can be manipulated with your fingers.

Determine what type of pad-alignment system is on the calipers. Use the procedures outlined in the earlier section for **THREADED-STUD/CURVED-WASHER PAD ALIGNMENT** (page 36-10), or **SMOOTH-STUD/CURVED-WASHER PAD ALIGNMENT** (page 36-11). Align the pads to the tolerances described in the next step.



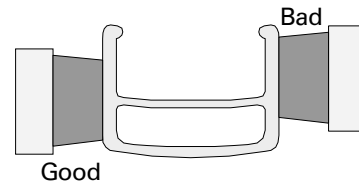
36.71 A threaded-stud/curved-washer pad-alignment design.



36.72 A smooth-stud/curved-washer pad-alignment design.

Pad height is a very critical consideration with U-brakes. The nature of a typical U-brake arm causes the pads to move up significantly as the pads move in toward the rim. Even the compression after the pads contact the rim also results in significant upward motion. The additional pad travel that results from pad wear has an even greater effect on the height of the pad as it reaches the rim. For these reasons, it is critical to set the pads as low on the rim as is safe, when setting up U-brakes. Normally, this lowest setting would place the bottom edge of the pad even with the bottom edge of the braking surface on the rim. Unfortunately, the braking surface is not always clearly delineated. If the braking sur-

face gradually transitions to the “bottom” of the rim, then the correct height is somewhat subjective. The following illustration shows good U-brake-pad height on a rim with a clearly delineated braking surface.



36.73 Correct U-brake-pad height.

2. [] Determine what pad-alignment system to use by looking at way shoes are mounted to caliper arm, then use appropriate pad-alignment-system procedure to achieve following tolerances (in order indicated by pad-alignment-system procedure):

Pad toe: entry-end of pad clears rim by .5–1.0mm when exit-end touches rim.

Vertical angle: vertical angle of pad face is parallel to vertical angle of rim face.

Pad tangent: top corners of pad are equidistant from top edge of rim.

Pad height: bottom edge of pad face is even with bottom edge of rim’s braking surface.

Smooth-stud engagement: Position shoes so that both contact rim and amount of shoe stud protruding past anchor bolts is equal on both sides.

INSTALL AND SIZE STRADDLE WIRE

1. [] Install brake lever and cable system, if not already installed.
2. [] Lubricate threads of pinch mechanism on caliper arm and threads of cable-adjusting barrel.
3. [] Set cable-system adjusting barrel to 3 full turns out from fully-in position.
4. [] Install cable carrier on primary brake wire so that name side and/or pinch nut faces away from frame or fork.
5. [] Position cable carrier so that there is minimum of 20mm between it and anything that it would bump into when cable is pulled by brake lever. It is preferable to have similar clearance (minimum 20mm) between bottom of carrier and caliper arms, if possible.
6. [] Hook one end of straddle wire into caliper arm with socket. This socket should be oiled.
7. [] Place straddle wire in cable-carrier cradle, between carrier and primary cable.
8. [] Thread end of straddle wire through pinch mechanism. Oil pinch-bolt threads.

36 – CABLE-OPERATED RIM-BRAKE CALIPERS

9. [] With brake pads held to rim by third-hand tool, draw slack out of straddle wire, and simultaneously primary wire, with fourth-hand tool.
10. [] Secure pinch bolt to torque of 50–70in-lbs (17–23lbs@3").

SETTING RETURN SPRING TENSION: DIA-COMPE AD-990/992

AD-990

1. [] Loosen mounting bolts if they have been secured.
2. [] Turn left tension-adjusting nut approximately 20°–30° clockwise, and hold it stationary while tightening mounting bolt to torque of 50–60in-lbs (17–20lbs@3").
3. [] Turn right tension-adjusting nut approximately 20°–30° counterclockwise, then hold it stationary while tightening mounting bolt to torque of 50–60in-lbs (17–20lbs@3").

AD-992

1. [] If brake return springs have too much tension already, release torque on mounting bolts and tension will be lost.
2. [] Secure mounting bolts to torque of 50–60-lbs (17–20lbs@3").
3. [] Turn spring adjusters with 19mm wrench to add tension.
4. [] Turn left one clockwise to increase tension.
5. [] Turn right one counterclockwise to increase tension.
6. [] Make sure mark on spring adjuster does not pass MAX mark on outside of caliper arm.

SETTING PAD CLEARANCE

1. [] Squeeze brake lever firmly 10 times so that cable system will be stressed and checked for failure.
2. [] Release lever, then pull it gently until pads just touch rim. There should be minimum 25mm clearance at this point between lever and bar.
3. [] If there is > 25mm clearance, turn cable-adjusting barrel in to reduce clearance at lever when pads reach rim. If cable-adjusting barrel does not provide enough adjustment, loosen straddle-wire pinch bolt and let some more cable back through pinch mechanism.
4. [] If there is < 25mm clearance, and cable-adjusting barrel is less than 5 full turns out of lever, use adjusting barrel until it is up to 5 full turns out to adjust clearance.

5. [] If adjusting barrel is already 5 full turns out and brake lever is too close to handlebar when pads reach rim, loosen straddle-wire pinch bolt and draw more cable through with fourth-hand tool.

PAD CENTERING

Shimano types

A tension-adjusting screw for the left arm return spring is recessed in a hole in the outward side of the caliper arm. It is fit by a 2mm Allen wrench.

1. [] If pad is too close on left, turn screw clockwise to increase clearance on left side and reduce clearance on right side.
2. [] If pad is too close on right, turning screw counterclockwise to decrease clearance on left side and increase clearance on right side.
3. [] Operate brake two or three times, then re-check pad centering and adjust further if necessary.

Dia-Compe types

The spring tension on either side is adjustable, but only one side needs to be adjusted to improve the centering. The AD-990 must have its mounting bolt loosened before the spring-adjuster nut can be turned.

Do not turn the adjuster nut past the MAX mark on the AD-992. If the mark is reached, loosen both mounting bolts to release all tension, and start from scratch. *Do not force the spring-adjusting nuts in the opposite direction to reduce the tension!*

1. [] If left pad is too close to rim, turn left spring-adjuster nut clockwise to increase clearance on left and reduce clearance on right.
2. [] If right pad is too close to rim, turn right spring-adjuster nut counterclockwise to increase clearance on right and reduce clearance on left.

FINISHING

See the section called **FINISHING** (page 36-43) for cable finish, rim cleaning, and test-ride procedures.

FINISHING

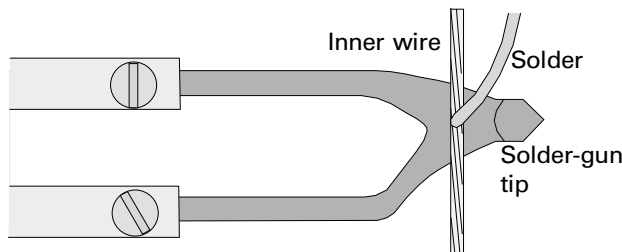
Trimming, soldering, and capping wires

Excess inner wire should be trimmed and finished. Excess length is unsightly and may get caught in the wheel or brake. Soldering prevents fraying, and allows reuse of the cable whether a wire cap is used or not. Wire caps do not prevent fraying, but they do prevent someone getting poked by the wire.

Trim the inner wire to leave about 25–30mm of wire past the pinch mechanism. Before doing this, check to see if the caliper manufacturer has provided a spot to hook the free end of the wire behind the caliper arm. If there is a good spot to do this, leave the wire just long enough to hook it in place.

1. [] **Trim inner wire with wire cutters 25–30mm past cable-pinch mechanism.**

The next step suggests soldering the end of the wire. This is easy to do and prevents fraying. To solder, a soldering gun, thin 40/60 rosin-core solder, and soldering flux are needed. Put flux on the inner wire. Hold the soldering gun tip flat against one side of the wire until the flux sizzles away. Still holding the soldering gun tip flat against one side of the wire, hold the tip of the solder against the other side of the wire until the heated wire causes the solder to melt and flow into the wire. Some wires are specially coated or made of stainless steel and will not accept solder. In these cases the wire will melt the solder, but the solder will not flow into the wire. Instead, it beads up and runs off the wire.



36.74 *Correct soldering technique.*

2. [] **Solder inner wire end.**

Wire-end caps are sometimes used instead of solder to prevent fraying. This will not work. Crimping the cap onto the wire frequently *causes* fraying. A soldered wire will not fray when the cap is crimped on. The real function of the wire cap is to cover the sharp end of the wire.

3. [] **Put cap on end of inner wire if desired.**

Rim cleaning and test-ride procedures

It is always important to clean the braking surface on a rim as you finish any brake job. It is also a very good idea to test ride the bike at that time. Cleaning the rims with alcohol or acetone removes residues left from hands, or just dirt left over from riding. Removing either ensures optimum brake performance. Test riding should be done to check for squeal, and to check overall brake performance. If squeal is detected, check for caliper-arm pivot play and adequate brake-pad toe.

CABLE-OPERATED RIM-BRAKE-CALIPER TROUBLESHOOTING

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Brake squeals when applied hard or softly.</i>	
Loose pivot(s).	Adjust pivot(s) if adjustable, and/or replace pivot bushings. Condition is not always correctable, particularly with cantilever brakes.
Contamination on rims (oil or dirt).	Clean rims with solvent or heavy-duty cleanser that leaves no residue.
Brakes shoes need toe adjustment.	Toe pads to a maximum clearance of 1.5mm at tail end of pad.
Caliper arms are flexing.	Long and/or skinny caliper arms are prone to flexing, which can only be prevented by using higher-quality, stiffer arms.
Humidity conditions.	Changes in humidity may change a brake's tendency to squeal; there is no solution.
Contamination on pad faces.	Replace pads or regrind pad face(s).
Pads incompatible with rim.	Changing brands of pads may reduce squeal.
Pads not broken-in to rim.	New pads may squeal under high braking force only, then not squeal once they have conformed to the shape of the rim. Recheck all pad alignments, or run emery cloth between the pads and the rim while applying the brakes gently, to accelerate pad break-in.
SYMPTOM: <i>Brake mechanism(s) squeak when applied and/or released.</i>	
Lever pivot(s) need oil.	Oil lever pivots.
Cable-anchor pivots in lever need oil.	Oil cable-anchor pivots.
Cable-end socket for barrel-ended cable needs oil in lever.	Oil cable-end socket.
Spring ends need oil where they brace against caliper arms.	Oil spring ends.
Spring coils need oil.	Oil spring coils.
SYMPTOM: <i>Sidepull caliper will not hold its center adjustment.</i>	
Caliper-mounting nut not secure.	Secure caliper-mounting nut.
Spring not fixed securely in slot in spring-mounting plate.	Peen down slot in spring-mounting plate to eliminate play between spring and spring-mounting plate.
Caliper pivots need oil.	Oil caliper pivots.
Spring ends need oil.	Oil spring ends.
Spring is fatigued.	Replace spring.
SYMPTOM: <i>Properly centered sidepull caliper has one arm that moves in before the other.</i>	
Cable housing resists motion of only one caliper arm.	This is a normal response and needs no correction. The arms act uniformly once both pads reach the rim.
Housing loop to rear brake may be too short, particularly on BMX bikes, so that it loses all bow before the pad contacts the rim.	Lengthen housing loop.

(continued next page)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Sidepull-caliper-pivot adjustment does not stay correctly adjusted.</i>	
Improper centering technique.	See section on sidepull-caliper-centering adjustment.
Inadequate adjustment security.	Reset adjustment and secure adequately.
Heavy-duty use.	Treat adjustment nut and adjustment-locknut threads with Loctite #222 and reset adjustment.
SYMPTOM: <i>Sidepull-caliper-pivot adjustment remains too tight no matter how it is adjusted.</i>	
Adjustment nut or pivot-bolt threads are stripped.	Inspect and replace damaged parts.
Return spring is fatigued.	Check and replace spring.
SYMPTOM: <i>Sidepull caliper will not release completely after release of the lever.</i>	
Pivot needs oil.	Oil pivot.
Pivot too tight.	Adjust pivot to eliminate bind and/or play.
Spring fatigued.	Check and replace spring.
Friction in cable system.	Inspect for poor cable routing, the remove cable system and inspect for rust, kinks, improperly finished housing ends, and lack of lubrication.
Sticky lever.	See BRAKE LEVERS chapter (page 34-9).
SYMPTOM: <i>Centerpull caliper will not hold its centering adjustment.</i>	
Mounting nut not secure.	Secure mounting nut.
SYMPTOM: <i>Cantilever brakes cannot be properly centered.</i>	
Wheel out-of-center in frame/fork.	Check and correct wheel centering.
Pivot studs in need of grease.	Remove calipers and grease pivot studs.
Link-wire improperly setup.	Setup again, using proper Pro-Set tool and technique.
Primary wire approaches brake from off-center approach.	It may be necessary to deviate from standard setup procedures to center brake when frame manufacturer forces primary wire to approach brake from off-center.
Caliper arm not pivoting freely on damaged (flared) pivot stud.	Remove arm and use Bicycle Research BM1 pivot-stud mill (or emery cloth) to reduce flare.
Pivot bushing of caliper arm longer than pivot stud.	File caliper-pivot bushing shorter.
Deformed mounting washer pressing against face of caliper arm.	Replace washer.
Depth of shoe stud in each anchor bolt not equal.	Reset shoe-stud depth.
Damaged, mis-matched, or mis-installed springs.	Disassemble caliper and inspect springs.
Springs not engaged in equal hole positions in multiple-hole braze-ons.	Reposition springs.
Braze-ons mis-positioned.	Not correctable.

(continued next page)

CABLE-OPERATED RIM-BRAKE-CALIPER TROUBLESHOOTING (continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Cantilever arm is not pivoting freely.</i>	
Pivot stud needs grease.	Grease pivot stud.
Pivot stud flared from over-tight mounting bolt.	Remove arm and use Bicycle Research BM1 pivot-stud mill (or emery cloth) to reduce flare.
Rust on pivot stud.	Clean with emery cloth and grease.
Caliper-arm-pivot bushing longer than pivot stud.	File bushing shorter.
Deformed mounting washer pressing against face of caliper arm.	Replace washer.
SYMPTOM: <i>Cantilever pads force their way to below the rim.</i>	
Pads adjusted too low on rim.	Reset pads to as high as possible on rim face.
Poor vertical-angle alignment causes pads to travel too far.	Align vertical angle of pad face to match vertical angle of rim face.
V-shaped rim cross-section incompatible with cantilever brakes.	– Use firm pads to reduce deflection. – Switch rim to more vertical or inverted-slope face.
SYMPTOM: <i>Cantilever pads cannot be adjusted to have proper height and vertical-angle alignment at the same time.</i>	
Improper pivot-stud position in relation to rim.	– No complete solution possible; sacrifice proper alignment for best possible height. – Wider rim, narrower rim, or rim with taller braking surface may help.
Caliper arm with threaded-stud/curved-washer pad-alignment system is having to swing too far to reach rim.	If available, switch fat washers from outboard of caliper arm to between caliper arm and brake shoe.
SYMPTOM: <i>U-Brake will not release completely when hooked up, even though there is no problem with the cables detached.</i>	
Straddle wire too short.	Lengthen straddle wire.
SYMPTOM: <i>Shimano U-Brake cannot be centered using the correct technique on the adjustment screw.</i>	
Pivot stud rusty or needing lube.	Remove, clean and lube.
Improper mounting.	Loosen mounting bolts and resecure with both caliper arms open fully, to reset basic spring tension.
Rim cannot be centered to pivot studs.	Loosen mounting bolt on side where clearance is greater, and re-secure caliper arm with pad rotated closer to rim.
Poorly matched springs.	Reset the basic spring tension to be higher or lower as necessary on just one side.

(continued next page)

36 – CABLE-OPERATED RIM-BRAKE CALIPERS

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Brake levers bottom-out easily when pads are set at minimal clearance to the rims.</i>	
Excess housing-loop length.	Shorten housing loops to minimum recommended length.
Spongy housing.	Upgrade housing.
Poorly finished housing ends and/or lack of end caps where they might improve fit.	Finish properly and use end caps.
Light-duty inner wires.	Upgrade inner wires.
Levers mis-positioned on handlebars.	Reposition levers to recommended guidelines.
Mismatched leverage ratio of lever and caliper arms.	Replace one or the other, using brand- and model-matched equipment whenever possible.
Poor vertical-angle pad alignment on cantilever brakes.	Realign vertical-angle alignment of pads.
SYMPTOM: <i>Brake has inadequate stopping power, but levers are not bottoming out on handlebars.</i>	
Excess cable friction.	Set housing-loop lengths properly, lubricate cables, finish ends properly, and use end caps where appropriate.
Poor pad alignment.	Realign pads to improve contact to rim.
Pad surfaces hardened from overheating or age.	Replace pads.
Cable carrier, link-wire head, or link-unit head is bumping into housing stop.	Check that there is 20mm clearance between cable carrier, link-wire head, or link-unit head and housing stop.
Straddle wire too long.	Shorten straddle wire to minimum recommended length.
Oil on rim.	Clean rim and replace pads.
Water on rim.	Use high-performance brake pads.
SYMPTOM: <i>Brake levers require a very high force to start motion, or when pulled gently, they seem to move as though indexed (jerky, not smooth).</i>	
Excess cable friction.	Set housing-loop lengths properly, lubricate cables, finish ends properly, and use end caps where appropriate.
Adjustable pivot adjusted too tight.	Check pivot adjustment.
Caliper pivot(s) need lubrication.	Lubricate caliper pivots.
Cable-anchor pivot in lever sticking.	Oil cable-anchor pivot.
Barrel-type cable end sticking in lever socket.	Lubricate cable-end socket.
SYMPTOM: <i>Levers require excess force to pull.</i>	
Dual-pivot caliper is off-center, causing rim to deflect laterally before second pad will contact.	Check and correct pad centering.
Excess cable friction.	Set housing-loop lengths properly, lubricate cables, finish ends properly and use end caps where appropriate.
Caliper-spring tension set too high.	Reset caliper-spring tension.
Lever pivots and caliper pivots sticky.	Oil all pivots.
SYMPTOM: <i>Cable frays where it leaves brake lever.</i>	
Bent or kinked cable housing.	Replace or trim housing.

(continued next page)

CABLE-OPERATED RIM-BRAKE-CALIPER TROUBLESHOOTING (continued)

<i>Cause</i>	<i>Solution</i>
SYMPTOM: <i>Lever fails to release.</i>	
Caliper pivot sticking.	Check pivot adjustment, pivot lubrication, pivot studs for damage or rust, or deformed washer on face of caliper.
Calipers with adjustable spring tension set too soft.	Reset spring tension.
Excess cable friction.	Set housing-loop lengths properly, lubricate cables, finish ends properly, and use end caps where appropriate.
Lever pivot sticking.	Oil pivot.
Adjustable lever pivot too tight.	– Check for gum-cover interference. – Check for bent pivot or lever. – Adjust lever pivot.
SYMPTOM: <i>Brakes are grabby or lack sensitivity.</i>	
Pivot adjustment loose.	Eliminate all free play if possible.
Wide or narrow seam on rim.	No solution.
Offset seam on non-welded rim.	Use rim pliers to eliminate offset.
Damaged rim sidewalls bulging out.	Use rim pliers to eliminate bulge.
Rim out-of-round (particularly with sloped sidewall rims).	Improve rim round.
Improper match of lever and caliper.	Use brand- and model-matched parts.
Excess cable friction.	Set housing-loop lengths properly, lubricate cables, finish ends properly, and use end caps where appropriate.
SYMPTOM: <i>Brake pads rub tire.</i>	
Pad height set wrong.	Reset pad height.
Loose sidepull-caliper pivot.	Eliminate all free play.
Wheel mounted incorrectly.	Check and remount wheel height and center.
Brake caliper's reach too short for frame and wheel combination.	Replace calipers.

37 – HYDRAULIC RIM BRAKES AND DISC BRAKES

ABOUT THIS CHAPTER

This chapter covers five specific brake models: the Hayes hydraulic disc brake, the Magura hydraulic rim brake, the Magura Gustav M disc brake, the Magura Louise (or Clara) disc brake, and the Shimano Deore XT disc brake. Unlike other chapters in this book, there is no general information preceding the procedural information for each of these items. There is little similarity between these brake systems other than that they use hydraulics at some point in their operation.

HAYES HYDRAULIC DISC BRAKE

ABOUT THIS SECTION

This section specifically covers the Hayes fully hydraulic disc-brake system. This does not include the Hayes cable-actuated disc brake system. The procedures covered in this section include wheel-building guidelines, rotor and wheel installation, lever installation, hose installation, filling and bleeding the system, caliper installation, caliper overhaul, and pad replacement.

TOOLS

No special tools are required for normal installation and adjustment. Hose replacement and bleeding and filling the system requires a Hayes bleed kit, which consists of a two hoses, a plastic fitting, and a squeeze bottle.

INSTALLATION

Wheel building guidelines

The recommended cross patterns are limited to 3X and 4X. Deceleration can occur much more rapidly than acceleration, so consequently the torsional loads from deceleration are much higher than those generated during acceleration. The recommended cross patterns are required to transfer the higher torsional loads that hub-mounted brakes can generate during rapid deceleration.

Although Hayes makes no recommendation regarding lacing patterns, other manufacturers require that the left-side head-out spokes radiate clockwise from the hub and that the right-side head-in spokes radiate counterclockwise from the hub. These are the same directions that result from following the wheel-lacing instructions in this manual. The vernacular terms for these patterns are that the “pulling” spokes are “head out” and the “pushing” spokes are “head in.” An alternate term to “pulling” is “trailing” and an alternate term to “pushing” is “leading.”

Rotor and wheel installation

NOTE: Build wheel before installing rotor.

1. [] Place rotor on hub with rotation arrow facing out from hub.
2. [] If rotor-mounting bolts are being reused, treat threads with Loctite 242 (not needed for first-time installation).
3. [] Using a Torx T25 wrench, thread in all six rotor bolts until heads just contact rotor.
4. [] Use marker to mark each bolt clockwise 1 to 6, then tighten each to 55in-lbs in a sequence of 1, 3, 5, 2, 4, then 6.

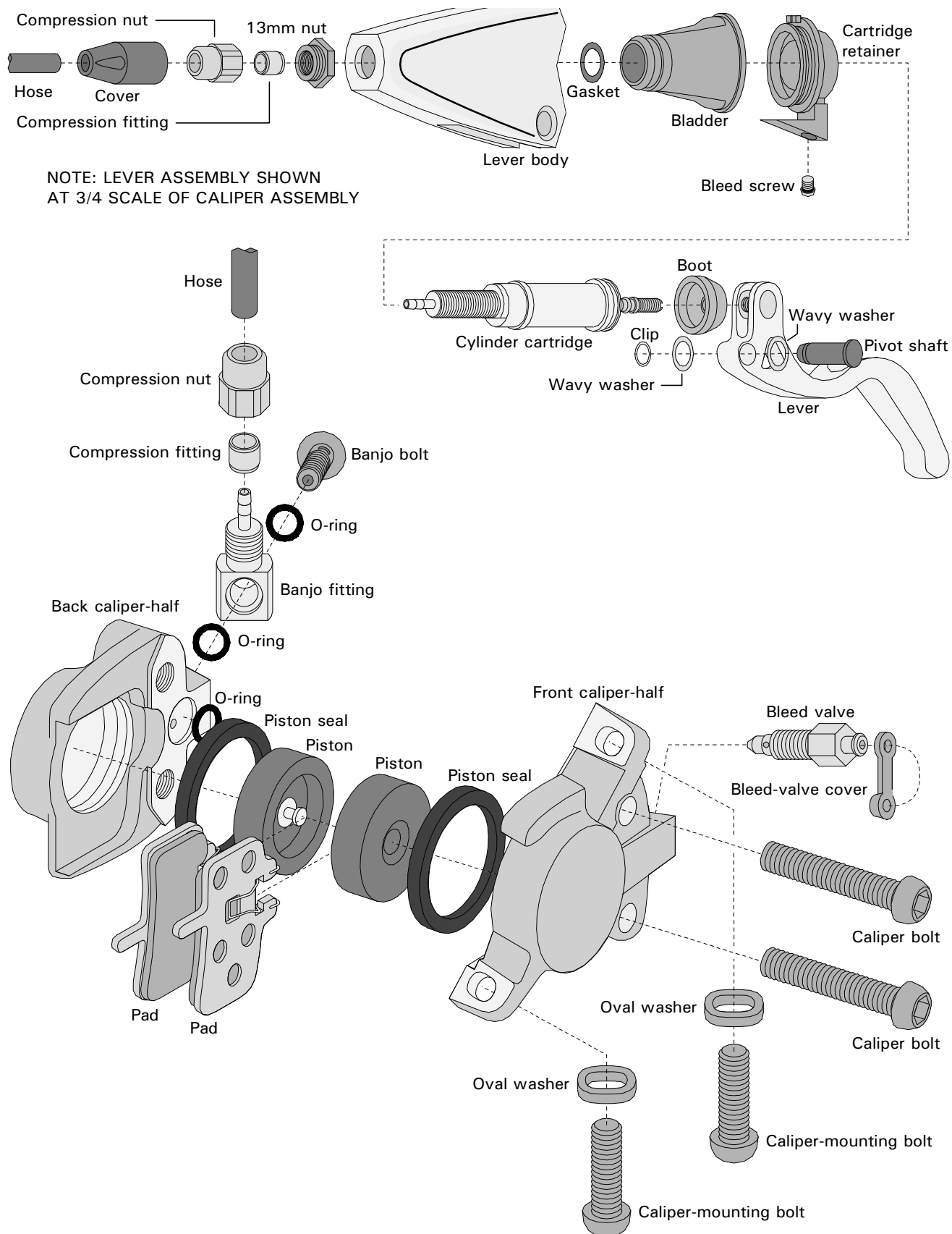
It is recommended that the quick-release skewer be installed opposite of normal. This insures that the quick-release lever, when fully closed, cannot interfere with the rotor. Although quick-release security is always of critical importance, wheel security is an even greater issue on a disc-brake hub than a hub with no brake. When securing the skewer, be sure to follow the guidelines in Chapter 18.

5. [] Install quick-release skewer into right end of axle (opposite of normal) then install adjusting nut on skewer.
6. [] Install wheel in proper alignment and with optimum quick-release security.

Brake-lever installation

7. [] Install brake lever in normal lateral and rotational position, then secure mounting bolts to 15–20in-lbs.
8. [] Use small slotted screwdriver to turn reach adjusting screw (in brass fitting at inner end of brake lever), fully counterclockwise, then back in two full turns. **Note:** reach adjustment does not affect clearance adjustment or brake operation—this adjustment is only intended to make reach appropriate for average-sized hands.

37 – HYDRAULIC RIM BRAKES AND DISC BRAKES



37.1 Hayes hydraulic disc brake caliper and lever.

Caliper installation and adjustment

NOTE: For frames or forks with International Standard mounting (bolt holes aligned perpendicular to bike, rather than parallel to bike), an adapter plate is mounted first. Install adapter and secure bolts to 110in-lbs (Loctite 242 on threads).

9. [] Treat threads of caliper-mounting bolts with Loctite 242.
10. [] Place caliper over rotor, align mounting holes in caliper with frame, fork, or adapter holes, then install and gently secure mounting bolts.
11. [] Squeeze brake lever firmly, then secure caliper mounting bolts to 110in-lbs. Release lever and check clearance between rotor and caliper pads. Rotor should be centered in slot between pads. If not, loosen bolts and align caliper to achieve equal pad clearance on each side of rotor, then secure bolts.

PAD REPLACEMENT

Theoretically, the pads can be used until just short of the point where the metal backing plates are exposed. However, if allowed to wear through to the metal the brakes will be unsafe and the rotor will be damaged. The braking material on new pads is approximately 1.8mm thick. When worn down to .3mm, the margin for safety is very narrow, so pads should be replaced if braking material thickness is .3mm or less. This means that each pad has a usable thickness of approximately 1.5mm. Remaining life can be calculated by determining the percentage of usable thickness that has been used up. If 1mm of thickness remains, then .8mm has been used up, and .7mm of usable thickness remains. The remaining life would be 47% ($.7 \div 1.5 = .466$).

1. [] Remove wheel.
2. [] Remove pads by pulling on tabs (pads are held in place by springs clips on back faces of pads).
3. [] Use depth gauge of caliper to measure remaining thickness (consider .3mm or less worn out).
4. [] Clean inside caliper around piston with water and detergent on brush. **CAUTION: Do not use automotive brake cleaners! Seal damage will occur!**
5. [] Use box end of 10mm wrench to depress pistons back into caliper. **Avoid pressing on studs in centers of pistons!** Pistons may need to be rocked back and forth until fully depressed.
6. [] Observe that one pad has tab in line with retaining spring, and other pad tab that is offset to retaining spring.
7. [] Install pad with in-line tab in outer side of caliper slot, then install other pad in inner side of caliper slot.
8. [] Install wheel.

HOSE INSTALLATION AND SIZING

If the caliper hose is damaged, too short, or too long, then it is necessary to install a new hose or re-size the existing hose. The same procedure suffices for both. A hose is too short if it must bend sharply at any time. A hose is too long only if it interferes with other components or snags on things during use of the bicycle. Performance of the brake system is unaffected by hose length.

CAUTION: This brake contains DOT 3 or DOT 4 brake fluid, which is a skin and eye irritant, damages paint, and destroys brake pads. Working with the hose means fluid will be released. Wear appropriate safety equipment to protect eyes and skin!

1. [] Remove wheel and brake pads.
2. [] Slide plastic sleeve on lever-end of hose away from brake lever, then unthread 10mm hose-nut fitting from brake lever.
3. [] **Only if replacing hose:** Unthread 10mm hose nut at caliper-end of hose and pull hose off banjo fitting.
4. [] **Only if replacing hose:** Install 10mm fitting removed from caliper-end of old hose onto new hose (round-end first).
5. [] **Only if replacing hose:** Place new compression bushing over caliper-end of hose, then press hose onto barbed fitting (long nipple) protruding from banjo fitting. Secure hose nut to 40in-lbs, plus one full turn.
6. [] Route hose to lever and decide on appropriate length. Use sharp razor knife to trim hose to desired length. End should be cut as square as possible.
7. [] Place plastic fitting cover (small-end first), hose nut (round-end first), then new compression bushing onto cut end of hose.
8. [] Press hose onto barbed fitting (long nipple) protruding from brake lever. Secure hose nut to 40in-lbs, plus one full turn.
9. [] Perform FILLING AND BLEEDING procedure.

FILLING AND BLEEDING

Filling and bleeding are normally done as part of hose replacement or sizing, or when repairing a leak in the system. Hayes does not recommend filling and bleeding as routine maintenance.

CAUTION: This brake contains DOT 3 or DOT 4 brake fluid, which is a skin and eye irritant, damages paint, and destroys brake pads. Wear appropriate safety equipment to protect eyes and skin!

1. [] Remove wheel from bike.
2. [] Remove both brake pads.
3. [] Put bike in position so that bleed fitting (brass fitting protruding from caliper) is pointing straight up. Remove rubber cap fully from bleed fitting.

37 – HYDRAULIC RIM BRAKES AND DISC BRAKES

4. [] Position handlebar and brake lever so bleed screw (Phillips screw) in brake lever is at highest point of brake system. Lever body should be pointing up from handlebar and hose leaving lever should be pointing down approximately 45°.
5. [] Suspend waste-oil receptacle from brake lever.
6. [] Remove Phillips bleed screw from brake lever, then insert hose with conical fitting into brake-lever bleed hole. Other end of hose goes into waste receptacle.
7. [] Fill squeeze bottle from bleed kit with fresh oil from sealed and uncontaminated container of DOT 3 or DOT 4 brake fluid. ***DOT 5 or mineral oil are not acceptable substitutes!***
8. [] Place remaining hose on nozzle of squeeze bottle.
9. [] Place other end of squeeze-bottle hose over bleed fitting, then secure hose to bleed fitting with zip tie.
10. [] Keeping squeeze bottle upside down, squeeze and release several times to release air bubbles in hose up into bottle.
11. [] Unthread bleed fitting 1/4 turn.
12. [] Squeeze bottle 5 seconds and release 3 seconds, repeating cycle continuously until no bubbles appear in bottle hose during release, then squeeze bottle continuously until fresh fluid with no bubbles is seen coming out hose at brake lever. ***Maintain pressure on bottle at completion of bleeding cycle!***
13. [] While maintaining pressure on bottle, secure bleed fitting.
14. [] Remove bottle hose from bleed fitting, then install rubber cap on bleed fitting.
15. [] Remove waste line from brake lever and install bleed screw until O-ring begins to compress.
16. [] Clean caliper of any fluid, then install brake pads and wheel.
17. [] Operate brake and check for soft or spongy feel and leaks at hose fittings, bleed fitting, and bleed screw. Repeat bleeding procedure if brake feels soft or spongy.

CALIPER OVERHAUL

Hayes supports overhauling the caliper. If a leak develops at the pistons, then seals in the caliper need to be replaced. If the studs on the pistons that engage the pads are bent or broken, the pads will fall out. In this case, the piston(s) need replacement. An overhaul kit includes new pistons, piston seals, and a transfer-port O-ring. All new parts should be used when servicing the caliper. The O-ring is a special material, so no substitution should be made.

CAUTION: *This brake contains DOT 3 or DOT 4 brake fluid, which is a skin and eye irritant, damages paint, and destroys brake pads. Servicing the caliper will drain the entire system of brake fluid. Wear appropriate safety equipment to protect eyes and skin!*

1. [] Remove wheel from bike.
2. [] Remove pads from caliper.
3. [] Unthread bolt through banjo fitting so hose detaches from caliper. Rubber O-rings on bolt will retain bolt is banjo fitting.
4. [] Remove caliper from mount.
5. [] Unthread two bolts in outer face of caliper and separate caliper halves, watching for small O-ring that is sandwiched between caliper halves.
6. [] Thread a short 6 × 1mm bolt into hole where banjo-fitting bolt was removed.
7. [] Wrap rag around one caliper half, leaving transfer port (small hole in center of O-ring that was sandwiched between caliper halves exposed).
8. [] Place rubber-tipped air gun against transfer port hole, then use compressed air to blow piston out of caliper half. Piston should be caught in rag.
9. [] Repeat steps 7–8 for other side, then remove bolt that was threaded into banjo-bolt hole.
10. [] Remove seal from inside each slave cylinder.
11. [] Clean all parts with alcohol and dry with compressed air. Thoroughly blow out all holes, including bleed fitting, which should be loosened to blow dry.
12. [] Lubricate new seals with DOT 3 or DOT 4, then seat carefully in grooves.
13. [] Lubricate pistons with DOT 3 or DOT 4, then press carefully into caliper halves until pistons seat fully (below seals). Difficulty seating pistons indicates seals are not in grooves properly.
14. [] Place transfer-port O-ring into seat in one caliper half.
15. [] Place caliper halves together, then thread in bolts and secure to 90–120in-lbs.
16. [] Thoroughly clean outside of caliper. Alcohol is preferred.
17. [] Install caliper to mounts and gently snug mounting bolts.
18. [] Inspect O-rings on banjo bolt and replace if torn or damaged. Special O-rings are required that are part of a banjo service kit.
19. [] Place banjo fitting on caliper and secure banjo bolt to 55in-lbs.
20. [] Fill and bleed system.
21. [] Install wheel, then align and secure caliper.

LEVER (MASTER CYLINDER) SERVICE

Hayes supports servicing the master cylinder. If a leak develops at the master cylinder (not at the hose), then the lever should be rebuilt. This usually just requires a service kit, but may require replacement of the master cylinder cartridge. An overhaul kit includes a new boot, new bladder, a gasket, and special grease. All new parts should be used when servicing the lever.

1. [] Remove hose from lever (if not servicing whole brake system, fix end of hose pointing up to retain fluid).
2. [] Unthread 13mm nut where hose came off (do not push in on shaft that nut is threading off of).
3. [] Pry clip of lever-pivot shaft and push out pivot shaft. *Watch for wavy washers sandwiched between lever and lever body!*
4. [] Use very small slotted screwdriver to thread reach adjuster clockwise until it threads out of brass fitting in lever.
5. [] Pull master-cylinder cartridge out back end of lever body.

NOTE: *The master cylinder cartridge may come out by itself, or with other pieces. The next step assumes the other pieces have remained in the lever body. If not, remove them in reverse order from the cartridge, instead.*

6. [] Remove cartridge retainer (plastic piece that bleed screw is threaded into) from lever body. Cartridge bladder may come out with cartridge retainer, or may stay inside lever body (remove it).
7. [] Remove round gasket from inside of lever body where end of cylinder cartridge seated inside body.
8. [] Remove small shaft boot from small shaft at end of cylinder cartridge.
9. [] Thoroughly clean lever body and cylinder cartridge (unless being replaced) with alcohol and blow dry with compressed air.
10. [] Insert cartridge shaft through small hole in shaft boot, making sure boot seats between raised rings on shaft, then seat large end of boot onto cartridge body.
11. [] Grease shaft boot with special grease supplied with service kit.
12. [] Insert cartridge into plastic cartridge retainer so cartridge body sticks out retainer the same way as the long plastic prong on retainer points, then seat cartridge into retainer with a "snap."
13. [] Grease inside edges of both ends of cartridge bladder with special grease, then slide bladder (large-end first) over cartridge.

14. [] Line up oval shape of bladder end with oval shape of plastic cartridge retainer, then seat bladder onto ridges of retainer.
15. [] Seat small end of bladder onto end of cartridge and against ridge on cartridge.
16. [] Rotate cartridge in cartridge retainer so flat on end of cartridge faces same way as long prong on cartridge retainer.
17. [] Place new gasket over end of cartridge.
18. [] Insert cartridge into lever body fully. Check that flat on cartridge has engaged flat inside lever body by trying to rotate exposed end of cartridge. It should not rotate.
19. [] Thread on 13mm nut hex-end first and secure to 55in-lbs.
20. [] Engage brass bushing of lever to threaded shaft at back end of cartridge, then use small slotted screwdriver to thread shaft fully into brass bushing.
21. [] Start lever pivot into lever outer face of lever body, then place wavy washer over shaft once it just protrudes inside lever body.
22. [] Place lever inside lever body, then push lever-pivot shaft partially through lever.
23. [] Place second wavy washer between lever and lever body, then push lever-pivot shaft fully through and push retaining ring onto shaft.
24. [] Put new compression bushing on end of hose, then engage hose nut to lever. Secure hose nut to 40in-lbs, then tighten one full turn more.
25. [] Bleed system.

MAGURA HS SERIES HYDRAULIC RIM BRAKES

The Magura HS series brakes use three hydraulic cylinders. One master cylinder is located at the brake lever. Hydraulic hose connects the master cylinder with two slave cylinders at the calipers. The brake pads are connected to the slave cylinders. The slaves are connected by hose, which equalizes pressure between the pads.

BRAKE INSTALLATION

Mounting

1. [] Lubricate brake-lever-mounting bolt.
2. [] Align rotational and lateral position of levers similar to other levers, then secure to 35in-lbs.

A 2mm Allen screw for micro-adjustment of the lever is located on the back side of the lever and behind the brake lever pivot. Locate it now. Some models have a knob at the base of the brake lever that is the micro-adjust. These models may not have a reach adjust screw.

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3. [] Loosen micro-adjuster fully counterclockwise.
Some models have a reach-adjustment screw located in front of the lever adjacent to the lever pivot.
4. [] Set brake-lever reach (if adjustable) to customer preference or shop standard.

The calipers consist of two slave cylinders, two cylinder rings, two pair of “Evolution” adapter brackets, two D-washers, one booster plate, two (or four) bracket-clamp bolts (5mm × .8mm), one bracket-mount bolts (6mm × 1mm), one quick-release stud (6mm × 1mm), and one quick-release mechanism.

The adapter brackets are offset, and may be switched from side to side. Changing the adapter brackets moves the cylinders laterally 10mm.

5. [] Treat all adapter-bracket-bolt threads with Loctite 242.
6. [] Install special quick-release stud into braze-on, then secure until shoulder contacts braze-on. (Quick release is mounted on left side of front brake and right side of rear brake.)
7. [] Place D-washer on each braze-on.
8. [] Assemble quick-release unit onto adapter plate.
9. [] Install booster plate on upper adapter bolt.
10. [] Assemble plastic rings over slave cylinders.
11. [] Place slaves between adapter brackets.
12. [] Slide quick-release unit onto bracket.

NOTE: If adapter bracket has adequate clearance to frame, D-washer may not be required. In some cases, more than one washer may be required for bracket to clear frame.

Some models use two 5mm bolts in the adapter bracket. Newer models replace the lower 5mm bolt with a hooking-tab system that holds the front and back evolution pieces together. The next step is written for the two-bolt system, but if the brake you are working with has a single bolt, the different technique required should be easily apparent.

13. [] Position slave cylinders in brackets so both are as far outward as possible.
14. [] Install and gently secure upper and lower 5mm bolts in adapter brackets. (It should still be possible to move slave cylinders in brackets at this point.)
15. [] Loosen both adapter-bracket bracing studs from back of adapter brackets by twisting stud flat with 13mm wrench.
16. [] Position non-quick-release cylinder and adapter plate to braze-on, then thread in 6mm braze-on mounting bolt.
17. [] Snug, but do not secure, all bolts in adapter bracket.
18. [] Put non-quick-release-caliper assembly onto braze-on and install bolt loosely.

19. [] Inspect backside of bracket so that curved portion of adapter bracket does not hit frame. (If clearance problem occurs, use supplied D-shaped washers to gain clearance. Flats on washers face up.)
20. [] Place lever of quick release in down (open) position, then slide other caliper onto braze-on fitting.
21. [] Pull upward on lever, which should be set too tight at this time.
22. [] Loosen quick-release stud 1/4 turn and attempt to close lever. Repeat until lever is properly set. Lever should have resistance through last half of swing, and should be pushed fully against cylinder. Lever must be parallel to adapter brackets.

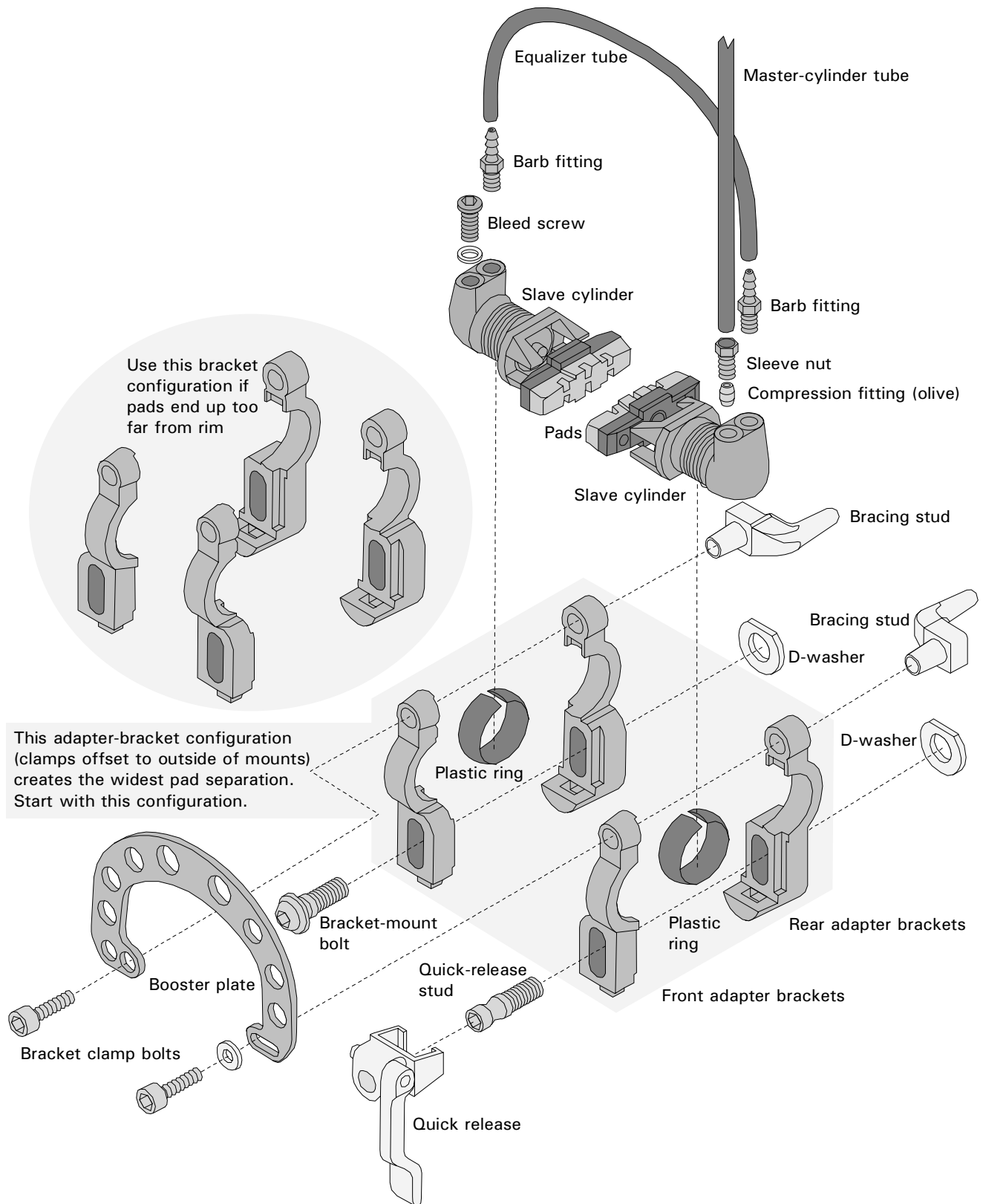
Bracket Adjustment

23. [] Install and center wheel to < 1mm difference between rim and each stay.
24. [] Loosen all bracket bolts, mounting bolts, and QR (if any),
25. [] Align each bracket to that it's inside face is at same angle as braking surface of rim, then secure mounting bolt (or QR) to hold each in position (brackets should be symmetrical).
26. [] Rotate bracing stud on non-QR side up or down until it contacts stay or fork blade (while maintaining bracket alignment), then secure upper bolt to 35in-lbs.
27. [] Engage brake booster (arch) to upper bolt of non-QR bracket. It may be necessary to try both mounting holes in booster to keep from misaligning QR bracket.
28. [] Rotate second bracing stud up or down to match the first one, so that it contacts stay or fork blade while angle of bracket is maintained, then secure upper bolt to 35in-lbs.

Pad Adjustment

29. [] On each side of rim, clean a 3" section with alcohol, and fix a 2mm stack of Post-it Notes to cleaned section of rim so that top edge of each stack is tangent to rim.
30. [] Use a bungee cord to fix wheel rotation so stacks of Post-it Notes are between rim and brake pads.
31. [] Loosen all bolts (or bolts and QR) in one bracket, then push in on cylinder while pulling out on bracket until pad face contacts Post-its. **NOTE: DO NOT PUSH CYLINDER ENOUGH TO DEFLECT RIM!**
32. [] Align cylinder so pad is flush to Post-its and tangent to rim, then secure clamp bolt(s) to 35in-lbs. and secure QR (or mounting bolt to 60in.lbs.) *Note: Pad height may be approximate at this time.*
33. [] Repeat steps 31–32 for other side.
34. [] Rotate rim and remove Post-its.

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35. [] Operate brake and check both pad heights. If necessary, loosen mounting bolt or QR on each side and adjust pad heights to be fully contacting brake surface and symmetrical with each other.
36. [] Use micro-adjuster to adjust pad clearance to 2mm per side, or customer preference.

ROUTING AND SIZING HYDRAULIC HOSE

Magura uses 5mm O.D. hose. The hose secures to both the brake lever and the caliper slave cylinder with compression fittings. Slave cylinders are connected with the barbed fitting (like a fish-hook barb — a fitting that slides into the hose, but bites into the hose to resist sliding out).

1. [] Loosen compression fitting counterclockwise using 8mm wrench.
2. [] Place rag over caliper and pull hydraulic hose from caliper, then remove sleeve nut and compression ring. (It is always recommended to use new compression ring when servicing hydraulic line.)
3. [] Route hose as short as possible, however use care not to stress hose at either fitting. (Full-suspension bikes may require excess hose to allow for movement of rear stays. Route to avoid abrasions or rubbing of hose.)
4. [] Cut hose with Magura hose cutter #431-880, or very sharp knife. Do not use diagonal cutters. Clean cut is required for good hydraulic seal.
5. [] Install sleeve nut onto hose with threads toward cut end, then install new compression ring onto hose. (Rounded side of ring faces cut end of hose.)
6. [] Slide compression ring to within 3mm of end of hose, then place in caliper and thread in sleeve nut.
7. [] Secure sleeve nut to 40in-lbs.
8. [] If necessary, barbed fittings may be removed using 8mm wrench.
9. [] To press barbed fitting into hose, secure hose vertically in vise using Magura installer clamps #431 883. (Place approximately 20mm of hose above clamps.)
10. [] Place barbed fitting with threaded-side upward and barbed-side facing into hose.
11. [] Tap fitting with plastic mallet until hose is flush with shoulder of fitting. (Note: Magura tool “Intruder” is press that installs hose into barbed fittings.)
12. [] Secure barbed fittings to 24in-lbs. (Barbed fitting will rotate inside hose to allow threaded end to secure.)

FILLING AND BLEEDING MASTER AND SLAVE CYLINDERS

Note: *Never use automotive or motorcycle brake-cylinder fluids. These fluids will damage seals and hydraulic hose of Magura system.*

Use Magura Aseol Terra 60-789 brake fluid or any bicycle-suspension fluid.

The Magura bleeding kit comes with two pieces of hose that have the barbed fittings attached. The shorter piece needs to be attached to the tip of the syringe. It will be a lot easier to thread the syringe into the caliper if the hose is cut to three inches.

1. [] Back out reach-adjuster and micro-adjuster fully.
2. [] Attach short piece of hose with barbed fitting to tip of syringe.
3. [] Insert tube on syringe into container of fluid and pull out on syringe plunger to fill syringe with hydraulic fluid.
4. [] Hold syringe pointing up, let air bubbles float to top, then depress syringe plunger to push all air out of syringe.
5. [] Remove bleed screw at caliper.
6. [] Thread barbed fitting on end of syringe into bleed screw hole in caliper.
7. [] Remove bleed screw at lever.
8. [] Screw waste line (other longer tube with barbed fitting) into bleed screw hole in lever.
9. [] Depress syringe plunger to push fluid through system until clean fluid and no more air bubbles are coming out of lever into waste line.
10. [] Remove waste line from lever.
11. [] Replace bleed screw in lever with new washer.
12. [] Remove syringe assembly from caliper.
13. [] Repeat steps 2–12 if syringe empties before air and old fluid are pumped out of system.
14. [] Replace bleed screw in caliper with new washer.
15. [] Operate brake system and inspect for leaks at bleed screws and all other fittings.

NOTES ON SERVICING

Brake pads are removed by pulling the pad from the cylinder. Remove the wheel to access pads. New pads install by snapping them onto the stud in the slave cylinder. Color codes designate pad compound hardness: clear is softest, black is medium, and gray is hardest.

In very cold climates, lighter-viscosity fluid will work best. Use low-viscosity bicycle-suspension fluids.

Special routing is possible using two fittings in the brake levers. One lever may be made to operate both front and rear calipers. Alternatively, two levers may be made to operate same caliper.

MAGURA GUSTAV M DISC BRAKE

ABOUT THIS SECTION

This section specifically covers the Magura Gustav M disc-brake system. The procedures covered in this section include wheel-building guidelines, rotor and wheel installation, lever installation, hose installation, filling and bleeding the system, caliper installation, and pad replacement. This section does not cover rebuilding the caliper, which Magura does not support.

TOOLS

No special tools are required for normal installation and adjustment. Hose replacement and bleeding and filling the system requires a syringe, a bleed fitting, a hose, and a tool for holding the hose when installing the barbed fitting, all of which are part of the Gustav Service Kit.

INSTALLATION

Wheel building guidelines

The recommended cross patterns are limited to 3X and 4X. Deceleration can occur much more rapidly than acceleration, so consequently the torsional loads from deceleration are much higher than those generated during acceleration. The recommended cross patterns are required to transfer the higher torsional loads that hub-mounted brakes can generate during rapid deceleration.

Although Magura makes no recommendation regarding lacing patterns, other manufacturers require that the left-side head-out spokes radiate clockwise from the hub and that the right-side head-in spokes radiate counterclockwise from the hub. These are the same directions that result from following the wheel-lacing instructions in this manual. The vernacular terms for these patterns are that the “pulling” spokes are “head out” and the “pushing” spokes are “head in.” An alternate term to “pulling” is “trailing” and an alternate term to “pushing” is “leading.”

Rotor and wheel installation

Prior to the 2000 model year, the Gustav M rotor is compatible only with the Gustav M hub and Mavic Crossmax or CrossLink wheels, but not other Magura hubs or International Standard disc-brake hubs. As of the 2000 model year, the Gustav M brake is fully compatible with International Standard hubs.

NOTE: *Build wheel before installing rotor.*

1. [] Place rotor on hub with rotation arrow facing out from hub. Two-piece rotors should be installed with smooth rivet heads facing out.
2. [] If rotor-mounting bolts are being reused, treat threads with Loctite 242 (not needed for first-time installation).
3. [] Thread in all six rotor bolts until heads just contact rotor.
4. [] Use marker to mark each bolt clockwise 1 to 6, then tighten each to 35in-lbs in a sequence of 1, 4, 2, 5, 3, then 6.

It is recommended that the quick-release skewer be installed opposite of normal. This insures that the quick-release lever, when fully closed, cannot interfere with the rotor. Although quick-release security is always of critical importance, wheel security is an even greater issue on a disc-brake hub than a hub with no brake. When securing the skewer, be sure to follow the guidelines in Chapter 18.

5. [] Install quick-release skewer into right end of axle (opposite of normal) then install adjusting nut on skewer.
6. [] Install wheel in proper alignment and with optimum quick-release security.

Brake lever installation

7. [] Install brake lever in normal lateral and rotational position, then secure mounting bolts to 35in-lbs.
8. [] Adjust reach with 2mm Allen screw (at lever pivot) to middle of range (approximately two turns from either end of range). *Note: reach adjustment doesn't affect clearance adjustment or brake operation—this adjustment is only to make reach appropriate for average-sized hands.*

Caliper installation and adjustment

The caliper assembly consists of two basic parts, the caliper mount and the caliper. The caliper mount has two threaded holes that the bolts that go through the frame or fork mounting holes. There is a smooth stud fixed to the caliper mount that goes through a hole in the caliper, and a smooth stud fixed to the caliper that goes through a hole in the caliper mount.

There are several models of caliper mounts available. A bolt threaded into the end of the smooth stud fixed to the caliper mount retains the caliper to the mount. This bolt can be removed to separate the two. It should be reinstalled with Loctite #222 and torqued to 26in-lbs.

The caliper mount floats side-to-side on the two smooth studs. This floating design allows the caliper to move laterally to accommodate rotor wobble. Observe that there is a slot in the caliper mount that coincides with the slot between the two brake pads in the caliper.

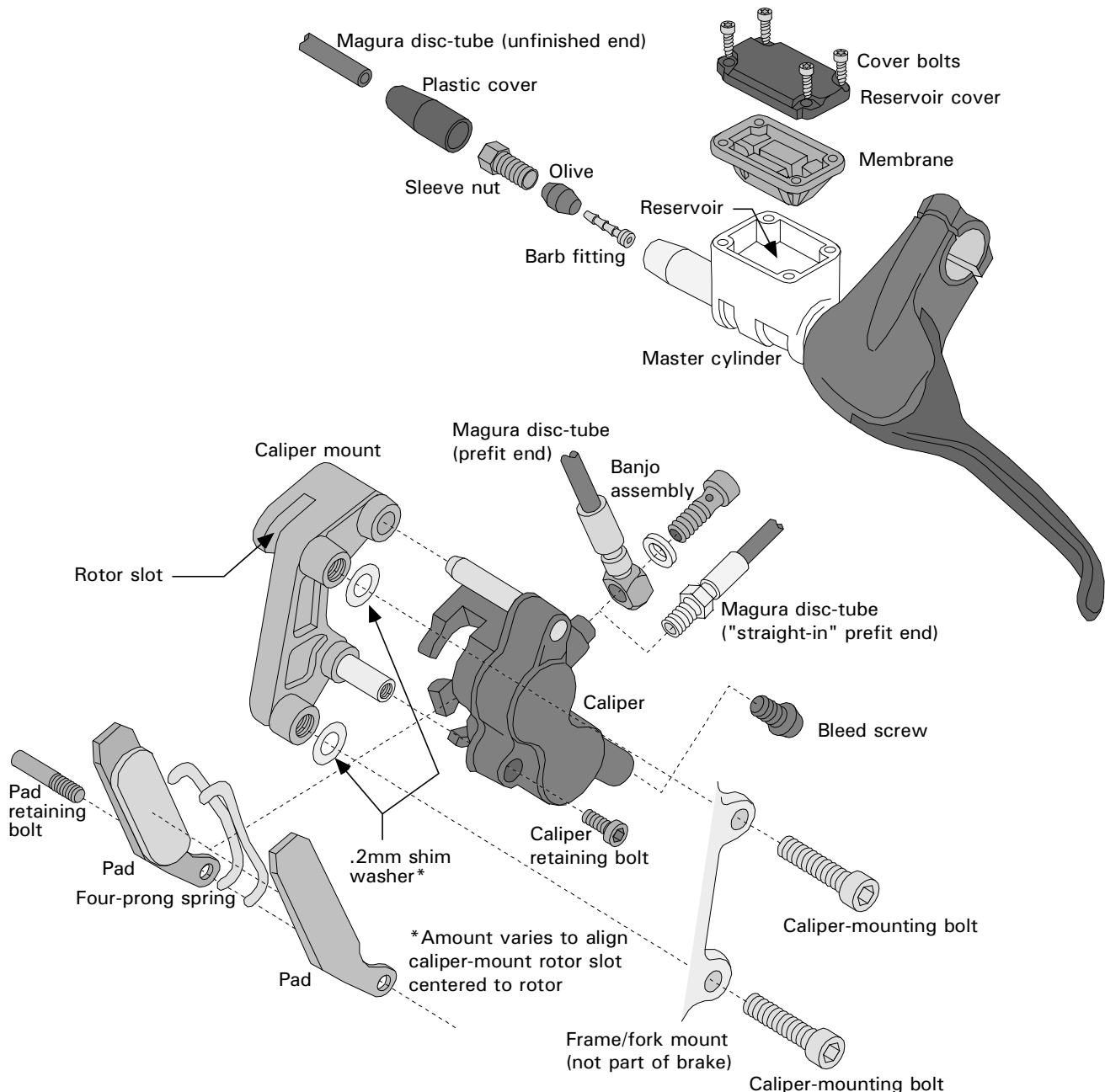
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The Gustav M brake has no adjustments for pad clearance. It is not problematic if it rubs lightly at times, similar to motorcycle and automotive disc brakes.

NOTE: For frames or forks with Hayes-type post mounting (bolt holes aligned parallel to bike, rather than perpendicular to bike), an adapter plate must be mounted first. Install adapter and secure bolts to 55–70in-lbs.

9. [] Remove plastic pad spacer (if any) from between brake pads, then slide caliper over rotor and align bolt holes in caliper with mounting holes of fork or frame.
10. [] If caliper-mounting bolts are being reused, treat threads with Loctite 242 (not needed for first-time installation).

11. [] Install and gently snug caliper-mounting bolts. Check clearance between rotor and slot in caliper mount. Rotor should be centered in slot. If rotor is closer to inside edge of slot, adjust clearance by remounting caliper with .2mm shim washer between caliper and each fork/frame mount. then check centering again.
12. [] Once centering is adequate, secure caliper-mounting bolts to 50in-lbs.
13. [] Secure hose to frame and/or fork, then turn handlebars and/or move suspension through its full range to check for interference with hose.



37.3 Magura Gustav M hydraulic disc brake caliper and lever.

PAD REPLACEMENT

The pads have “ears” at the end of the caliper opposite the hose. A shaft goes through the ears, which retains the pads in the caliper. With the brake operated to close the pads firmly to the rotor, measure the distance between the ears. If the measurement is 4.8mm or less, the pads must be replaced. With fresh pads in the caliper, this measurement is about 6.8mm. Remaining pad life can be estimated by calculating the reduction of the current measurement from the original 6.8mm as a percentage of the 2mm total wear life. In other words, if the current measurement is 5.8mm (1mm reduction from 6.8mm), then the pads have 50% of their life remaining (1mm is 50% of 2mm).

1. [] Remove wheel, then unthread bolt through ends of pad plates with 2mm Allen wrench.
2. [] Remove pads and four-prong spring out rotor slot in inner edge of caliper.
3. [] Clean inside caliper at piston with water and detergent on brush. **CAUTION: Don't use automotive brake cleaners, seal damage will occur!**
4. [] Assemble replacement pads and four-prong spring so braking-material sides face each other and spring is sandwiched between them, with prongs contacting metal plates (not contacting surface of braking material). When properly assembled, tips of spring prongs point to edge of pads that pad ears angle away from.
5. [] Install pad assembly into caliper slot so closed end of spring goes in first and ear-ends of pads are at end of caliper opposite where hydraulic hose attaches.
6. [] Treat pad-retaining bolt threads with Loctite 222.
7. [] Install pad-retaining bolt through hole in inner face of caliper and through holes in ears of pads, then secure bolt to 9in-lbs.
8. [] Face backside of caliper, put your thumbs into access holes on back face of caliper, then press firmly against inner brake shoe. This causes slave pistons to retract fully into caliper, which allows adequate clearance for the rotor.
9. [] Install wheel.

HOSE INSTALLATION AND SIZING

If the caliper hose is damaged, too short, or too long, then it is necessary to install a new hose or re-size the existing hose. The same procedure suffices for both. A hose is too short if it must bend sharply at any time. A hose is too long only if it interferes with other components or snags on things during use of the bicycle. Performance of the brake system is not affected by hose length.

1. [] Slide plastic sleeve on lever-end of hose away from brake lever, then unthread 8mm hose fitting from brake lever. It may be necessary to remove brake lever from handlebar if hose twists with fitting.
2. [] Only if replacing hose, unthread bolt through banjo fitting (or hex-fitting built into end of hose) at brake caliper.
3. [] Only if replacing hose, install bolt (with new washer) through banjo fitting (or thread in hex fitting built into end of hose) and secure to 35in-lbs. **Note: Use only hoses marked “Magura disc-tube.”**
4. [] Route hose to lever and decide on appropriate length. Use Magura hose cutter or sharp razor knife to trim hose to desired length. End should be cut as square as possible.
5. [] Place plastic fitting cover (small-end first), sleeve nut (hex-end first), then new Magura olive fitting (black, never brass) onto cut end of hose.
6. [] Press hose into slot in red tool (part of service kit) so approximately 20mm of hose extends past tool, then insert new barbed fitting into hose until fitting head contacts hose. If installation is difficult, sandwich red tool and hose in soft jaws of vise and tap barbed fitting in with plastic mallet.
7. [] Insert end of hose into hole in brake lever, then hand thread sleeve nut into brake lever.
8. [] After installing sleeve nut as far as possible by hand, secure nut to 35in-lbs.
9. [] Perform FILLING AND BLEEDING procedure.

FILLING AND BLEEDING

Filling and bleeding are normally done as part of hose replacement or sizing. Magura does not recommend filling and bleeding as routine maintenance.

CAUTION: At all times while working with oil, it is critical to keep oil off rotor surface and brake pads!

1. [] Remove wheel from bike.
2. [] Remove both brake pads.
3. [] Put bike in position so that head of bleed screw (at opposite end of caliper from hose) is at top of caliper.
4. [] Remove bleed screw with 5mm Allen wrench.
5. [] If necessary, attach hose and 6mm-thread bleed fitting to syringe, then fill syringe with Magura Blood hydraulic oil. With syringe upright, pump until all air bubbles are out of syringe and bleed hose. Other mineral oils such as Finish Line 5wt suspension oils are also suitable.
6. [] Thread bleed fitting into caliper where bleed screw was removed and gently secure fitting.

7. [] Position bike and/or brake lever so that reservoir cap on face of brake lever is completely horizontal.
8. [] Use T7 Torx wrench to remove 4 bolts that retain reservoir cap, then remove cap and rubber membrane.
9. [] Slowly pump syringe contents into system, being prepared to catch overflow at lever. Continue pumping until no air bubbles are seen in reservoir.
10. [] Place rubber membrane into bottom face of reservoir cap, then insert four bolts into reservoir cap.
11. [] Place reservoir-cap assembly on top of lever so that overflow hole in edge of reservoir cap will be at top edge of cap when brake lever is in normal position.
12. [] Gradually tighten 4 bolts in crisscross pattern until all are tight to equivalent of 5in-lbs.
13. [] Return bike to position that puts caliper in same position as when bleed screw was removed, then unthread bleed fitting from caliper.
14. [] Install bleed screw into caliper and secure to 51in-lbs.
15. [] Clean caliper of any oil, then install brake pads and wheel.
16. [] Operate brake and check for soft or spongy feel and leaks at hose fittings and bleed screw. Repeat bleeding procedure if brake feels soft or spongy.

MAGURA LOUISE & CLARA DISC BRAKES

ABOUT THIS SECTION

This section specifically covers the Magura Louise and Clara disc-brake systems. Service techniques are identical for both systems. The procedures covered in this section include wheel building guidelines, rotor and wheel installation, lever installation, hose installation, filling and bleeding the system, caliper installation, and pad replacement. This section does not cover rebuilding the caliper, which Magura does not support.

TOOLS

No special tools are required for normal installation and adjustment. Hose replacement and bleeding and filling the system requires a syringe, a bleed fitting, hose, and a tool for holding the hose when installing the barbed fitting, all of which are part of the Louise Service Kit.

INSTALLATION

Wheel building guidelines

The recommended cross patterns are limited to 3X and 4X. Deceleration can occur much more rapidly than acceleration, so consequently the torsional loads from deceleration are much higher than those generated during acceleration. The recommended cross patterns are required to transfer the higher torsional loads that hub-mounted brakes can generate during rapid deceleration.

Although Magura makes no recommendation regarding lacing patterns, other manufacturers require that the left-side head-out spokes radiate clockwise from the hub and that the right-side head-in spokes radiate counterclockwise from the hub. These are the same directions that result from following the wheel-lacing instructions in this manual. The vernacular terms for these patterns are that the “pulling” spokes are “head out” and the “pushing” spokes are “head in.” An alternate term to “pulling” is “trailing” and an alternate term to “pushing” is “leading.”

Rotor and wheel installation

If installing the rotor on a 1999 Magura Gustav hub or Mavic Crossmax or CrossLink wheels, use the 3mm-thick spacer between the rotor and the hub. If using a Magura Louise Pro or Louise Comp hub, no spacer is needed behind the rotor.

NOTE: *Build wheel before installing rotor.*

1. [] Place rotor on hub with rotation arrow facing out from hub.
2. [] If rotor-mounting bolts are being reused, treat threads with Loctite 242 (not needed for first-time installation).
3. [] Thread in all six rotor bolts until heads just contact rotor.
4. [] Use marker to mark each bolt clockwise 1 to 6, then tighten each to 35in-lbs in a sequence of 1, 3, 5, 2, 4, then 6.

It is recommended that the quick-release skewer be installed opposite of normal. This insures that the quick-release lever, when fully closed, cannot interfere with the rotor. Although quick-release security is always of critical importance, wheel security is an even greater issue on a disc-brake hub than a hub with no brake. When securing the skewer, be sure to follow the guidelines in Chapter 18.

5. [] Install quick-release skewer into right end of axle (opposite of normal) then install adjusting nut on skewer.
6. [] Install wheel in proper alignment and with optimum quick-release security.

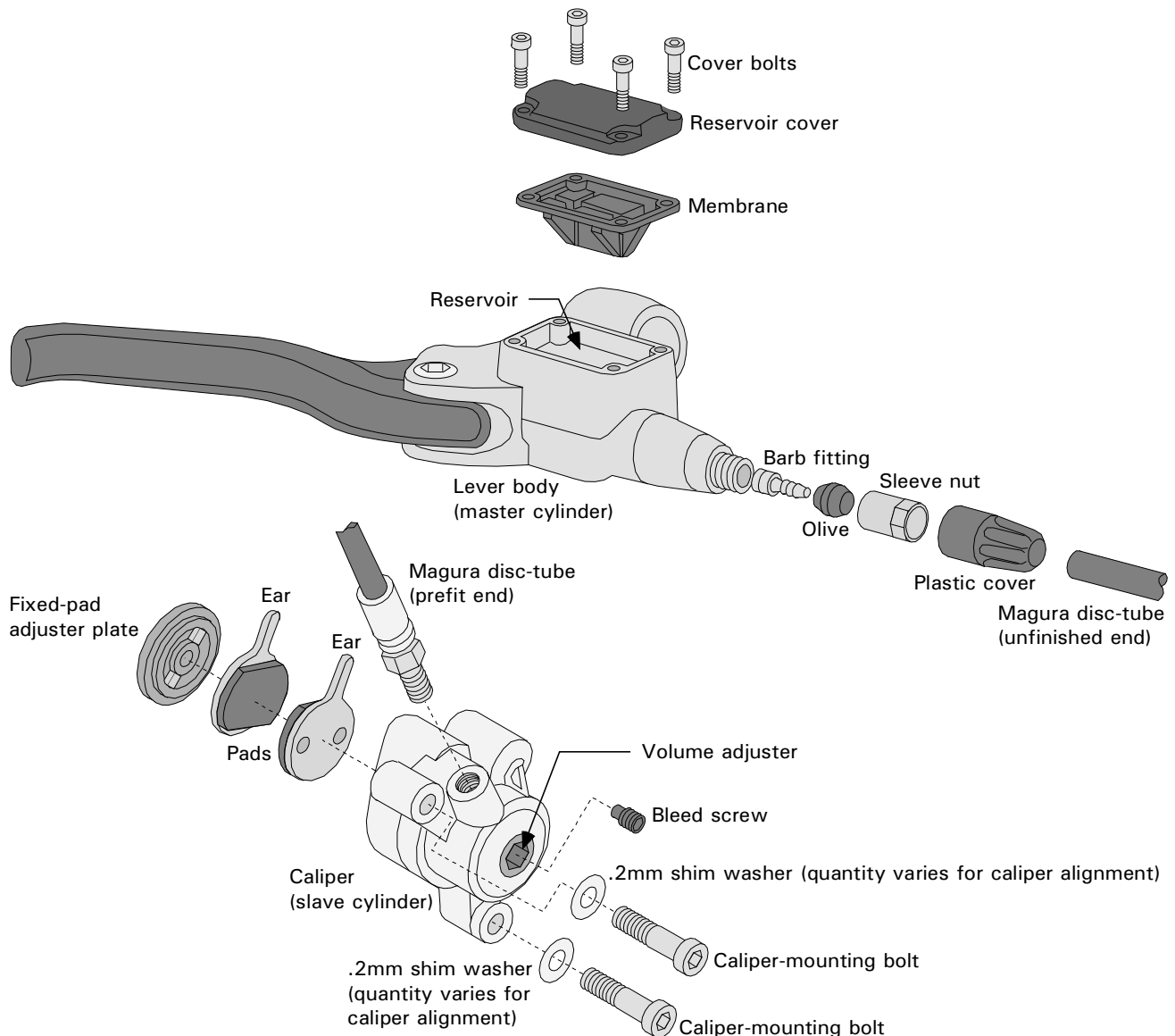
Brake lever and hose installation

7. [] Install brake lever in normal lateral and rotational position, then secure mounting bolt to 35in-lbs.
8. [] Adjust reach with 2mm Allen screw (at lever pivot) to middle of range (approximate two turns from either end of range). *Note: reach adjustment does not affect clearance adjustment or brake operation—this adjustment is only intended to make reach appropriate for average-sized hands.*

Caliper installation and adjustment

NOTE: For frames or forks with Hayes-type post mounting (bolt holes aligned parallel to bike, rather than perpendicular to bike), an adapter plate must be mounted first. Install adapter and secure bolts to 55–70in-lbs.

9. [] Loosen volume-adjusting bolt on outer face of caliper fully with 5mm Allen wrench.
10. [] Remove fixed-shoe adjusting plate from inside face of caliper with 5mm Allen wrench, treat threads with Loctite 242, then install plate until face is just flush with inner face of caliper.
11. [] Remove plastic pad spacer (if any) from between brake pads, then slide caliper over rotor and align bolt holes in caliper with mounting holes of fork or frame.
12. [] If caliper-mounting bolts are being reused, treat threads with Loctite 242 (not needed for first-time installation).
13. [] Install and gently snug caliper-mounting bolts. Check clearance between rotor and inner edge of caliper slot (spin rotor). If there is contact, remount caliper with a .2mm shim washer between caliper and each fork/frame mount and check for rub again.



37.4 Magura Louise hydraulic disc brake caliper and lever.

14. [] Once clearance is adequate, secure caliper-mounting bolts to 50in-lbs.
15. [] With wheel stationary, turn fixed-shoe adjusting plate on inner face of caliper clockwise just until gap between pad and rotor disappears, then loose just enough to see gap again. Spin wheel and check for rub. If rub occurs, loosen adjusting plate a tiny amount and check again.
16. [] With wheel spinning, slowly tighten volume-adjusting bolt on outer face until slight rub is heard, then loosen bolt just enough to eliminate rub.
17. [] Operate brake several times, then spin wheel to check for rub. If rub persists, only the volume adjusting bolt needs to be loosened.
18. [] Secure hose(s) to frame and/or fork, then turn handlebars and/or move suspension through its full range to check for interference with hose(s).

PAD REPLACEMENT

The pads have “ears” which protrude out a small slot in the outer edge of the caliper (opposite the slot for the rotor). With the brake operated to close the pads firmly to the rotor, measure the distance between the ears. If the measurement is 4mm or less, the pads must be replaced. With fresh pads in the caliper, this measurement is about 6.5mm. Remaining pad life can be estimated by calculating the reduction of the current measurement from the original 6.5mm as a percentage of the 2.5mm total wear life. In other words, if the current measurement is 5.25mm (1.25mm reduction from 6.5mm), then the pads have 50% of their life remaining (1.25mm is 50% of 2.5mm).

1. [] Remove wheel, then unthread fixed-pad adjusting plate from inner face of caliper.
2. [] Pull both pads out hole where adjusting plate was removed. A magnet can be used.
3. [] Clean inside caliper around piston with water and detergent on brush. **CAUTION: Do not use automotive brake cleaners! Seal damage will occur!**
4. [] Install first pad so braking material faces you and the pad “ear” goes out slot in outer edge of caliper.
5. [] Install second pad so braking material faces away from you and pad “ear” goes out slot in outer edge of caliper.
6. [] Loosen volume-adjusting bolt on outer face of caliper fully with a 5mm Allen wrench.
7. [] Treat threads of fixed-shoe adjusting plate with Loctite 242, then install plate until face is just flush with inner face of caliper.
8. [] Install wheel, then perform steps 15–17 of *Caliper installation and adjustment*.

HOSE INSTALLATION AND SIZING

If the caliper hose is damaged, too short, or too long, then it is necessary to install a new hose or re-size the existing hose. The same procedure suffices for both. A hose is too short if it must bend sharply at any time. A hose is too long only if it interferes with other components or snags on things during use of the bicycle. Performance of the brake system is not affected by hose length.

1. [] Fully loosen volume-adjusting bolt in outer face of caliper with 5mm Allen wrench.
2. [] Slide plastic sleeve on lever-end of hose away from brake lever, then unthread 8mm hose fitting from brake lever. It may be necessary to remove brake lever from handlebar if hose twists with fitting.
3. [] Only if replacing hose, unthread hose fitting from brake caliper.
4. [] Only if replacing hose, thread end of hose with pre-installed fitting into caliper and secure to 35in-lbs. **Note: Use only hoses marked “Magura disc-tube.”**
5. [] Route hose to lever and decide on appropriate length. Use Magura hose cutter or sharp razor knife to trim hose to desired length. End should be cut as square as possible.
6. [] Place plastic fitting cover (small-end first), sleeve nut (hex-end first), then new Magura olive fitting (black, never brass) onto cut end of hose.
7. [] Press hose into slot in red tool so approximately 20mm of hose extends past tool, then insert new barbed fitting into hose until fitting head contacts hose. If installation is difficult, sandwich red tool and hose in soft jaws of vise and tap barbed fitting in with plastic mallet.
8. [] Insert end of hose into hole in brake lever, then hand thread sleeve nut into brake lever.
9. [] After installing sleeve nut as far as possible by hand, secure nut to 35in-lbs.
10. [] Perform FILLING AND BLEEDING procedure.

FILLING AND BLEEDING

Filling and bleeding are normally done as part of hose replacement or sizing. Magura does not recommend filling and bleeding as routine maintenance.

CAUTION: At all times while working with oil, it is critical to keep oil off rotor surface and brake pads!

1. [] Remove wheel from bike.
2. [] Remove fixed-pad adjusting plate from inner face of caliper, then remove both brake pads.
3. [] Put bike in position so that outer face of caliper is pointing straight up.
4. [] Loosen volume-adjusting bolt in outer face of caliper fully with 5mm Allen wrench.

5. [] Use 2mm Allen wrench to remove bleed screw from center of volume-adjusting bolt.
6. [] If necessary, attach hose and bleed fitting to syringe, then fill syringe with Magura Blood hydraulic oil. With syringe upright, pump until all air bubbles are out of syringe and bleed hose. Other mineral oils such as Finish Line 5wt suspension oils are also suitable.
7. [] Thread bleed fitting into caliper where bleed screw was removed.
8. [] Position bike and/or brake lever so that reservoir cap on face of brake lever is completely horizontal.
9. [] Use 2mm Allen wrench (T7 Torx wrench for Clara model) to remove 4 bolts that retain reservoir cap, then remove cap and rubber membrane.
10. [] Slowly pump syringe contents into system, being prepared to catch overflow at lever. Continue pumping until no air bubbles are seen in reservoir.
11. [] Place rubber membrane in bottom face of reservoir cap, then insert four bolts into reservoir cap.
12. [] Place reservoir-cap assembly on top of lever so that overflow hole in edge of reservoir cap will be at top edge of cap when brake lever is in normal position.
13. [] Gradually tighten 4 bolts in crisscross pattern until all are tight to equivalent of 5in-lbs.
14. [] Return bike to position that puts face of caliper pointing up, then unthread bleed fitting from caliper.
15. [] Install bleed screw into caliper and secure to 8in-lbs.
16. [] Install wheel, then install pads and adjust clearance as per steps 3–8 of PAD REPLACEMENT.
17. [] Operate brake and check for soft or spongy feel and leaks at hose fittings and bleed screw. Repeat bleeding procedure if brake feels soft or spongy.

SHIMANO DISC BRAKE

ABOUT THIS SECTION

This section specifically covers the Shimano Deore XT M755 disc brake system. The procedures covered in this section include wheel-building guidelines, rotor and wheel installation, lever installation, hose installation, filling and bleeding the system, caliper installation, and pad replacement. This section does not cover rebuilding the caliper, which Shimano does not support. There are four bolts holding the two caliper halves together, but nothing can be accomplished by separating the halves.

INSTALLATION

Wheel building guidelines

Shimano specifies the cross pattern to be used when building a wheel with their disc-brake hub, and also specifies which way the pulling and pushing spokes should radiate.

The recommended cross patterns are limited to 3X and 4X. Deceleration can occur much more rapidly than acceleration, so consequently the torsional loads from deceleration are much higher than those generated during acceleration. The recommended cross patterns are required to transfer the higher torsional loads that hub-mounted brakes can generate during rapid deceleration. Shimano will not warranty failures when other cross patterns are used!

Shimano additionally requires that the left-side head-out spokes radiate clockwise from the hub and that the right-side head-in spokes radiate counterclockwise from the hub. These are the same directions that result from following the wheel lacing instructions in this manual. The vernacular terms for these patterns are that the “pulling” spokes are “head out” and the “pushing” spokes are “head in.” An alternate term to “pulling” is “trailing” and an alternate term to “pushing” is “leading.”

Rotor and wheel installation

Shimano makes a 160mm rotor and a 170mm rotor. The 160mm size fits most configurations, but when using the adapter plate on a Hayes-type post mounting on a front fork, the 170mm size is required.

NOTE: Build wheel before installing rotor.

1. [] Place rotor on hub with rotation arrows facing out from hub.
2. [] If rotor-mounting bolts are being reused, treat threads with Loctite 242 (not needed for first-time installation).
3. [] Place a tightening plate (thin plate shaped somewhat like a chain-link plate) over each pair of holes with flat side of each plate against rotor.
4. [] Thread in all six rotor bolts until heads just contact tightening plates.
5. [] Use marker to mark each bolt clockwise 1 to 6, then tighten each to 20–35in-lbs in a sequence of 1, 4, 3, 6, 2, then 5.

In the next step, the tightening plates are bent so that they work as a lock to prevent accidental loosening of the rotor bolts. If removing a rotor, it will be necessary to flatten the plate again before loosening a bolt. Repeated installation and removal of the rotor is likely to necessitate replacement of the tightening plates.

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6. [] Pry under raised edge of each tightening plate to fold plate up against one flat of each triangular bolt head.

Shimano recommends the quick-release skewer be installed opposite of normal. This insures that the quick-release lever, when fully closed, cannot interfere with the rotor. Although quick-release security is always of critical importance, wheel security is an even greater issue on a disc-brake hub than a hub with no brake. When securing the skewer, be sure to follow the guidelines in Chapter 18.

7. [] Install quick-release skewer into right end of axle (opposite of normal) then install adjusting nut on skewer.
8. [] Install wheel in proper alignment and with optimum quick-release security.

Brake lever and hose installation

9. [] Install brake lever in normal lateral and rotational position, then secure mounting bolt to 55–70in-lbs.
10. [] Adjust reach with 2mm Allen screw (at lever pivot) to middle of range (approximate six turns from either end of range). *Note: reach adjustment does not affect clearance adjustment or brake operation—this adjustment is only intended to make reach appropriate for average-sized hands.*
11. [] Check for O-rings in recess in each face of banjo fitting at each end of hose. O-rings should not protrude.
12. [] Slide rubber cover over banjo fitting at one end of hose.
13. [] Place covered banjo fitting over hole at inner end of brake-lever body, then thread in hollow bolt finger tight (do not secure). Check for protruding O-ring and correct.
14. [] With bike in on-ground position (axles equal height), align banjo fitting at lever to point straight down, then secure banjo-fitting bolt to 45–60in-lbs. Check for protruding O-ring again and correct.
15. [] Attach other banjo fitting to caliper and install but do not secure bolt. Check for protruding O-ring and correct.
16. [] Rotate banjo fitting at caliper to point away from caliper and to be parallel to plane of rotor slot (in or out 10° is acceptable), then secure to 45–60in-lbs. Check for protruding O-ring and correct.

Filling system with oil

This segment of the procedure describes both filling a new (empty) system, flushing and refilling a used system, and bleeding a system. Certain steps, as noted, apply to a limited number of these alternate proce-

dures. In step #17, the reservoir cover is removed. If the system is used, at this point inspect the brake fluid. If it is dark and discolored, it should be replaced.

CAUTION: *At all times while working with oil, it is critical to keep oil off rotor surface and brake pads!*

17. [] Position bike so plate on top of brake-lever reservoir is completely flat and parallel to ground, then remove reservoir cover-plate screws, metal cover, plastic cover, then rubber diaphragm.
 18. [] Arrange hose and caliper so they dangle straight down from lever, without bends or kinks in the hose, with room for a waste-oil receptacle below. *Note: if bleeding an already-installed system, remove caliper and install pad spacer between pads!*
 19. [] *Only if filling empty system:* Turn bleed valve 1/8 turn counterclockwise to open.
 20. [] Flip rubber cap off bleed valve on caliper, then attach plastic tubing to bleed-valve nipple and route tubing to waste receptacle.
 21. [] *Only if flushing and refilling system:* Open bleed valve 1/8 turn, pump brake lever repeatedly to clear oil from system, then allow several minutes for draining to complete.
- Shimano recommends only using Shimano Mineral Oil in the brake at the time of this writing. In the following steps where oil is mentioned, it is assumed the recommended oil is being used. Shimano Mineral Oil comes in a one-use size container to eliminate concerns about contamination. Mineral oil (Shimano or other) that is left open can absorb moisture from the air, which can vaporize when the brake reaches high temperature. Do not use any mineral oil that is possibly contaminated with moisture!
- NOTE:** *In the next step, it is critical to not allow the reservoir to become empty to keep from introducing air into the system!*
22. [] *Only if filling empty system:* Fill reservoir with mineral oil, then compress brake lever repeatedly to prime system with oil, adding oil as necessary to keep reservoir full. Stop when oil is seen in plastic tubing and close bleed valve.
 23. [] Compress brake lever repeatedly and watch for air bubbles rising in reservoir. Stop for a minute or two, then repeat. No further repetition is needed when bubbles cease to rise.
 24. [] Compress brake lever firmly with Quick-Grip clamp or similar device.
 25. [] Open and close bleed valve repeatedly for 1/2 second intervals (1/8 turn each time), watching for air bubbles in plastic tubing. Repeat two more times, or until no air bubbles are seen, then leave bleed valve closed. Remove clamp from lever.

37 – HYDRAULIC RIM BRAKES AND DISC BRAKES

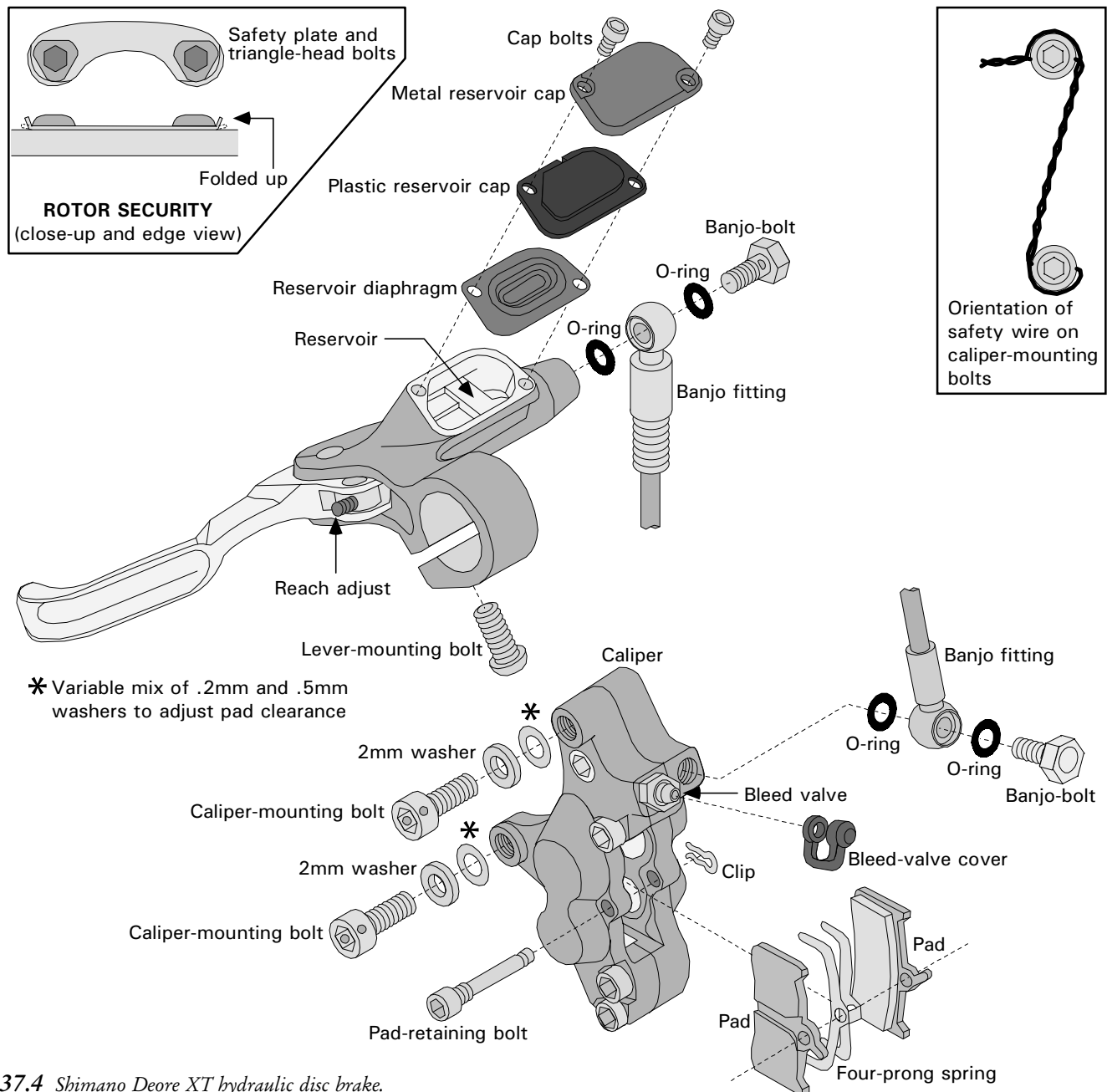
26. [] Move caliper to location where overflowing oil from brake-lever reservoir cannot drip on caliper.
27. [] Check and refill reservoir to overflow point as needed.
28. [] Assemble plastic reservoir cap to metal cap, then assemble rubber diaphragm to plastic cap.
29. [] Fill grooves in rubber diaphragm with oil, then quickly place cap assembly on reservoir and secure cap with screws.
30. [] Thoroughly wipe excess oil off of lever and all other parts. Rotor may be cleaned with alcohol or similar solvent, but all other parts should be cleaned with water and detergent to avoid degrading plastic and rubber parts and seals.

31. [] Squeeze brake lever firmly numerous times while checking at reservoir cap, banjo fittings, and bleed valve for oil leaks.
32. [] Remove plastic tube from bleed valve, then cap valve.

Caliper installation

NOTE: For frames or forks with Hayes-type post mounting (bolt holes aligned parallel to bike, rather than perpendicular to bike), an adapter plate must be mounted first. Install adapter and secure bolts to 55–70in-lbs, then use steps 41–45 before proceeding.

33. [] If caliper-mounting bolts are being reused, treat threads with Loctite 242 (not needed for first-time installation).



37.4 Shimano Deore XT hydraulic disc brake.

37 – HYDRAULIC RIM BRAKES AND DISC BRAKES

- 34. [] Put longer caliper-mounting bolt through frame/fork mounting hole further from drop-out, and shorter bolt through other frame/fork mounting hole.
- 35. [] Put .5mm shim washer on end of each bolt on inner face of frame/fork mounting plate.
- 36. [] Remove plastic pad spacer from caliper, slide caliper onto rotor, align caliper mounting holes with mounting bolts, then engage mounting bolts and snug bolts finger tight.
- 37. [] Inspect for interference between rotor and ends of bolts. If interference exists, remove bolts and put 2mm washer under each bolt head and reinstall bolts finger tight.
- 38. [] Compress brake lever with clamp and rotate wheel in operating direction, then secure bolts gently with Allen wrench.

In the next step, inspect for rub between the pads and rotor. Light rub is tolerable, but increasing or reducing the .5mm shim thickness between the caliper mount and caliper can correct excessive rubbing. Rubbing is easy to hear, but locating whether it is against the outer pad or inner pad can be difficult. Try back-lighting the gaps between the pads and the rotor with a flashlight, or try a .05mm feeler gauge. Unlike some disc-brake systems, this brake is self-adjusting for pad clearance, so there is no manual adjustment to eliminate rub other than changing the shim stacks.

- 39. [] **Spin rotor and listen for rubs. If rubs are heard, inspect closely for whether they are at inner or outer pad, and which end of the pad the rub is occurring.**

When changing the shim stack to reduce rub, using different combinations of shims can make adjustments by as little as .1mm increments. It is acceptable to shim each bolt differently. Possible combinations are:

- 0mm – no shims
- .2mm – one .2mm shim
- .4mm – two .2mm shims
- .5mm – one .5mm shim
- .6mm – three .2mm shims
- .7mm – .5mm and .2mm shim
- .8mm – four .2mm shims

- 40. [] Use different combinations of .2mm and .5mm shims to move one end of caliper in or out, then check again for rub and redo shimming as necessary. *Note: use step 38 technique each time caliper is secured!*
- 41. [] When rub is minimized, torque mounting bolts to 55–70in-lbs. Check for change in rub and correct if necessary.

- 42. [] Feed 6" safety wire halfway through upper mounting bolt head, wrap one end clockwise around bolt head to meet other end, then twist ends together tightly with pliers until twisted section is approximately 50mm long.
- 43. [] Wrap twisted pair clockwise around bolt head less than one full turn, then pull wire to second bolt head so that it approaches second bolt head on opposite side from where it left first bolt head (wire goes on diagonal line from first bolt to second bolt). Insert one wire end through first wire hole in bolt head, then out second wire hole.
- 44. [] Wrap remaining wire end counterclockwise around second bolt until it reaches point first wire end comes out of second bolt, then tightly twist ends together.
- 45. [] Hook second twist around section of twisted wire between bolts so that loose end cannot get tangled in brake mechanism.
- 46. [] Secure hose(s) to frame and/or fork, then turn handlebars and/or move suspension through its full range to check for interference with hose(s).

PAD REPLACEMENT

Pads need to be replaced when the braking-material thickness is reduced at any point to .5mm. Since the braking material is originally 2mm thick, remaining life can be predicted by measuring pad thickness. For example, when the thickness is 1.5mm, two-thirds of the pad life remains, and when the thickness is 1mm, one third of the pad life remains.

Pad removal

- 1. [] Remove clip from end of pad axle bolt, then unthread bolt.
- 2. [] Pull out four-leg pad spring and pads.
- 3. [] Measure braking material thickness at thinnest point and replace pads if .5mm or less.
- 4. [] Clean inside caliper around pistons with water and detergent on brush. **CAUTION: Do not use automotive brake cleaners! Seal damage will occur!**

Pad installation

NOTE: If original pads are being reinstalled and brake lever has not been squeezed while pads or rotor was out, then skip the next step.

- 5. [] Insert stack of feeler gauges between pistons and one side of rotor to fill gap between pistons and rotor, then insert a slotted screwdriver between other pistons and rotor and press pistons back into caliper. Switch feeler gauge stack to opposite side and repeat. *Note: if wheel is removed, use box end of a small combination wrench to push pistons back into caliper.*

6. [] Install onto pad axle bolt in order: first pad (metal-side first), pad spring (with legs straddling braking material), then second pad (braking-material-side first).
7. [] Inspect all four ends of spring to verify spring ends are not beyond ends of metal shoe backs, or resting against face of braking material.
8. [] Squeeze pads together until gap between them is just enough to fit rotor, then insert pad stack partially into slot in caliper and remove pad-axle bolt.
9. [] Press pad stack in until holes in pads and spring line up with hole in caliper for pad axle bolt, then insert pad axle bolt (treat threads with Loctite 222).
10. [] Secure pad-axle bolt to 20–35in-lbs, then install clip in slot in end of bolt.
11. [] Operate brake, then spin rotor and check for unacceptable pad rub. Adjust shims as necessary to reduce rub.

38 – SUSPENSION FORKS AND REAR SHOCKS

ABOUT THIS CHAPTER

This chapter is about suspension forks and shock units used on suspension frames. After some general information, there are sections for the following specific types of equipment.

CANE CREEK REAR SHOCKS

MANITOU MACH 5 FORKS

MANITOU MACH 5 SX EFC OIL DAMPERS

MANITOU '98-'00 SX & XVERT FORKS

MARZOCCHI '99-'00 FORKS-

COIL & OIL-DAMPER TYPES

MARZOCCHI '97-'00 FORKS-

COIL & ADJUSTABLE OIL TYPES

MARZOCCHI '99-'00 FORKS-AIR SPRUNG TYPES

RISSE ASTRO-5 REAR SHOCK

RISSE TERMINATOR REAR SHOCK

ROCKSHOX '97-'99 INDY & JETT FORKS

ROCKSHOX '99-'00 JETT HYDRACOIL FORKS

ROCKSHOX '97-'99 JUDY CARTRIDGE FORKS

ROCKSHOX '99-'00 JUDY HYDRACOIL FORKS

ROCKSHOX '98 SID FORKS

ROCKSHOX '99-'00 SID CARTRIDGE FORKS

ROCK SHOX DELUXE REAR SHOCK

ROCK SHOX SUPER DELUXE REAR SHOCK

RST '98 MOZO FORKS

WHITE BROTHERS FORKS

Each of the listed sections includes complete information on service procedures and tuning considerations. The **GENERAL INFORMATION** section that begins this chapter covers generic terminology, prerequisites, indications, tool choices, time and difficulty ratings for suspension service, and complications that may occur. The final section in the chapter is **TUNING DATA REPORT**, presented in a generic format for reporting to the customer the “before and after” conditions of the suspension.

GENERAL INFORMATION

TERMINOLOGY

Suspension: A device that permits a wheel to travel up and down independently of the rest of the bicycle.

Suspension fork: A bicycle fork that incorporates a suspension device.

Rear shock: The spring and/or damper unit that provides suspension to a pivoting structure attached to the rear of a frame.

Air/oil suspension: A suspension system that uses an air spring and oil for damping.

Elastomer/oil suspension: A suspension system that uses an elastomer spring and oil for damping.

Spring/oil suspension: A suspension system that uses a metal coil spring and oil for damping.

Damping: A function that modifies the rate of suspension compression or rebound.

Oil damping: A system that uses the resistance to oil flow through holes in a valve to provide a means to alter the rate of suspension compression or rebound.

Friction damping: A system that uses the resistance of friction caused by bushings, seals, elastomers, and friction rings to provide a means to alter the rate of suspension compression or rebound.

Compression damping: Restriction of the rate that the suspension compresses under load.

Rebound damping: Restriction of the rate that the suspension rebounds when load is relieved.

Compression: The phase of the suspension operation in which the wheel travels up, or travels closer, to the frame.

Rebound: The phase of the suspension operation in which the wheel returns to its original position, following completion of the compression phase. When a suspension rebounds, it is extending its length.

Travel: The amount that the wheel moves between the most compressed and most extended states of the suspension.

Stanchion tube: The suspension-fork tube fixed to the fork crown. It remains stationary during the operation of the suspension. The comparable part on rear suspensions is the piston.

Piston: The part of a rear-suspension spring/damper that slides back and forth inside the main body of the suspension unit. In most cases, the comparable part on a suspension fork is the stanchion tube.

Slider: The tube of a suspension fork that remains fixed to the wheel. It slides up and down on the stanchion as the suspension operates. The comparable part on a rear shock is the cylinder.

Cylinder: The part of a rear shock in which the piston slides. It may also be called *shock body*.

38 – SUSPENSION FORKS AND REAR SHOCKS

Fork crown: The component that joins the stanchion tubes to the fork column.

Stanchion clamp: The portion of the fork crown that clamps around the top of the stanchion tube.

Slider brace: An arch that joins the two sliders together. It may also serve as a mount for the cable-housing stop for the front brake. It is sometimes called a *brake arch*, or *fork brace*.

Pivot stud: The stud on which the brake caliper arm (usually a cantilever brake) is mounted to. Pivot studs are mounted to the slider, and often help retain the slider brace.

Dropout: The end of the slider where the wheel attaches.

Elastomer spring: A spring made from a rubber-like substance; when an elastomer spring is compressed, it tends to return to its original length vigorously. Elastomers have some potential to provide damping by converting dynamic energy to heat energy as they heat up from repeated compression. *Elastomer spring* will often be shortened to *elastomer*.

MCU elastomer: This stands for **m**icro-**c**ellular urethane elastomer. Micro-cellular urethane is full of tiny air cells that act like springs when the elastomer is compressed.

Durometer: A method of describing the firmness of an elastomer spring. High-durometer elastomers are stiffer.

Bumper: An other word for an elastomer spring.

Pre-load: A condition of compressing an elastomer before the operating loads are put on the suspension, so that it provides a stiffer spring rate.

Spring rate: The rate at which the resistance of a spring increases as it is compressed.

Top-out bumper: A rubber or elastomer device that absorbs the small shock that occurs when the load is taken off a suspension so that it is allowed to rebound to its limit (also called *rebound bumper*).

Bottom-out bumper: A rubber or elastomer device that absorbs the shock that occurs when a suspension is compressed to its limit.

Stiction: The tendency of parts that slide against each other to remain stuck together until adequate force is expended to cause them to begin moving in relation to each other.

Air spring: An enclosed body of air that shrinks in volume as the suspension is compressed. This reduction in size acts like a spring, because the air has a tendency to try to return to its original volume.

Valve: A mechanism that controls the flow of oil between a stanchion and slider, or between a piston and cylinder.

Hydraulic oil: A fluid that is used in some suspension designs to provide damping. It is usually a mineral oil with special characteristics that determine how it reacts when exposed to compressed air, how it changes viscosity when its temperature changes, and how it moves through valves.

Oil weight: A description of the relative viscosity of an oil, such as hydraulic oil. Oils with low weight numbers (5w or 10w) flow through valves with less resistance; oils with high weight numbers (15w or 20w) flow through valves with more resistance.

Viscosity: A description of how a liquid flows. Liquids with high viscosity are thicker and flow less easily or quickly than liquids with low viscosity.

Bushing: A cylindrical sleeve that acts as a bearing.

Seal: A stiff neoprene-rubber ring sometimes reinforced with a metal washer that fits tightly between two components in order to prevent escape of oil or air pressure.

O-ring: A soft, flexible neoprene-rubber ring with a round cross-section, that is used for sealing and retention.

Wiper seal: A neoprene-rubber seal that keeps dirt out, but is not designed to keep in oil or air pressure.

Dust boot: A soft, flexible sleeve (usually with an accordion-like shape) that covers the portion of the stanchion tube that goes in and out of the slider. *Dust boot* may be shortened to *boot*.

Internal snap-ring: A metal ring with a gap that allows compression. The outer perimeter of the ring is a smooth circle, and the ends have two tabs (on the inner perimeter) with holes that are engaged by a snap-ring plier for purposes of removing and installing the ring. Internal snap-rings sit in grooves on the inside of cylinders.

External snap-ring: A metal ring with a gap in it that allows expansion; the inner perimeter of the ring is a smooth circle, and the ends have two tabs (on the outer perimeter) with holes that are engaged by snap-ring pliers for purposes of removing and installing the ring. Internal snap-rings sit in grooves on the outside of cylinders.

C-clip: A metal ring with a wide gap that allows expansion; the outer perimeter of the ring is a smooth circle, and the ends have two tabs (on the inner perimeter) that engage the groove in which the C-clip sits. C-clips sit in grooves on the outside of cylinders. C-clips are unlike external snap-rings in that they push

on and off the side of the cylinder on which they are mounted. External snap-rings are expanded by a tool called a snap-ring plier so that they can be slipped on and off the end of the cylinder.

E-clip: Like a c-clip, but with a third tab on the inner perimeter directly opposite the gap in the clip.

Circlip: Like an internal snap-ring, but with no holes for a snap-ring plier to engage. The end of the ring needs to be deflected radially towards the center, so that it can be pried out of its slot.

Détente: An indentation that causes a rotating adjuster to stop at fixed increments. It usually operates by means of a spring-loaded ball bearing pressing into the détente.

PREREQUISITES

For oil change for an air/oil fork

There are no prerequisites for performing an oil change in most air/oil-suspension forks except wheel removal and installation.

For suspension-fork overhaul

Wheel removal and brake service are always required. It is optional, but recommended, to remove the fork from the frame, which requires headset overhaul and stem removal and installation.

For service of rear shocks

There are usually no prerequisites for any type of service that can be performed on a rear-suspension spring/damper.

INDICATIONS

Oil maintenance

Suspension systems that use oil for damping purposes need periodic oil changes. Oil breaks down and becomes contaminated. Performance and durability can be improved by periodic oil changes. Oil systems are temperature-range sensitive, so it may be necessary to put in lighter-weight oils for cold weather, and heavier-weight oils for hot weather.

Air pressure maintenance

Air/oil systems can bleed air slowly even when the seals have not lost their integrity. Periodic pressurization is needed, but probably not as often as for a tire.

Seal maintenance

Seals wear out and periodically need replacement. If seals are not maintained, then they may fail and cause air pressure loss or oil loss in and air/oil-suspension system.

Bushing maintenance

Bushings are the bearings between a fork stanchion tube and a fork slider. When bushings wear they should be replaced. Worn bushings cause slop between the stanchion and slider, and cause stiction by allowing the stanchion to misalign with the slider when the fork is fully extended.

Dirt and lubrication maintenance

Dirt contaminates a suspension as the stanchion or piston goes in or out of the slider or cylinder. Dirt increases wear and friction, so suspensions should be cleaned periodically. Greases are used to reduce friction and enhance seals. Eventually, however, grease dissolves and breaks down. Periodic regreasing of bushings, elastomers, and seals improves durability, maintains seal integrity, and reduces stiction.

Symptoms indicating need of seal replacement

If an air/oil system fails to hold air pressure for a reasonable time, or leaks oil at the seal, then seal replacement is needed.

Symptoms indicating need of bushing replacement

If the bike exhibits symptoms of a loose headset (but the headset is not loose), then the bushings between the stanchions and sliders in the fork are probably worn out. Clunking sounds when hitting bumps, or applying the brake, knocking sensations, or a feeling of sloppiness in the handling all may indicate worn bushings.

Symptoms indicating need of general overhaul

In addition to the presence of symptoms indicating need for seal or bushing replacement, problems with excess stiction or failure of the suspension mechanism to compress or rebound properly, indicate that the suspension should be fully serviced.

TIME AND DIFFICULTY

An oil change on an air/oil fork is a 15 minute job of little difficulty. A complete service of an air/oil fork is a 50 minute job of moderate difficulty. A complete service of an air/oil rear shock is a 25–35 minute job of moderate difficulty. A complete service of an elastomer fork is a 15–20 minute job of little difficulty.

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TOOL CHOICES

Table 38-1 is a list of all the suspension-specific tools required to perform *all* of procedures in this chapter. If a tool's use is limited to a specific brand or model, it is indicated in the **Fits and considerations** column.

SUSPENSION TOOLS (table 38-1)

Tool	Fits and considerations
RockShox 70100	Kit for servicing many RockShox models, and useful in many applications for non-RockShox suspensions (includes: stanchion-clamping blocks #70101, seal and bushing installer #70103, seal and bushing puller #70113, valve-body tool #70105, and dropout vise blocks #70107)
RockShox 70106	Bushing-removal tool for Quadra 5, 21, and 21R
RockShox 70108	Bushing-installation tool for Quadra 5, 21, and 21R
RockShox 70113	Friction-ring installer for original (1993) Quadra
RockShox 70118	Bushing-removal tool for Judy fork
RockShox 70119	Bushing-installation tool for Judy fork
RockShox 70142	Judy damper-cartridge-service tool kit
RockShox 70165	Kit for servicing Deluxe and Super Deluxe rear shocks
RockShox 59309	Pump required for pressurizing Deluxe and Super Deluxe rear shocks
Risse bullet tool	For installing seal head on Risse Genesis and Elroy rear shocks
12mm Allen wrench	For Marzocchi Zokes fork
United Bicycle Tool RS-109	Needle-type pump with 60psi capacity, bleeder valve, and gauge for pressurizing Rock Shox air/oil systems
United Bicycle Tool RS-300R	Needle-type pump with 300psi capacity, bleeder valve, and gauge for pressurizing Risse air/oil systems without Schrader valve
United Bicycle Tool RS-300S	Schrader-valve pump with 300psi capacity, bleeder valve, and gauge for pressurizing forks with recessed Schrader valve
Amp vise blocks	Split block of aluminum with split holes for clamping to various diameters of Amp damper shafts
Marzocchi 104	For threading onto Schrader valve to pull air cap out of stanchion on various Marzocchi air/oil suspensions
6"section of 3/8" round bar stock	For servicing Amp and Risse shocks, available at hardware store
6"section of 5/16" round bar stock	For servicing Amp and Risse shocks, available at hardware store
Bicycle Research 1–1/8" frame block	Used for holding Risse piston in vise
Sport-ball inflation needle	Use for depressurizing air chambers, must be type that has hole in end, not hole on side of tip (wrong type will damage air seal)
Bulb syringe (automotive battery type)	Useful for adjusting oil level in air/oil forks
United Bicycle Tool CV-521	Reversible snap-ring pliers with assorted tips in a variety of angles and thickness

COMPLICATIONS

Difficult seal removal on air/oil forks

Seals are deliberately a very tight fit. Most forks with seals require some sort of puller, but some manufacturers expect the mechanic to use brute force. These methods are inconsistent, messy, and potentially dangerous.

Air contamination in rear shocks

Certain units are designed to have no air in the chamber where there is oil. The presence of air may be noisy, or it may interfere with the passage of oil through tiny valve holes. Furthermore, air can introduce a spring effect. Special care is required to get the unit assembled without air getting inside, and in some cases it is required to perform the assembly while the whole unit is submerged in the same hydraulic fluid that is going inside the unit.

Frozen bolts in bottom of slider

A number of products put bolts down in the bottom of the slider, where moisture from condensation collects. This can lead to corrosion developing on threads, and very difficult bolt removal. Persistence and penetrating oil are the only solutions.

Stripped threads in fork crowns and sliders

Very soft materials, such as aluminum and magnesium, are used in certain sliders and fork crowns. Female threads in these parts strip easily when bolts are over-tightened. Use Loctite to eliminate the need for higher torques, and *always* use torque wrenches.

Unreplaceable bushings

Some poorly-designed forks rely on bushings that are a permanent part of the slider or the stanchion tube. The only way to replace these bushings is to replace the slider or stanchion, which is usually impractical (due to price or availability).

Wear on impractical-to-replace parts

Some forks are designed so that the bushings slide up and down against the inside surface of an aluminum or magnesium slider. These softer materials wear out easily; replacement is usually impractical (due to price or availability). Stanchion tubes on air/oil forks can fail in two ways: the surface may become nicked or scratched so that seal integrity is lost, or the stanchions may become bent from excessive load.

Clip failure

The snap-rings, c-clips, e-clips, and circlips used in suspensions are delicate; expansion or compression is required to install them, and they are easily damaged.

If they are slightly deformed, they may appear to be secure, but may fail during use. There is sometimes a great deal of load placed on these clips. Most clips have asymmetrical faces; one face has sharp corners on the edges, and the other has more rounded corners on the edges. As a rule, always install these clips so that the sharper-edged side faces away from the direction of the load (or pressure) that is against the item being retained by the clip.

Hydraulic-fluid toxicity

The fluids used in oil-damped systems may be toxic. Minimize your exposure and wear rubber gloves while working with these units.

OIL-VISCOSITY TESTING

Viscosity testing is needed for two reasons. First, there is no way to know what oil is being removed from a suspension without testing. If the original oil is unknown, then there is no way to know what might be suitable as a replacement. Second, manufacturer's ratings of their own oils are often unreliable. By testing, it is possible to know how different oils compare.

Viscosity testing of suspension fluid

The viscosity of shock fork fluid has a large impact on the performance of the fork. The following fluid-viscosity table (page 38-6), and fluid viscosity-test procedure (page 38-6), can help the mechanic estimate the current relative viscosity of a shock fork fluid.

When a shock fork is disassembled, most mechanics simply remove the old fluid and dump it in the recycling barrel. The new fluid selected may be quite different than the old fluid. This will, of course, affect the handling in a way which may or may not be desired by the customer. It is possible to determine the approximate viscosity of the old fluid, then compare it to known viscosities of popular brands. It is likely that the old fluid is dirty. This particulate matter may, in fact, have changed the viscosity of the fluid. However, because the dirty fluid is what the customer was most currently using, it is still appropriate to test the old fluid. Remember that the test rates the "effective viscosity" of the old fluid, not necessarily its original viscosity.

Needed testing equipment

Clear "Bic" pens (the Bic Classic Stic, model #MSP10). These are plastic, and are somewhat fragile, so purchase several. Older and used pens are often warped and deformed, so purchase new pens.

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Stop watch accurate to one tenth of a second.
Magnet strong enough to hold a ball bearing through the plastic.

A 3/16" ball bearing.

A vise or other devices that will hold the pen steady and vertical during the testing. Again, the pens are plastic, so take care in how you hold it.

The Bic Classic Stic pen needs some modification.

Use a drop of super-glue to cover the side-hole.

Remove the top cap.

Remove the pen tip and pull the ink tube off of the pen tip. The ink tube is not needed for the test.

Reinstall pen tip.

Put a rubber-coated strap clamp (that fits tubing the size of the pen) around the pen, then secure the clamp with a nut and bolt. Grasping the bolt and nut in the vise will be the way the pen will be held upright.

Mark the "starting line" for the test with a permanent marker or a scribe line. The starting line for the ball bearing is the middle of the U in the phrase, "Made in USA." This is 5mm from the top.

Viscosity-test procedure

1. [] Secure pen vertically in vise.
2. [] Fill to top with fluid to be tested.
3. [] Inspect for air bubbles; allow oil to sit if bubbles are present.
4. [] Place 3/16" ball bearing on a magnet.
5. [] Place ball in top of pen, then force it off magnet with your finger while holding magnet close to pen top (magnet will hold bearing inside pen, at top).
6. [] Position center of bearing at middle of U in USA, or at marked line.

7. [] Pull magnet away and start timer simultaneously.

8. [] Stop timer when ball stops at bottom.

9. [] Repeat at least three times, to see if results are consistent. Record time here: ____secs.

10. [] See table 38-2 for data for common bicycle-suspension fluids, and compare result in step 9 to determine what fluid might be comparable.

Upon completing the test, remove the pen tip and drain the fluid. Clean inside the pen with a mineral spirit solvent. Do not use acetone or other solvents that harm plastics. Dry the inside with compressed air, then install the tip.

Hydraulic-fluid viscosity

Table 38-2 can be used to compare the relative viscosity of popular brands of bicycle hydraulic fluids. Viscosity is a nominal measurement of the degree to which a fluid resists flow under applied force. The popular measurement of this property is referred to as a fluid's *weight*. The more a fluid resists flow, the more the assigned *weight*. Manufacturers are not necessarily consistent with one another regarding their assigned weights, but they tend to be consistent within their own product line. For example, one manufacturer's 5 *weight* can have a higher viscosity than another manufacturer's 5 *weight*.

Table 38-2 (below) is based on the preceding test of fluid viscosity (see preceding procedure). Note that the table is only a measure of a fluid's relative viscosity, and is not intended to be a statement on its quality. The exact viscosity may also differ between different shipments from the same manufacturer.

COMMON BICYCLE-SUSPENSION FLUIDS (table 38-2)

Brand	Weight or Designation	Time at 72° (in seconds)	Time at 45° (in seconds)	% change 72° to 45°
Englund	blue 5w	5	9	80%
Finish Line	2.5w	6	8	33%
RockShox	5w	7	18	128%
Englund	purple (approx. 7w)	7	13	85%
Finish Line	5w	9	17	88%
Englund	red (approx. 10.5 w)	11	21	91%
Finish Line	10w	13	28	115
RockShox	8w	14	36	157%
Pedro's	no designation	15	32	133%
Englund	gold (approx. 12.5 w)	18	39	117%
Finish Line	20w	22	60	172%

CANE CREEK REAR SHOCKS

ABOUT THIS SECTION

This section applies to the following models: AD-4, AD-5, AD-8, and AD-10. Procedurally, there is virtually no difference between the AD-4 and AD-5, and there is also virtually no difference between the AD-8 and AD-10. There are small technique differences between the 4 or 5 and the 8 or 10, but one procedure with notations about the differences follows.

TOOLS

There are no special tools provided by the manufacturer for working on these shocks. The AD-4 and AD-8 have a large ring that is unthreaded by hand that can be difficult to break loose. Wrapping a large rubber band around the ring, such as the rubber band that comes in Aheadset packages, improves grip. A section of inner tube also works, but not quite as well.

FULL SHOCK SERVICE

Services include cleaning and lubrication, replacement of seals when air leaks develop, and changing the valving for tuning purposes (AD-4 and AD-5 only).

Disassembly

1. [] Depress valve plunger to deflate shock.
2. [] **AD-8 and AD-10 only:** Loosen compression and rebound adjusters to just short of point O-rings are revealed.
3. [] Clamp body eyelet carefully into soft jaws in vise (use rag to protect finish).
4. [] Wrap wide rubber band around black ring at top of body to improve grip, then turn ring counterclockwise to unthread.
5. [] Pull up on shaft to remove shaft/piston assembly from shock body.
6. [] Clamp eyelet end of shaft assembly in the soft jaws in vise (protect finish with rag).
7. [] Use pin spanner (Park SPA-1) to unthread piston.
8. [] **AD-8 and AD-10 only:** Remove compression cylinder and compression washer from inside of shaft assembly, and record compression washer thickness here: _____
9. [] **AD-4 and AD-8:** Pull seal head off shaft, then inspect and remove damaged seals and O-rings.
AD-5 and AD-10: Pull lockring off shaft assembly, then pull seal bushing off shaft assembly. Inspect and remove damaged seals and O-rings from lockring and seal bushing.

10. [] **AD-4 and AD-5 only:** Pull up on white plastic plug to remove it from volume adjusting plate.
AD-8 and AD-10 only: Pull on aluminum adjuster rod to remove it from volume adjusting plate.
11. [] Remove shaft from vise, then insert rubber-tipped blow gun into hole in volume adjusting plate and use compressed air to force out plate. *Note: Be prepared for plate and two small plastic adjusting ramps to fly out of shaft!*
12. [] **AD-8 and AD-10 only:** Inspect inside shaft for valve adjuster ramps that may have remained in shaft during step 11.
13. [] Inspect and remove damaged O-rings from volume adjusting plate.
14. [] Remove compression and rebound adjusters fully. O-rings will provide light resistance to removal after threads are disengaged.
15. [] Use 8mm socket to remove valve nut from bottom face of piston.
16. [] Remove washer, then remove compression valve shim and record thickness here: _____

Cleaning

17. [] Clean all parts with mild detergent and dry with compressed air and/or lint-free rag.

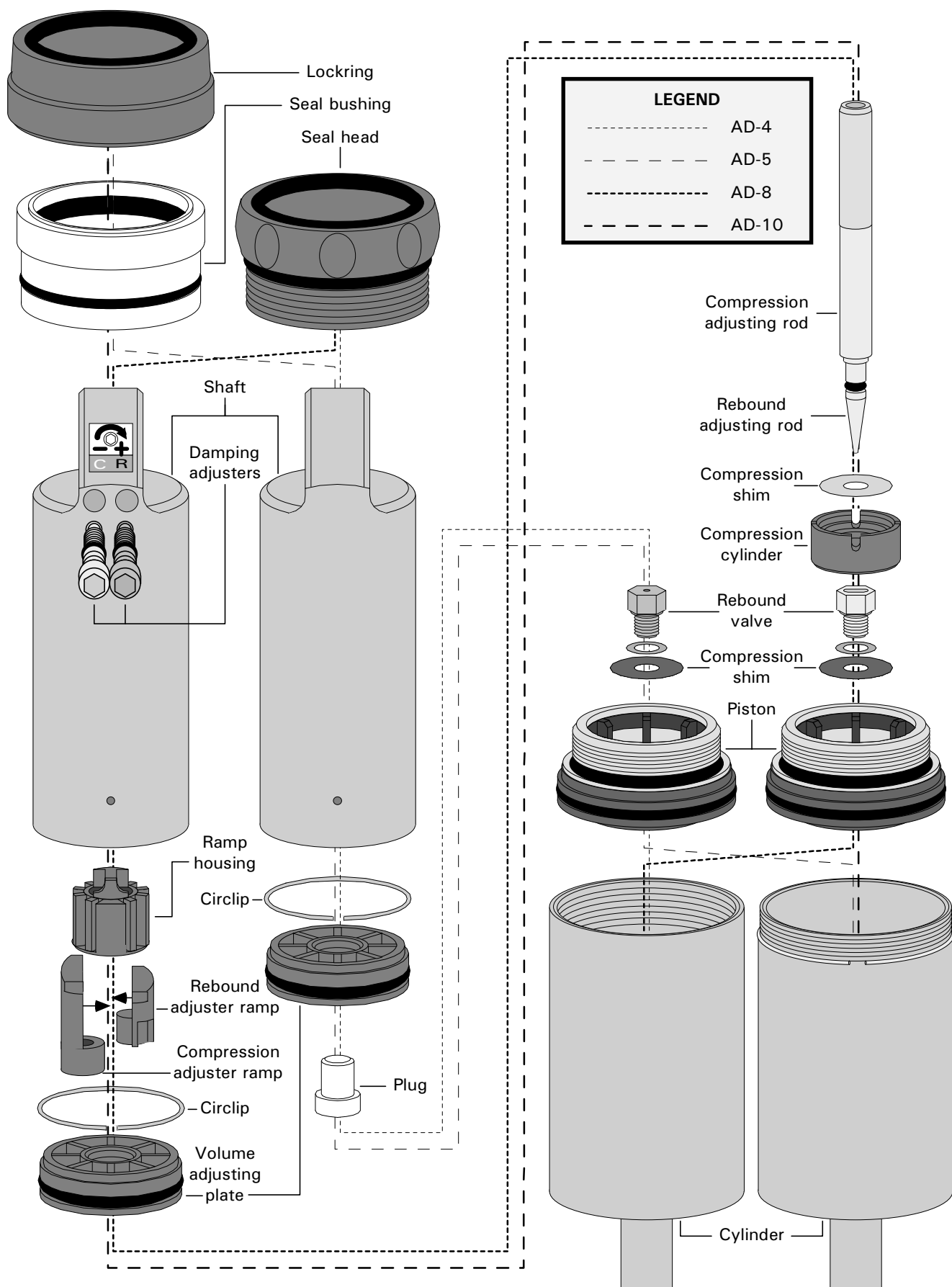
Volume adjustment

18. [] If it is desired to change volume to change spring rate, carefully remove circlip inside shaft and move to higher groove to increase spring rate, or lower groove to decrease spring rate.

Assembly

19. [] Replace all damaged O-rings and seals that were removed, then grease all O-rings.
20. [] Install compression shim, small washer, and then valve nut into piston.
21. [] **AD-4 and AD-8 only:** Slide seal head onto closed end of shaft, threaded-end first.
AD-5 and AD-10 only: Install seal bushing (small end first) over closed end of shaft, then install lockring (knurled-end first) over closed end of shaft.
22. [] Secure eyelet end of shaft into vise (open-end up).
23. [] **AD-8 and AD-10 only:** Inspect ramp housing inside shaft unit. It must be aligned with its center divider parallel to axis of holes for adjuster bolts. Push one adjuster bolt into its hole to see if tip of bolt appears inside ramp housing. If not, try rotating ramp housing 180°.

38 – SUSPENSION FORKS AND REAR SHOCKS



38.1 Cane Creek AD-4, AD-5, AD-8, and AD-10 shocks.

In the next step, when the bolts with O-rings are inserted into the holes in the shaft, it is difficult not to damage the O-rings by catching them on the lips of the holes. Use a small chamfering tool to chamfer the holes and it will be no problem.

24. [] **AD-8 and AD-10 only:** Thread silver adjusting screw into hole marked “C,” and black adjusting screw into hole marked “R,” taking care not to deform or tear O-rings. Thread in bolts just until first calibration mark on smooth bolt shaft reaches the top of hole.
25. [] **AD-4 and AD-5 only:** Insert white plug into volume adjusting plate.
AD-8 and AD-10 only: Grease blunt end of adjuster-rod assembly, mate valve adjuster ramps together, then install ramp assembly onto blunt end of adjuster-rod assembly. Insert assembly into ramp housing inside shaft so that slope of ramps face toward holes for valve adjusters.
26. [] Insert volume-adjusting plate into shaft, smooth-face up, until it seats fully.
27. [] **AD-8 and AD-10 only:** Place compression valve shim on top of valve adjusting rod, then place compression cylinder (notched end first) on top of compression valve shim.
28. [] Thread in and secure piston.
29. [] Grease inside of shock body with recommended grease, then carefully slide over piston.
30. [] Turn shock over and carefully grasp body eyelet in vise.
31. [] **AD-4 and AD-8 only:** Thread seal head into shock body as far as it will go (wrap with rubber band to improve grip).
AD-5 and AD-10 only: Slide bushing seal as far as it will go into body, then slide locking over seal bushing and thread it onto body (until locking covers half of wire clip at end of body threads).
32. [] Inflate shock. Cover with soapy water to check for leaks.

TUNING OPTIONS

Air pressure

A simple formula can be used to determine an appropriate pressure for the shock, depending on the rider's weight: rider's weight (in pounds) plus 10 equals pressure (in psi). If the rider finds the suspension bottoms out too frequently, the pressure should be increased. If the rider finds the suspension is too stiff, pressure should be reduced. Adjustments should be used in five-pound increments.

Air volume

These shocks have a volume adjusting plate in the shaft section of the shock. Changing the volume changes how progressive the spring is. For example, with the plate adjusted to reduce volume, even if the starting pressure is constant, it will take more force to compress the suspension fully. The suspension will be progressively more stiff the more it is compressed and less likely to bottom on big hits. Conversely, if the plate is adjusted to increase volume, even if the starting pressure is constant, it will take less force to compress the suspension fully. The suspension will be less stiff when it is compressed the same amount and the ride will be softer.

Compression and rebound adjusters

The AD-8 and AD-10 have external adjusters for compression and rebound damping. They are clearly marked. The rider should determine the optimal settings by using simple trial and error. The AD-4 and AD-5 have no external adjustment, but rebound damping can be adjusted by means of replacing the valve nut with one with a different size orifice, and compression damping is adjusted by changing a valve shim washer inside the shock.

AD-4 and AD-5 compression shim washers

Cane Creek makes available a tuning kit with an assortment of thickness of compression shim washers. Changing the compression washer is the only way to change the compression damping on the AD-4 and AD-5. The washer(s) should be changed on the AD-8 and AD-10 only if the external adjuster cannot be loosened or tightened enough to achieve the desired amount of damping. All models have a compression washer that is removed in step #16 (of the preceding procedure) from beneath the valve nut. Another compression washer is the washer removed in step #9 (AD-8 and AD-10 only).

Three washers are available with thickness measurements of .10mm, .15mm, and .20mm. These increments are large, so in most cases a change of one step up or down should be the most attempted at first.

AD-4 and AD-5 valve orifice diameter

The tuning kit also includes three sizes of valve nuts, with orifice diameters of .56mm, .61mm, and .66mm. These are used to adjust the rebound damping on the AD-4 and AD-5 only. Smaller orifice size creates greater damping. To identify the size of the installed valve or the replacement valve, look for a number stamped on the side of the valve. The number “6” indicates the smallest size, “7” the middle size, and “8”

38 – SUSPENSION FORKS AND REAR SHOCKS

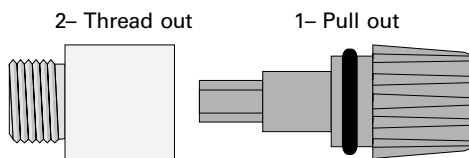
the largest size. Unfortunately, early production runs of the shocks and the tune-up kits had unmarked valves. In this case, the only way to identify the size is by purchasing very rare drill bits in wire sizes #71 and #73. If the #71 fits in the hole, then it is the largest. If the #71 doesn't fit, but the #73 does fit, it is the middle size. If neither fits, then it is the smallest size. These inexpensive drill bits are available from Grainger Industrial Supply (www.grainger.com) and are part nos. 1F945 and 1F950.

MANITOU MACH 5 FORKS

This section covers three models of forks: Comp, Pro XC, and SX. They are functionally identical, except that the SX model has an oil damper in the left leg. Servicing the SX oil damper is included in the **MANITOU EFC/MACH 5 SX OIL DAMPERS** section.

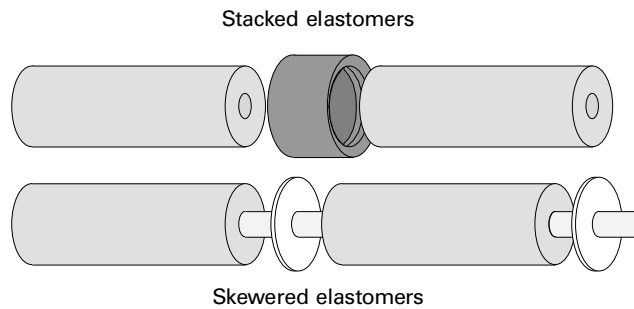
DISASSEMBLY

1. [] **SX model only:** Count number of turns it takes to turn each adjuster knob at top of stanchion to most counterclockwise position, then record here: Turns on left: _____ Turns on right: _____
2. [] **SX model only:** Count number of turns it takes to turn each adjuster knob at bottom of left slider to most counterclockwise position, then record here: _____
3. [] Disconnect front-brake cable.
4. [] Jiggle sliders to feel for free play that indicates bushings are worn.
5. [] **Comp & Pro XC (either leg), & SX (right leg):** Remove bolts on bottom ends of sliders.
SX left leg only: Pull or pry knob out of cylinder at bottom of left slider, then use 8mm Allen wrench to unthread cylinder.



38.2 SX left leg damper-adjuster assembly.

6. [] Turn stanchion caps counterclockwise, to remove elastomer stacks from top of stanchion tubes.



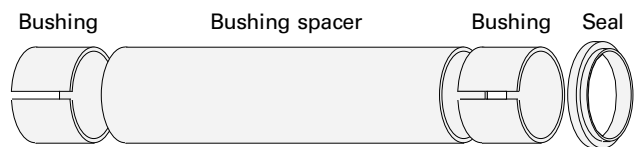
38.3 Stacked elastomers (Comp and Pro XC) and skewered elastomers (SX) assemblies.

7. [] Note sequence of washers and elastomers in skewer stacks.

8. [] Remove elastomers and washers from skewer shafts (or from top caps).
9. [] Pull slider assembly off ends of stanchions.
10. [] Pull dust boots off of stanchions.
11. [] Use 1/8" slotted screwdriver to deflect end of circlip in top of slider inward, then pry circlip out of slider.
12. [] Lift wiper seals out of tops of sliders.
13. [] Pull top bushings out of tops of sliders.
14. [] Pull bushing spacers out of sliders.

In some cases, the lower bushing may fall out of the slider effortlessly. If it does not, a custom bushing remover can be fabricated by grinding the threaded end of a spoke to a fine point and bending about 1/2" of the threaded end over, at a 90° angle. The pointed tip of the spoke can then be used to snag the bottom edge of the lower bushing.

15. [] Pull lower bushings out of sliders with custom bushing puller.



38.4 Wiper seal and bushing assembly.

NOTE: To service damper of SX left leg, go to **MANITOU MACH 5 SX OIL DAMPERS** section (page 38-12) now.

16. [] **Comp and Pro XC only:** Pull keeper plate out of slot in black shaft that is protruding from end of stanchion tube.
17. [] **Comp & Pro XC (either leg), & SX (right leg):** Pull bumper(s) off black shaft.

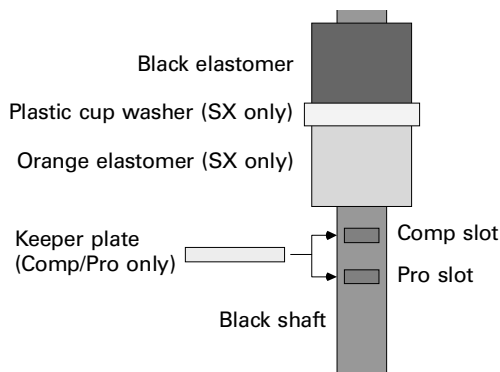
18. [] Turn stanchion over to remove black shaft.
19. [] Repeat steps 11–18 for other leg.

CLEANING AND INSPECTION

20. [] Clean all parts with non-abrasive cleansers. Avoid chemicals that might violate plastic and rubber parts.
21. [] Inspect bushings for variable thickness, indicating wear.
22. [] Inspect seal for nicks, tears, or cracking.
23. [] Inspect elastomers for cracks or other deterioration.

ASSEMBLY

24. [] *Comp & Pro XC (either leg), & SX (right leg):* Drop black shaft into stanchion, then make sure shaft sticks out hole in bottom of stanchion tube.
25. [] Grease elastomer stacks, then assemble elastomers to skewer or between separator washers.
26. [] Drop elastomer stacks and top caps into stanchions and thread in top caps.
27. [] *Comp & Pro XC (either leg), & SX (right leg):* Slide greased bumper(s) onto black shaft, until just past slots in shaft.



38.5 Shaft-bumper arrangements on Comp, Pro XC, and SX shafts.

28. [] *Comp and Pro XC only:* Slide keeper plate into slots in black shaft (upper slot for Comp, lower slot for Pro XC).
29. [] Slide dust boots onto stanchion tubes.
30. [] Grease bushings and bushing spacers inside and out.
31. [] Insert bushing, bushing spacer, then bushing into each slider.
32. [] Seat wiper seals (conical-ends up) into sliders.
33. [] Place circlips over wiper seals.
34. [] Install slider assembly onto ends of stanchions and push up fully.

35. [] *Comp & Pro XC (either leg), & SX (right leg):* Treat mounting-bolt threads with Loctite 222, then gently secure mounting bolt into bottom end of slider.
SX left leg only: Treat threads of large sleeve nut with Loctite 222, thread large sleeve nut into bottom of slider, then insert adjuster knob on bottom of slider.
36. [] *SX left leg only:* Turn adjuster knob at bottom of slider fully counterclockwise, then clockwise number of turns indicated in step 2.
37. [] *SX only:* Turn adjuster knobs on tops of stanchions fully counterclockwise.
38. [] *SX only:* Turn adjusters clockwise number of turns recorded in step 1.

SECURING STANCHION TUBE IN FORK CROWN

NOTE: The following procedure applies only to models that have one 6mm bolt in the crown that is inward of each of the stanchion tubes. The following torques do not apply to the original Manitou forks, which had two bolts in the crown between the fork column and each stanchion tube, or to Manitou models that have two bolts outward of each stanchion.

1. [] Remove crown bolts.
2. [] Adjust height of stanchion tube so top is no lower than top of fork crown, and no higher than the maximum-height mark on the stanchion tube. (In the absence of a maximum-height mark, position top of stanchion tube flush with top of fork crown.)
3. [] Treat bolts with Loctite 242.
4. [] Torque mounting bolts 110–130in-lbs (27–33lbs@4").

TUNING OPTIONS

Changing elastomers

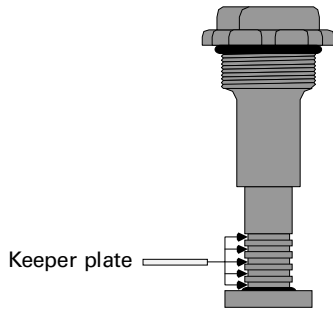
A variety of elastomers with different durometers are available for these forks. Stiffer durometer elastomers will give the fork greater resistance to compression and offer faster rebound. The different elastomers can be combined in any way (both legs should match), as long as the original elastomer stack length is maintained.

Adjusting Comp and Pro XC pre-load

The adjuster knobs at the tops of the stanchions must be threaded out of the stanchions to adjust the pre-load. Once the knobs are out, the plunger on the bottom of the knob can be pulled out. The clip can be

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moved to different slots to change the pre-load. When the clip is moved further up, the pre-load is increased, and decreased when the clip is moved further down.



38.6 To change the pre-load adjustment on the Comp and Pro XC models, move the keeper plate to a different slot.

Adjusting SX pre-load

The adjuster knobs at the tops of the sliders can be turned to change the effective spring stiffness. Turning the knobs clockwise increases spring stiffness and turning the knobs counterclockwise decreases spring stiffness.

Adjusting damping on Manitou SX left leg

The adjusting knob on the bottom of the left slider primarily adjusts rebound damping but compression damping will be increased slightly whenever rebound damping is increased significantly. Turning the knob counterclockwise decreases rebound damping and turning the knob clockwise increases rebound damping.

See **MANITOU MACH 5 SX OIL DAMPERS** (immediately following this section) for damper service.

Changing oil in damper in SX left leg

Oil weight affects the damping rate. The weight of the oil affects both the compression and rebound damping. Heavier-weight oils increase the damping effect (retarding compression and rebound); lighter-weight oils decrease the damping effect (speeding up compression and rebound).

Oil weight also might be varied to compensate for weather conditions, with very light-weight oils being used for extreme-cold conditions.

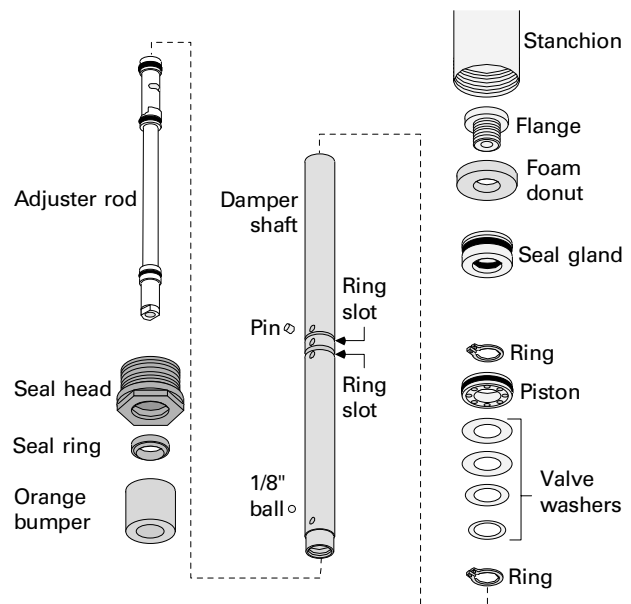
See **MANITOU MACH 5 SX OIL DAMPERS** (immediately following this section) for damper service.

MANITOU MACH 5 SX OIL DAMPERS

The oil damper is built into the left stanchion tube on SX models. The damper can be replaced as a whole by replacing the stanchion, or the damper can be serviced by disassembling the stanchion assembly.

DISASSEMBLY

1. [] Use **DISASSEMBLY** steps 1–15 of **MANITOU MACH 5 FORKS** (page 38-10) to access oil damper.
2. [] Remove left stanchion assembly from fork crown.
3. [] Prepare to catch ball bearing that is trapped under elastomer on end of shaft, then carefully remove elastomer from shaft.
4. [] With stanchion held upside down, carefully unthread seal-head with large hex fitting on bottom end of stanchion, then pull seal-head a few millimeters away from stanchion.



38.7 Blow-up of EFC and Mach 5 SX oil damper.

5. [] Turn stanchion over so that oil will drain into catch pan.
6. [] Carefully pull seal-head off end of shaft.
7. [] With end of stanchion still pointing into catch pan, pump shaft fully in and out to pump oil out of stanchion.

NOTE: If changing oil only, go to step 32 now. Do not go to step 8 unless in possession of a re-build kit.

8. [] Insert long rod into top of stanchion tube, then push remaining parts out bottom of stanchion.

9. [] Holding shaft securely by bottom 25mm (in fashion that will not mar shaft), use 5mm Allen wrench to unscrew flange from top end of shaft.
10. [] Pull foam donut and seal gland off top end of shaft.
11. [] Remove O-ring from outside of seal gland, then seal ring from inside of seal gland.

For the remaining steps, it is important to differentiate between the top and bottom of the shaft. The bottom end has a diameter reduction for the last 7mm and also has a hole in the shaft about 12mm from the end.

12. [] Being careful not to scratch shaft, remove external snap-ring from topside of piston/valve assembly at center of shaft.
13. [] Remove small metal washer, plastic washer, two large metal washers, and then piston.
14. [] Remove O-ring from outside of piston.
15. [] Find pin that was covered by piston, then tap shaft on soft surface so that pin will fall out; pushing plastic adjuster rod inside shaft one way or other can relieve load on pin, so that it will fall out.
16. [] Pushing from top end of shaft, push adjuster rod out bottom end of shaft.
17. [] Remove three O-rings from adjuster rod.
18. [] Remove O-ring from outside of threaded stanchion seal-head, then seal ring from inside of seal-head.

CLEANING AND INSPECTION

19. [] Clean all parts with mild detergent and water, then dry thoroughly with compressed air. *Avoid leaving solvents or lint from rags on, or in, any part!*
20. [] Inspect shaft for scratches or gouges on portions of shaft that move through O-rings in seal gland and seal-head.

ASSEMBLY

21. [] Thoroughly grease all O-rings and seal rings.
22. [] Install O-ring (outside) and seal ring (inside) of threaded seal-head.
23. [] Install 3 O-rings on adjuster rod.
24. [] Install O-ring (outside) and seal ring (inside) of seal gland.
25. [] Install O-ring on outside of piston.
26. [] Slide onto top end of shaft in order: piston, two large metal washers, plastic washer, then small metal washer.
27. [] Carefully slide external snap-ring over top end of shaft, then seat in groove above washer(s).
28. [] Slide foam donut over top end of shaft.

29. [] Find face of seal gland that internal seal ring is closest to, then carefully slide seal gland (with that face first) over top end of shaft.
30. [] Holding shaft securely by bottom 25mm (in fashion that will not mar shaft), use 5mm Allen wrench to secure flange into top end of shaft.
31. [] Taking care to not damage seal-gland O-ring on threads in end of stanchion, insert shaft/piston assembly into end of stanchion (flanged-end first), then bottom shaft fully into stanchion.
32. [] Holding stanchion tube upside down, carefully fill stanchion with 2.5w, high-quality, suspension oil.
33. [] Without moving shaft to its limit in either direction, slowly pump shaft up and down, several times to pump air out of system.
34. [] When bubbles have dissipated from top of oil, add more oil until level is 2–3mm below end of stanchion.
35. [] Look at bottom face of seal-head to find location of bleed hole.
36. [] Keeping track of location of bleed hole, carefully slide stanchion seal-head over end of shaft until threads of seal-head contact threads in end of stanchion.
37. [] Wrap rag around stanchion, then thread stanchion onto seal-head while holding seal-head stationary, until seal-head is engaged a few threads.
38. [] Tip stanchion in direction that will keep bleed hole on high side, until stanchion is leaning at about 45°.
39. [] Holding seal-head stationary, thread stanchion on to seal-head until O-ring just contacts end of stanchion.

In the following step, great care is needed to prevent the O-ring from becoming trapped between the seal-head flange and the end of the stanchion. As the seal-head is threading in, the oil coming out the bleed hole tends to force the O-ring out of its groove. Backing the seal-head out slightly after threading it in a little encourages the O-ring to settle back down into the groove of the seal-head. *Important! If at any time it appears that the O-ring is being squeezed between the seal-head flange and the end of the stanchion, remove the seal-head and start over again!*

40. [] Thread seal-head in tiny amount, back out slightly less, in again, out slightly less again (repeatedly), until flange on seal-head is seated against end of stanchion.
41. [] Secure seal-head to 35–50in-lbs.
42. [] Turn adjuster rod in end of shaft fully counterclockwise.

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- 43. [] Pull shaft out of stanchion to its limit.
- 44. [] Place ball bearing in its socket 12mm from end of shaft, then slip bumper over shaft to retain bearing.
- 45. [] Place upper end of stanchion fully into fork crown, then secure bolt in fork crown to 110–130in-lbs.

TUNING OPTIONS

Adjusting damping on Mach 5 SX left leg

The adjusting knob on the bottom of the left slider primarily adjusts rebound damping but compression damping will be increased slightly whenever rebound damping is increased significantly. Turning the knob counterclockwise decreases rebound damping and turning the knob clockwise increases rebound damping.

Damper oil change in Mach 5 SX left leg

Oil weight affects the damping rate. The weight of the oil affects both the compression and rebound damping. Heavier-weight oils increase the damping effect (retarding compression and rebound); lighter-weight oils decrease the damping effect (speeding up compression and rebound).

Oil weight also might be varied to compensate for weather conditions, with very light-weight oils being used for extreme-cold conditions.

MANITOU '98-'00 SX & XVERT FORKS

ABOUT THIS SECTION

This section covers a wide range of Manitou SX and XVert models from 1998 through 2000 models. This section does not cover the air-sprung 2000 Mars models, which were not available at the time of this writing. This section does not cover the 1999 Spyder or 2000 Magnum models. The covered 2000 models can be distinguished from the covered 1998 and 1999 models by looking for the “preload” adjuster, which is on the right side on the 2000 models. These 2000 models are essentially the same fork to service as the earlier ones, with one significant exception. In 1998 and 1999, all the models had a spring assembly in the right leg and a hydraulic damper in the left leg. For the 2000 models, this is reversed. This section covers full fork service, including bushing replacement.

The bushing removal and installation procedure utilizes the following tools. The removal tool can be easily modified to improve its function. The modifications are described at the point in the procedure where the use of the tool is described. These bushing tools were introduced in 2000, but are similar to the older tools (remover #85-3892 and installer #38-3893).

Answer Products #85-3909 bushing remover

Answer Products #85-3911 bushing installer

Other tools needed are:

Modified 24mm socket ground on end to eliminate internal bevel to improve purchase.

Modified 27mm socket ground on end to eliminate internal bevel to improve purchase.

FULL FORK SERVICE

This section covers a wide range of Manitou models from 1997 through 2000 models, as long as they feature TPC damping. All the covered models should have a decal that indicates it is a TPC model.

Slider-assembly removal

- 1. [] Pull plastic adjuster knob from bottom of left leg (right leg if 2000 model).
- 2. [] Remove bolt that adjuster was removed from with 8mm Allen wrench.
- 3. [] Remove second bottom bolt with 4mm Allen wrench, then remove bushing (if any).
- 4. [] Pull slider assembly off stanchion tubes, then remove boots from stanchions.

Spring-stack and plunger-shaft removal

- 5. [] Count number of turns to turn pre-load adjuster on top of sprung leg fully counterclockwise and record here: _____ turns
- 6. [] Unthread cap with pre-load adjuster with fingers (27mm wrench if equipped with flats), then remove spring-stack assembly.
- 7. [] Remove elastomer stack from shaft on spring side and note sequence of elastomers and spacers.
- 8. [] Push plunger shaft out top end of stanchion where spring was removed. A spoke or similar long, skinny object may be necessary to push shaft fully out.
- 9. [] Remove accordion-like top-out bumper from shaft by pulling it off bottom end of shaft.

Damper removal

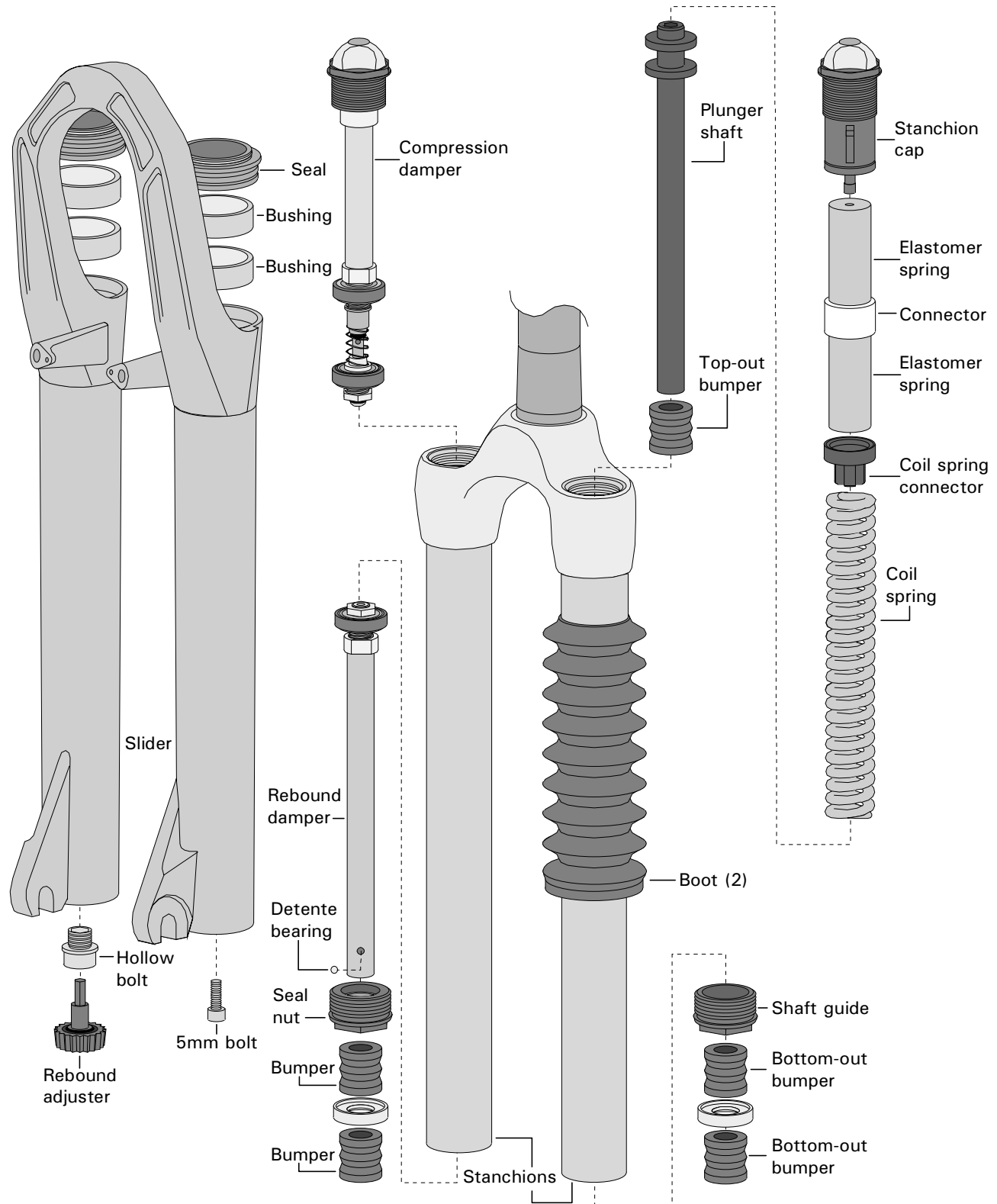
Dampers are removed to facilitate cleaning and inspection. Damper-valve disassembly is not necessary, and is not supported by separate parts from the manufacturer.

- 10. [] With fork upright, unthread top cap and slowly remove damper piston to avoid spilling oil.

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11. [] Carefully turn fork over to drain oil from stanchion into waste receptacle.
12. [] Be prepared to catch small ball bearing trapped under bumper on rebound-damper shaft, then remove bumper(s) from end of shaft, noting sequence if multiple.

13. [] Push rebound-damper shaft almost fully into seal nut on bottom of stanchion.
14. [] Use 24mm or 27mm socket to remove seal nut, then pull damper piston out bottom of stanchion.
15. [] Pull seal nut off end of rebound-damper shaft.



38.8 Manitou '00 X-Vert fork.

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16. [] Use rebound-damper adjuster knob to fully unthread adjuster shaft, then pull adjuster out bottom of damper shaft. *Note: Adjuster shaft has needle tip that will be damaged if something is inserted thorough top of damper to push out adjuster!*

Seal and bushing removal

The pre-2000 bushing remover is a relatively crude tool that relies on awkward yanking to remove the bushings. With a few simple modifications, it can be made to work on a threading principal, instead of by yanking on it. The 2000 tool comes with a slide-hammer system that is superior to the yanking approach, but it, too, can be made to work on a threading principal.

There are four additional parts needed for the modification. They include a pressed headset cup from a bike with a 1" fork diameter; a threaded race or locknut (type without a metal lip) from the same-sized headset; an old quill stem with a 22.2mm quill diameter (extra-tall preferred); and a 100mm section of steel frame tubing with outside diameter of 1-1/8". For purposes of simplicity, the following procedure will call these four pieces, in respective order, the "cup," the "locknut," the "stem," and the "short tube."

The remover tool (#85-309) itself has several pieces, which are described below with the names that are used in the procedure:

Tube with lip on one end and threads on other – "column"

Aluminum knurled cylinder – "handle"

Short cylinder split along its length – "expander"

7-1/2" tube – "long tube"

Steel knurled cylinder on acme-threaded shaft – "slide hammer" (2000 and later model only)

The version of the tool introduced in 2000 has two of everything above, except the slider hammer. The smaller-diameter version of each item is for Magnum model forks only. There are three sizes of expanders. The smallest is for Magnum forks, the medium is for SX and Spyder forks, and the largest is for X-Vert forks.

NOTE: Steps 17–24 work for the 2000 model tool in its stock configuration. If using modified tool, skip to alternate step 17 (following step 24).

17. [] Pry seals out of top ends of sliders.
18. [] Install largest expander (tapered-end first) on larger column, then install long tube.
19. [] Assemble slide hammer assembly to handle, then thread handle onto column.
20. [] Insert column into slider, then use slide hammer to push expander through first bushing.

21. [] Holding handle, push long tube down column to force expander to end of column.
22. [] Turn assembly upside down and use slide hammer to pull bushing from slider.
23. [] Repeat steps 18–22 for remaining bushings.
24. [] Proceed to step 32.

NOTE: Alternate steps 17–31 work if remover has been modified to work on a threading principle.

17. [] Pry seals out of top ends of sliders.
18. [] Clamp handlebar-clamp end of stem securely in vise so that quill of stem is above vise and horizontal.
19. [] Using rubber mallet, make sure expander is compressed so that it is a close fit to diameter of top end of column.
20. [] Slide expander (tapered-end first) down column just to point column fattens.
21. [] Place long tube over column, thread locknut on just until it reaches long column, then slide column assembly onto stem several inches and secure stem-binder bolt.
22. [] Place slider over end of column assembly until bushing contacts expander.
23. [] Push slider until expander is forced through top bushing.
24. [] Thread locknut to end of threads.
25. [] Pull firmly on slider assembly until expander is felt to bottom against lip at end of column, remove assembly from stem, then remove locknut and long tube from column.
26. [] Place cup (cupped-side first) and long tube over column, then thread on locknut. Make sure cup is seated over lip on top of slider.
27. [] Install column back onto stem and secure, tighten locknut until bushing pulls out, then remove slider assembly.
28. [] Loosen locknut completely, slide loose pieces up to locknut, then close adjustable wrench onto flats filed onto column lip. Tap on wrench to drive expander off fat part of column.
29. [] Remove all tools and pieces, leaving stem in vise.
30. [] Repeat steps 19–29 for lower bushing, using short tube instead of long tube in step 26.
31. [] Repeat bushing removal for other leg.

Cleaning and inspection

32. [] Clean all parts with mild detergent and dry with lint-free rag and compressed air. *Avoid using solvents to prevent damage to plastic and rubber parts!*
33. [] Check all O-rings and rubber seals for tears or nicks and replace as needed.
34. [] Inspect stanchion tubes for bends and wear marks.

35. [] Inspect bushings for wear. Cream-colored plastic coating in bushings will be partially missing, exposing metal base material if bushings are worn out.
36. [] Inspect rebound damper shaft for scratches or wear marks.

Bushing and seal installation

The 2000 model installation tool (#85-3911) has several pieces, which are described below with the names that are used in the procedure (pre-2000 tool has fewer pieces and fits fewer models):

- 12" threaded rod – “shaft”
- Three multi-stepped cylinders, each measuring 25.5mm, 28.5mm, or 30mm diameter at second-largest point – “installation mandrills”
- One two-step cylinder – “sizing mandrill”
- Fifteen donut-shaped rings – “sizing donuts”
- A 25.4mm O.D. cylinder, 17mm long – “17mm spacer”
- Two long sleeves, 5–3/8" and 3–5/8" long sleeve respectively – “depth gauges”
- Two 3" long sleeves (one small and one large diameter) – “upper sleeves”
- Two round plates with slot – “slotted plates”
- Knurled steel cylinder with hole in one end – “weight”

The sizing donuts consist of three sets. The 1.003–1.006 set is for Magnum forks only, and is used with the smallest mandrill. The 1.128 through 1.131 set is for all forks with 28.5mm O.D. stanchions and are used only with the medium mandrill. The 1.186 through 1.191 set is for forks with 30.0mm O.D. stanchions, and are used only with the large mandrill. Only two sizing donuts are used at one time, and these should always be consecutive sizes. For example, 1.128 and 1.129 can be used together but 1.128 and 1.130 cannot be used together.

Once the correct set is selected for the model being serviced, always start installation with the smallest pair, which provides the tightest fit to the stanchions. If the fit proves too tight, then use the next larger pair on the mandrill, instead.

37. [] Assemble bushing-installer parts in following order to one end of shaft:
 - nut
 - installation mandrill (large-diameter-end first)
 - smallest sizing donut (of correct set)
 - 17mm spacer
 - second-smallest sizing donut (of correct set)
 - washer
 - nut
38. [] Secure nuts together, with assembly fully at one end of shaft, then install third nut on other end of shaft just until it is fully engaged.

39. [] Place smaller O.D. bushing over sizing donuts and onto mandrill, then place depth gauge (marked-end up) over other end of shaft. Put 3-4 drops of Loctite 680 on bushing.
40. [] Insert assembly into slider, then tap on top of shaft with weight until maximum mark is within 1" of top of slider tube.
41. [] Remove depth gauge and place slotted plate over shaft and against end of slider (flat-face up). *Note: Small slotted plate fits Magnum only.*
42. [] Tighten nut until both sizing donuts pull through bushing, then remove tools.
43. [] Test fit stanchion in bushing and decide whether fit is too tight. If too tight, replace installation mandrill with sizing mandrill, reassemble tool with 3rd then 2nd largest donuts and repeat procedure. When satisfied with fit, reinstall installation mandrill with smaller then larger sizing donuts finally used.
44. [] Place larger O.D. bushing over sizing donuts and onto installation mandrill. Put 3-4 drops of Loctite 680 on bushing.
45. [] Insert assembly into slider, then tap on top of shaft with weight until nut on top of mandrill is only partially above top of slider.
46. [] Place upper sleeve and slotted plate over shaft and against end of slider (flat-face up). *Note: Use smaller-diameter upper sleeve and slotted plate for Magnum model only.*
47. [] Tighten nut until both sizing donuts pull through bushing, then remove tools.
48. [] Tap seals into tops of sliders.

Slider installation

49. [] Install boots onto stanchion tubes.
50. [] Install adjuster rod into rebound damper, making sure threads engage and it is fully threaded in, then install seal nut (threaded-end first) onto rebound-damper shaft.
51. [] Thread rebound damper into left stanchion (right stanchion if 2000 model).
52. [] Install bumper(s) and spacer (if any) that were removed from rebound-damper shaft to just past small hole in side of shaft.
53. [] Insert 1/8" bearing into hole in side of rebound-damper shaft, then pull bushing(s) down until bearing is covered.
54. [] Install top-out bumper onto plunger shaft, then insert 6mm Allen bit on long extension(s) and guide plunger shaft down stanchion and out hole at bottom.
55. [] Install bottom-out bumpers onto shaft.
56. [] Grease stanchion tubes and bushings, then carefully guide slider assembly onto stanchions just until bottoms of shafts contact bottoms of sliders.

38 – SUSPENSION FORKS AND REAR SHOCKS

- 57. [] **Treat bottom bolts with Loctite 242, insert bolts (and bushing, if any) through holes in bottoms of sliders, then thread bolts into shafts.**
- 58. [] **Stabilizing plunger shaft with 6mm bit socket on the extension(s), secure small bolt to 25–30in-lbs.**
- 59. [] **Secure large bottom bolt to 25–30in-lbs with 8mm bit socket.**
- 60. [] **Insert plastic adjuster knob into large bolt.**

Spring and compression-damper installation

- 61. [] **Thoroughly grease spring elastomer and coils, insert spring assembly into side with small bolt at bottom, then secure top caps with wrench flats to 20–30in-lbs (no wrench flats–finger tight).**

Answer Products recommends over ten different oil-level ranges for the forks covered in this section. Many of these recommended ranges overlap, so the following four recommended ranges are all within the manufacturer's recommendations, but may not be as wide a range as the manufacturer's recommendations. Furthermore, the manufacturer cautions strongly against too much or too little oil, and oil level can be difficult to measure, so these more conservative ranges reduce the risk of ending up with an unacceptable oil level.

'00 XVert, '00 XVert DC	80–85mm
'99 XVert TI and all other double-crown XVerts	205–225mm
'98 XVert TI	130–175mm
Other single-crown XVerts except XVert TI, all SX's	95–105mm

- 59. [] **Fill stanchion with 5wt suspension fluid to appropriate level.**
- 60. [] **Carefully insert compression damper, then thread in and secure top caps with wrench flats to 20–30in-lbs (no wrench flats–finger tight).**

TUNING OPTIONS

Compression damping

On some models, compression damping is externally adjustable. There is a clearly-marked adjusting knob on top of the left top cap, if this is the case. It is on the opposite side from the knob marked "preload."

On models that are not externally adjustable, the compression damper may be internally adjustable. The compression damper is the top damper piston. It can be removed without any other fork disassembly. Be careful of overflowing oil that will occur if the damper

is removed too quickly. Once removed, locate the small Allen set screw in the side of the top end of the piston assembly. Tightening the screw increases the damping, and loosening the screw reduces the damping. Use one-turn increment adjustments. If there is no set screw, the model has no compression adjustment.

In some cases, it is possible to disassemble the valving on the compression piston, and in other cases the nut has been permanently bonded. In addition to this complication to customizing the valving, there is the fact that the manufacturer has been very poor at supporting customization with individual valve parts. Add to these problems the fact that understanding and evaluating changes in valving is too esoteric for the vast majority of mechanics, and the practicality of customizing the valving is close to none. If the ability to adjust valving by the means provided by the manufacturer was inadequate, this would be a problem, but the built-in adjustability has a very broad range of performance.

Rebound damping

The rebound damper is the lower damper piston in the left leg. It is externally adjustable by turning the adjuster knob on the bottom of the left leg. Turning the knob clockwise increases the rebound damping, and counterclockwise reduces the damping. The knob moves in 1/6 turn clicks so that it is possible to track the amount of adjustment. From fully clockwise to fully counterclockwise is about 40–42 clicks, or up to seven full turns.

Although it is theoretically possible to disassemble the valving on the rebound damper, the same complications that make it impractical to customize the compression damper apply to the rebound damper.

Spring pre-load adjustment

The spring system has adjustable pre-load. When the knob is turned clockwise the spring is stiffened, and when it is turned counterclockwise the spring is softened. The pre-load adjustment is used to set the desired sag. The manufacturer does not provide recommended sag guidelines, but sag is typically set in a range from 10–20% of total travel.

Spring-tuning kits

Spring-tuning kits are available in a range of spring stiffness. If the fork has inadequate sag when the pre-load is fully loose, or the fork never bottoms under any of the conditions the rider experiences, then a softer spring kit is called for. If the fork has too much sag no matter how much the pre-load is tightened, or bottoms frequently when ridden, then a firmer spring kit is called for.

MARZOCCHI '99-'00 FORKS- COIL & OIL-DAMPER TYPES

ABOUT THIS SECTION

Marzocchi made three basic types of forks during this period. The most basic type is a simple coil spring with non-adjustable oil damping, which is covered in this section. This type is identified by the lack of any slotted rods protruding from the top caps and the lack of air valves (on front or back of top end of slider tubes, or hidden under a plastic cap on top of the stanchion cap). Another type has coil springs, but adjustable oil damping. These are covered in **MARZOCCHI '97-'00 FORKS-COIL & ADJUSTABLE OIL TYPES** (page 38-22). The third type has air springs and oil damping. These are covered in **MARZOCCHI '99-'00 FORKS-AIR SPRUNG TYPES** (page 38-26).

The forks covered in this section include many models (listed below), but have a few minor variations (regarding service techniques). One variation is distinguished by external pre-load adjusting knobs. Another variation is distinguished by pre-load adjusters hidden under rubber caps on top of the stanchion top caps. The models and the type of pre-load adjuster used are:

Year and model	Pre-load adjuster
'00 Z3 BAM 80	external
'99 & '00 Z1 Dropoff	external
'00 Z3 QR 20	external
'99 & '00 Jr T & Jr T QR 20	external
'99 Z3 Light, Z3 Long Travel	external
'99 Z4 Alloy	hidden
'00 Z3.5 & Z3 M80	hidden
'00 Z5 QR 20 Spring	hidden

Some of the models, regardless of the pre-load adjuster type, have removable stanchions, and some have stanchions permanently fixed in the fork crown. The presence of two bolts in the crown at the top of each stanchion indicates the stanchions are removable. Some models have one additional difference. Most of the other models have a stanchion top cap that threads into the stanchion, but a few models have a top cap that inserts into the stanchion and is retained by an internal circlip.

All of these variations are covered in the following procedure. It can be difficult to correctly identify the year and model of fork being worked on, but when there are variations and alternate procedures are provided, by reading all the alternate pro-

cedures and examining the features on the fork, it should be possible to determine which alternate procedure is appropriate.

TOOLS

Marzocchi makes two tools for servicing this fork, specifically for bushing and seal removal and installation. These are the Slider Protector #536003AB and the Seal Press #R5068. In addition, two sizes of sockets are needed for the top caps. Due to the low profile of the wrench flats on the top caps, it is necessary to custom grind the ends of the sockets to eliminate any internal bevel. The socket sizes are 21mm and 26mm.

RockShox Dropout Vise Blocks #70107 are very useful for securing the sliders in the vise with minimal chance of cosmetic or structural damage. The dropout vise blocks only work on models that fit a standard quick-release hub. An alternative is to put a dummy axle set into the dropouts, clamp the axle set directly into the vise jaws, then attach the fork to the axle set. One more alternative is to use a fork mount such as those used for securing a bike in the bed of a pickup truck.

FULL FORK SERVICE

Top-cap and spring removal

- [] Remove brake calipers and cable system from fork.
- [] **External pre-load models:** Counting number of turns, turn pre-load adjuster knobs fully in “-” direction and record number of turns here: right _____ left _____
Hidden pre-load models: Remove rubber cap (if any), or unthread cap with 4mm Allen fitting from stanchion cap, then use 4mm Allen to turn pre-load adjuster. Counting number of turns, turn pre-load adjuster fully counterclockwise (until it reaches top of stanchion cap) and record number of turns here: right _____ left _____
- [] **All external pre-load models except '00 Z3 BAM 80:** Remove circlips from grooves in stanchion caps (just above top of fork crown).
- [] **Models with removable stanchions:** Remove crown bolts, then remove stanchions from crown.
- [] **'00 Z5 only:** Depress top cap slightly, then remove internal snap-ring. **Caution—spring may eject top cap suddenly. Do not stand directly over stanchion!**

38 – SUSPENSION FORKS AND REAR SHOCKS

6. [] *If stanchions have been removed and top caps are still in place:* Clamp stanchion tube in bike-stand clamp, then unthread stanchion cap from stanchion.
All others: Unthread stanchion caps.
7. [] Remove aluminum sleeves (if any), washers, and springs from inside of stanchions.
8. [] Carefully drain old oil into waste receptacles, pumping stanchions to drain out oil.

Slider and plunger removal

9. [] Place RockShox dropout vise blocks on dropout, and secure in vise so that access hole on bottom of slider is accessible.
10. [] Use 15mm socket on extension to break loose bolt inside access hole in bottom of slider.
11. [] While pulling continuously on stanchion, continue to loosen 15mm bolt until stanchion separates from slider.
12. [] Remove bolt from bottom of slider.
13. [] Repeat previous three steps for other side.
14. [] Remove aluminum caps from bottoms of plunger rods (caps may have fallen off inside stanchions).
15. [] Remove snap-rings from bottoms of stanchions, then pull out plunger-rod assemblies.
16. [] Remove valve sleeves, plastic washers, stop rings, and top-out springs from shafts.
17. [] Remove split rings from piston heads on plunger rods.

NOTE: Do not proceed with further disassembly unless inspection or symptoms have indicated need for seal replacement or bushing replacement. If either item is removed, it must be replaced with a new one.

Seal and bushing removal

18. [] If necessary, re-clamp slider in dropout vise blocks so top end of slider is accessible.
19. [] Pry out dust seals, then use screwdriver or seal pick to pry out triple-dip clip that retains seal in slider.
20. [] Place slider protector over top of slider, and use large flat screwdriver to pry out seal (be careful not to get screwdriver under washer that is just below seal, pry as though you were trying to lift seal through slot in protector).
21. [] Lift large washer out of slider.
22. [] Using seal pick with 90° bend, lift bushing out by catching tip of seal pick under lip of bushing at slot in bushing.

Cleaning and inspection

23. [] Using mild detergent, thoroughly clean and dry all parts, making sure there is no cleanser or lint left on parts.
24. [] Inspect all O-rings for nicks and tears.

Bushing and seal installation

NOTE: If bushings and seals were not removed, skip to step 32.

25. [] With slider clamped upright in dropout vise blocks, carefully slide thoroughly-oiled bushing into slider so that slot in bushing ends up on side of slider.
26. [] Place large steel washer over bushing
27. [] Place thoroughly greased seal (lip side up) onto seal installer then tap seal into slider until bottomed.
28. [] Place triple-dip clip into slot above seal.
29. [] Check carefully that triple-dip clip is fully seated in groove inside slider.
30. [] Repeat steps 25–29 for other side.
31. [] Place dust seal(s) onto seal installer and install into slider(s).

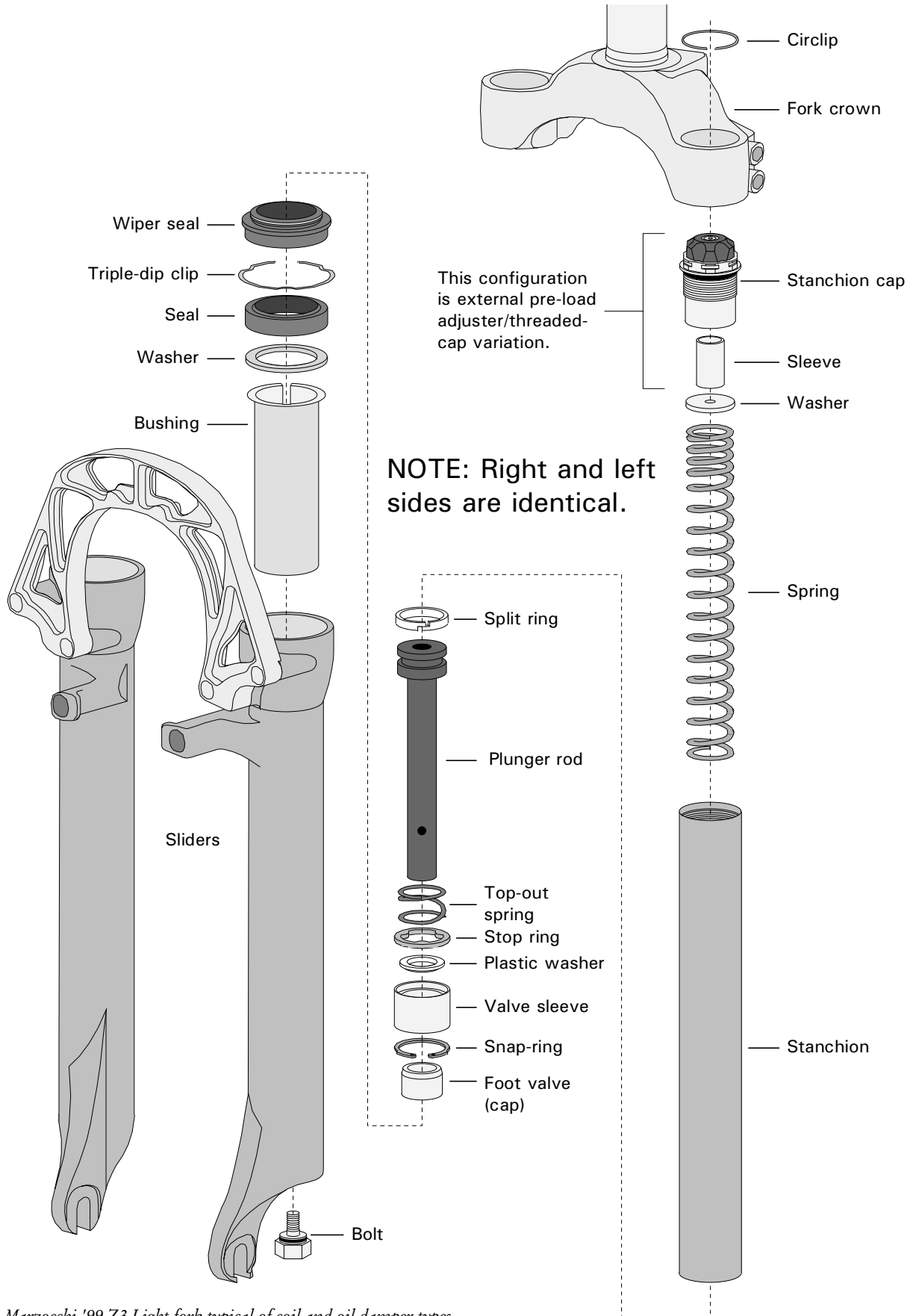
Plunger and slider installation

32. [] Install split rings into grooves in piston heads on top ends of plunger rods.
33. [] Install onto plunger rods in order: short top-out springs, metal stop plate (with three tabs on inner perimeter), plastic washer (lip-face first), then valve sleeve (cupped-face first).
34. [] Insert plunger assemblies into stanchions, install snap-rings into stanchions (sharp-edged-faces out), then install aluminum caps onto ends of shafts.
35. [] Insert 15mm-head bolt in socket, and check whether any portion of bolt more than the wrench flats is inside socket. If too much bolt is in socket, wad some tissue paper to fill socket until no more than wrench flats are in socket.
36. [] Clamp slider in dropout vise blocks so that slider is upright and hole on bottom of slider is accessible to 15mm socket on extension.
37. [] Use socket on extension to hold bolt in access hole on bottom of slider in place.
38. [] Install stanchions into sliders.
39. [] Using foot-long 7/8" dowel or similar device, exert downward pressure on plunger unit while turning extension to engage 15mm bolt. Maintaining downward pressure on plunger unit, tighten nut to 80in-lbs.
40. [] Repeat steps 36–39 for other side.

Oil, spring, and top-cap installation

41. [] Pull stanchions fully up.

38 – SUSPENSION FORKS AND REAR SHOCKS



38.9 Marzocchi '99 Z3 Light fork typical of coil and oil-damper types.

38 – SUSPENSION FORKS AND REAR SHOCKS

42. [] Fill each stanchion with recommended amount 7.5wt non-foaming oil.

Model	Volume
'99 Z3 Light & Z3 Long Travel	65cc
'99 Z4 model	65cc
'99 Z3 M80& '00 Z3 BAM 80	85cc
'00 Z3.5 & Z1 Dropoff 100mm	90cc
'00 Z1 Dropoff 130mm, Z3 OR 20	95cc
'99 Z1 Dropoff	100cc
'00 Z5 QR 20 Spring	100cc
'99 Jr T	160cc
'00 Jr T's	175cc

43. [] Place long compression springs into stanchions, then place aluminum washers and sleeves on top of springs.

44. [] *Models with unthreaded stanchion caps:* Insert top cap until groove for snap-ring is exposed, then insert snap-ring (sharp-edged-face up).

Models with threaded stanchion caps: Hand thread stanchion caps fully into stanchions until cap lips contact tops of stanchions.

45. [] *Models with removable stanchions:* Secure each stanchion into bike-stand clamp, and secure each stanchion cap to 105in-lbs.

NOTE: When tightening a pair of clamp bolts, always go back and forth between bolts until both are stationary at the recommended torque!

46. [] *Models with removable stanchions:* Insert stanchions into fork crown fully, then secure stanchion clamp bolts to 70in-lbs.

47. [] *'00 Z3 BAM 80 only:* Secure stanchion caps to 105in-lbs.

48. [] *Models with external pre-load adjuster:* Engage circlips in grooves in stanchion caps.

49. [] *Models with external pre-load adjuster:* Turn pre-load adjuster rings fully in “–” direction, then back number of turns indicated in step 2. *Models with hidden pre-load adjuster:* Turn pre-load adjuster rings fully counterclockwise, then clockwise number of turns indicated in step 2. Install covers over pre-load adjusters.

50. [] Re-attach brake system and install wheel.

51. [] Check torque on crown bolts at base of fork column. Recommended torque is 70in-lbs.

Sag guidelines are not provided by the manufacturer, but when the rider sits stationary on the bike, the fork should compress about 10–20% of its total travel. More sag improves comfort, and less sag suits high-performance or competitive riding.

On the models with external pre-load adjusting knobs, the knobs are turned fully counterclockwise (except '98 models) to maximize sag, and fully clockwise to minimize sag. On the models with hidden pre-load adjusters, a rubber cap must be pried out, or an aluminum cap threaded out, then the adjuster is turned with a 4mm Allen wrench. The direction of adjustment is the same on the external and hidden adjusters.

Damping adjustments

These forks do not have adjustable damping. The non-adjustable oil dampers are rebound dampers only. The only way to change the rebound damping response is by changing the oil weight. As always, using a heavier-weight oil increases damping, and a lighter-weight oil reduces damping. The standard weight for these forks is 7.5wt. The design of the damping units makes it critical that a non-foaming suspension fluid is used.

MARZOCCHI '97-'00 FORKS- COIL & ADJUSTABLE OIL TYPES

Marzocchi made three basic types of forks during this period. The most basic type is a simple coil spring with non-adjustable oil damping, which is covered in **MARZOCCHI '99-'00 FORKS-COIL & OIL-DAMPER TYPES** (page 38-19). Another type, covered in this section, has coil springs but adjustable oil damping. One or two slotted rods protruding out the top caps identifies a fork as belonging to this type (except Mr. T, which can be identified by decals). The third type has air springs and oil damping. These are covered in **MARZOCCHI '99-'00 FORKS-AIR SPRUNG TYPES** (page 38-26).

The forks covered in this section include many models (listed below), but have a few minor variations (regarding service techniques). One variety has two adjustable oil dampers. These have two slotted rods protruding from the top caps. Another variety has one adjustable oil damper. This variety has one slotted rod protruding from the top caps.

TUNING OPTIONS

Spring pre-load

The pre-load on the springs is adjustable. Pre-load should be adjusted to achieve the desired amount of sag. Pre-load in both legs should be adjusted equally.

Year and model	Adjustable dampers
'97-'98 Z2	one
'99 Z2 Alloy, Atom Bomb	one
'99 Z2 BAM	one
'00 Z2 Atom 80	one
'97-'98 Z1 & Mr. T	two
'99 Z1 Alloy & Z1 BAM	two
'99 Z1 QR20	two
'99 Z1 Dual Slalom	two
'99-'00 Mr. T	two
'99-'00 Monster T	two
'00 Z1 CR & Z1 QR 20	two

All of the models above, except the '00 Z2 Atom 80, have removable stanchions. The presence of two bolts in the crown at the top of each stanchion indicates the stanchions are removable. The Mr. T and Monster T models are similar to the other models covered in the following procedure, but have enough differences that the following procedures can only be used as a general guideline. Covering the variations for the Mr. T and Monster would make the following procedure too complex.

The one or two adjustable damper varieties and the removable or non-removable stanchion varieties are covered in the following procedure. It can be difficult to correctly identify the year and model of fork being worked on, but when there are variations and alternate procedures are provided, by reading all the alternate procedures and examining the features on the fork, it should be possible to determine which alternate procedure is appropriate.

TOOLS

Marzocchi makes two tools for servicing these forks, specifically for bushing and seal removal and installation. These are the Slider Protector #536003AB and the Seal Press #R5068. In addition, two sizes of sockets are needed for the top caps. Due to the low profile of the wrench flats on the top caps, it is necessary to custom grind the ends of the sockets to eliminate any internal bevel. The socket sizes are 21mm and 26mm.

RockShox Dropout Vise Blocks #70107 are very useful for securing the sliders in the vise with minimal chance of cosmetic or structural damage. The dropout vise blocks only work on models that fit a standard quick-release hub. An alternative is to put a dummy axle set into the dropouts, clamp the axle set directly into the vise jaws, then attach the fork to the axle set. One more alternative is to use a fork mount such as those used for securing a bike in the bed of a pickup truck.

FULL FORK SERVICE

Top-cap and spring removal

- [] Remove brake calipers and cable system from fork.
- [] Counting number of turns, turn pre-load adjuster rings fully counterclockwise and record number of turns here:
right _____ left _____
- [] Counting number of turns, turn rebound damping adjuster fully in “-” direction and record number of turns here: _____
- [] *Removable stanchion models only:* Remove circlips from grooves in stanchion caps (just above top of fork crown).
- [] *Removable stanchion models only:* Remove crown bolts, then remove stanchions from crown.
- [] Use 1.5mm Allen wrench to loosen set screws in perimeters of pre-load adjuster rings, and pull rings off.
- [] Carefully remove e-clips from studs on top of stanchion caps.
- [] *'00 Z2 Atom 80 only:* Use socket to unthread stanchion caps.
- [] All except *'00 Z2 Atom 80:* Clamp stanchion tube in bike-stand clamp, then unthread stanchion cap from stanchion. (Single-damper models only: on left side, stanchion cap assembly comes out all at once – push stud out of cap. Single damper right side and both sides of double damper models: cap will come out alone, leaving adjuster rod in place.)
- [] Unthread pre-load adjusting cylinders clockwise off tops of studs.
- [] Push stanchions down, then remove plastic washers and springs from inside of stanchions.

Slider and plunger removal

- [] Carefully drain old oil into waste receptacles, pumping stanchions and damping adjuster rod as necessary to drain out oil.
- [] Place RockShox dropout vise blocks on dropout, and secure in vise so that access hole on bottom of slider is accessible.
- [] Use 15mm socket on extension to break loose nut inside access hole in bottom of slider.
- [] While pulling continuously on stanchion, continue to loosen 15mm nut until stanchion separates from slider. (Right side, damper and top-out spring are free to fall out; left side, plunger and top-out spring are free to fall out.)
- [] Repeat previous two steps for other side.

38 – SUSPENSION FORKS AND REAR SHOCKS

Seal and bushing removal

NOTE: Do not proceed with further disassembly unless inspection or symptoms have indicated need for seal replacement or bushing replacement. If either item is removed, it must be replaced with a new one.

17. [] If necessary, re-clamp slider in dropout vise blocks so top end of slider is accessible.
18. [] Pry out dust seals, then use screwdriver or seal pick to pry out triple-dip clip that retains seal in slider.
19. [] Place slider protector over top of slider, and use large flat screwdriver to pry out seal (be careful not to get screwdriver under washer that is just below seal, pry as though you were trying to lift seal through slot in protector).
20. [] Lift large washer out of slider.
21. [] Using seal pick with 90° bend, lift bushing out by catching tip of seal pick under lip of bushing at slot in bushing.

Cleaning and inspection

22. [] Using mild detergent, thoroughly clean and dry all parts, making sure there is no cleanser or lint left on parts.
23. [] Inspect all O-rings for nicks and tears.

Bushing and seal installation

NOTE: If bushing and seal were not removed, skip to step 30.

24. [] With slider clamped upright in dropout vise blocks, carefully slide thoroughly-oiled bushing into slider so that slot in bushing ends up on side of slider.
25. [] Place large steel washer over bushing.
26. [] Place thoroughly greased seal (lip-side up) onto seal installer and tap seal into slider until bottomed.
27. [] Place triple-dip clip into slot above seal.
28. [] Check carefully that triple-dip clip is fully seated in groove inside slider.
29. [] Repeat steps 24–28 for other side.
30. [] Place dust seal(s) onto seal installer and install into slider(s).

Plunger and slider installation

31. [] Install stanchions (threaded-ends up) into sliders.
32. [] Install short top-out springs into stanchions.
33. [] Clamp slider in dropout vise blocks so that slider is upright and hole on bottom of slider is accessible to 15mm socket on extension.

34. [] Use socket on extension to hold nut in access hole on bottom of slider in place, then drop plunger (left side of single-damped models) or damper unit (all others) into stanchion so coarse-threaded stud (of either) is pointing down. **Note:** Double-cartridge '00 models have different left and right cartridges. Cartridge with multiple holes at bottom end of cylinder is left-hand cartridge.
35. [] **Side without adjustable damper:** Using foot-long 7/8" dowel or similar device, exert downward pressure on plunger unit while turning extension to engage 15mm nut. Maintaining downward pressure on plunger unit, tighten nut to 105in-lbs.
Side(s) with adjustable damper: Maintaining downward pressure on adjuster rod, tighten nut to 105in-lbs.
36. [] Repeat steps 33–35 for other side.

Oil, spring, and top-cap installation

37. [] Pull stanchions up fully, then fill each stanchion with appropriate amount of 7.5wt oil:

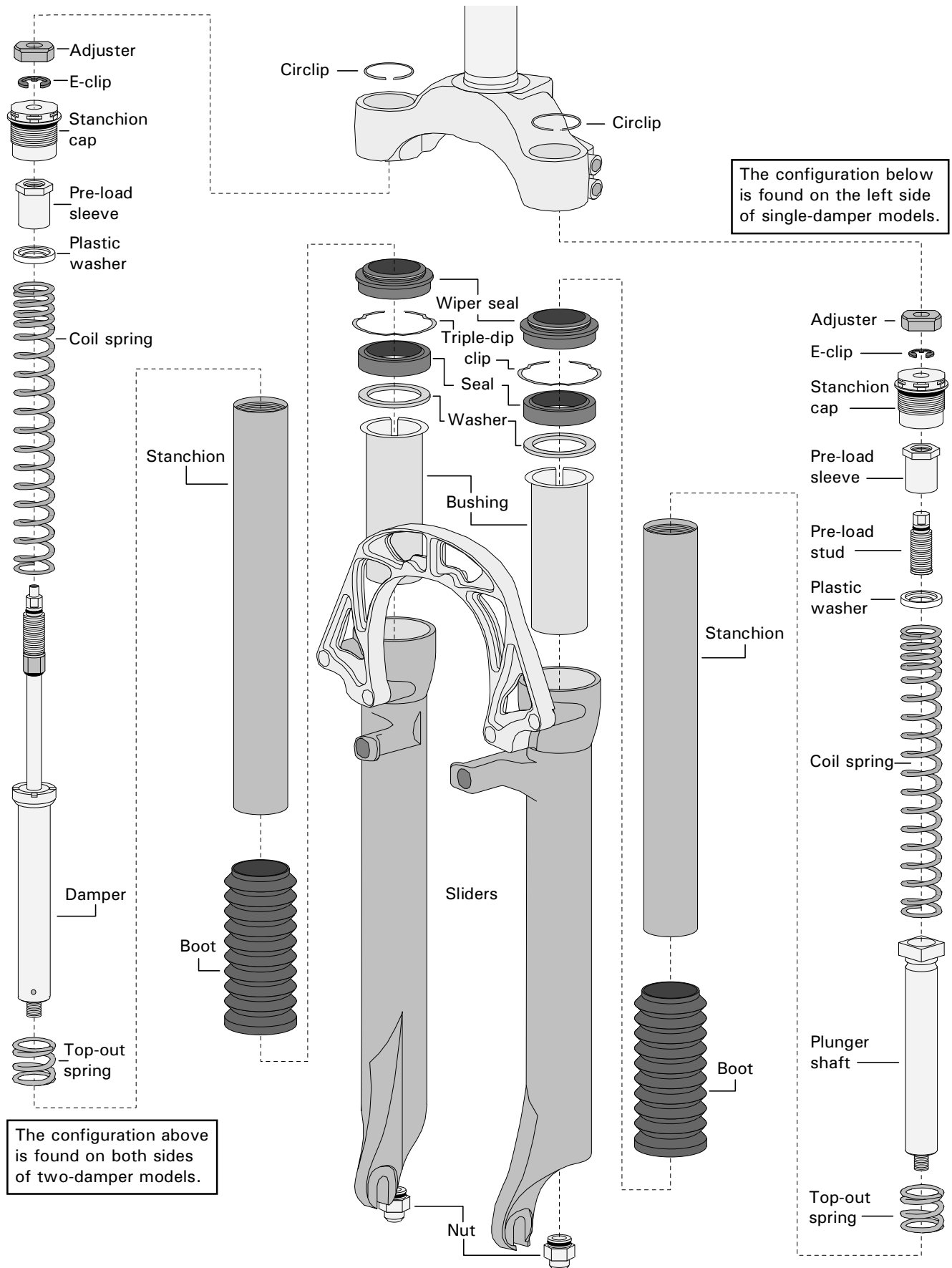
Model	Volume Lt./Rt.
'97-'98 Z2	85/75cc
'99 Z2 Atom Bomb & Z2 Alloy	85/75cc
'99 Z2 BAM & '00 Atom 80	100/900cc
'97-'98 Z1 & Mr. T	90/90cc
'99 Z1 Alloy	96/96cc
'99 Z1 BAM & Z1 Dual Slalom	100/100cc
'99-'00 Z1 QR 20	100/100cc
'99 Mr. T	160/160cc
'00 Mr. T QR 20	170/170cc
'99-'00 Monster T	380/380cc

38. [] Push stanchions down, then carefully pump damper-unit rod(s) up and down repeatedly to pump air out, and oil into, damper.
39. [] Place long compression springs into stanchions, then place plastic washers (cavity-face up) on top of springs.

NOTE: In the next four steps, the right-side version of each step is done at the fork assembly, but the left-side version is done with parts that are not yet part of the fork assembly. The left-side versions only apply to single-adjustable damper models. Double adjustable models use right-side versions on both sides.

40. [] Thread pre-load adjuster cylinder (round-end first) onto stud that goes through stanchion cap, until four threads are exposed beyond hex-end of cylinder.
41. [] Slide stanchion cap(s) onto pre-load adjuster cylinders until caps snap into place and expose e-clip slot on stud (above top of cap).
42. [] Put e-clips into slots in studs.

38 – SUSPENSION FORKS AND REAR SHOCKS



38.10 Marzocchi '99 Z2 fork typical of coil and adjustable-oil types.

38 – SUSPENSION FORKS AND REAR SHOCKS

- 43. [] Place pre-load adjuster rings on flats of stud, then secure setscrews with 1.5mm Allen.
- 44. [] Pull stanchions up, then hand thread stanchion caps fully into stanchions until cap lips contact tops of stanchions.
- 45. [] *All except '00 Z2 Atom 80:* Secure each stanchion into bike-stand clamp, and secure each stanchion cap to 105in-lbs.
Only '00 Z2 Atom 80: Secure each stanchion cap to 105in-lbs.
- 46. [] Slide boots (if any) over stanchions and engage boots to lips on dust seals.

Stanchion installation and final setup

NOTE: When tightening a pair of clamp bolts, always go back and forth between bolts until both are stationary at the recommended torque!

- 47. [] *All except '00 Z2 Atom 80:* Insert stanchions into fork crown fully, then secure stanchion clamp bolts to 70in-lbs.
- 48. [] *All except '00 Z2 Atom 80:* Engage circlips in grooves in stanchion caps.
- 49. [] Re-attach brake system and install wheel.
- 50. [] Turn pre-load adjuster rings fully counter-clockwise, then clockwise number of turns indicated in step 2.
- 51. [] Turn rebound damper adjuster fully counter-clockwise, then clockwise number of turns indicated in step 3.
- 52. [] Check torque on crown bolts at base of fork column. Recommended torque is 70in-lbs.

TUNING OPTIONS

Spring pre-load adjustment

The pre-load on the springs is adjustable. Pre-load should be adjusted to achieve the desired amount of sag. Pre-load in both legs should be adjusted equally. The manufacturer does not provide sag guidelines, but when the rider sits stationary on the bike, the fork should compress about 10–20% of its total travel. More sag improves comfort, and less sag suits high-performance or competitive riding.

On the models with external pre-load adjusting knobs, the knobs are turned fully in the “–” direction to maximize sag, and fully the opposite way to minimize sag. On the models with hidden pre-load adjusters, a rubber cap must be pried out, or an aluminum cap threaded out, then the adjuster is turned with a 4mm Allen wrench. The direction of adjustment is the same on the external and hidden adjusters.

Damping adjustments

Depending on the model year, these forks have different degrees of adjustable damping.

With 1997 and 1998 models, single and dual adjustable cartridge models are both adjustable for rebound damping by turning the adjuster rod(s). Clockwise increases rebound damping. The only way to change compression damping is by changing oil weight. The stock oil is 7.5wt non-foaming oil. Changing the oil weight also changes the potential amount of rebound damping.

With 1999 models, single and dual adjustable cartridge models are adjustable for compression and rebound by turning the adjusting rod(s). Clockwise adjustments increase rebound and compression damping simultaneously.

With 2000 models, single adjustable cartridge models are adjustable for rebound only. Compression damping can only be changed by changing oil weight, which also affects the potential amount of rebound damping. For this model year only, dual adjustable cartridge models have compression damping adjustment in the left cartridge and rebound damping adjustment in the right cartridge. Turning either adjuster clockwise increases the damping.

MARZOCCHI '99–'00 FORKS-AIR-SPRUNG TYPES

Marzocchi made three basic types of forks during this period. The most basic type is a simple coil spring with non-adjustable oil damping, which is covered in **MARZOCCHI '99–'00 FORKS-COIL & OIL-DAMPER TYPES** (page 38-19). Another type has coil springs but adjustable oil damping. One or two slotted rods protruding out the top caps identifies a fork as belonging to this type. These are covered in **MARZOCCHI '97–'00 FORKS-COIL & ADJUSTABLE OIL TYPES** (page 38-22). The third type, covered in this section, has air springs and oil damping. For identification purposes, look for a standard air valve in one of three locations: on the front of the slider adjacent to the brake-pivot stud, on the back of the fork directly behind the brake-pivot stud, or under a three-pronged cap in the top cap on each stanchion.

The forks covered in this section include many models (listed below), but have a few minor variations (regarding service techniques). One variety has adjustable oil dampers. These have the air valve on the front

or back of the sliders. The other variety has non-adjustable oil dampers. This variety has the air valves inside the top caps.

Year and model	Adjustable dampers
'99 Z5 Alloy	no
'99 Z2 Superfly	yes
'00 Z5 QR 20	no
'00 Z5 Flylight Air	no
'00 Z5 Flylight 100	no
'00 Z4 Flylight Air	no
'00 Z2 X Fly QR 20	yes
'00 Z2 X Fly	yes
'00 Z1 X Fly	yes

Several of these models, have removable stanchions. The presence of two bolts in the crown at the top of each stanchion indicates the stanchions are removable. Other models have stanchions that are an integral part of the fork crown. These differences in stanchion configuration occur with no correlation to other differences. Additionally, some of the models have stanchion caps that thread in, and others are threadless and retained by a snap-ring. When alternate procedures exist for all these variations, the following terms will be used:

Adjustable and non-adjustable dampers

Integral and non-integral stanchions

Threaded and unthreaded stanchion caps

Front, back, and top air valves

All varieties are covered in the following procedure. It can be difficult to correctly identify the year and model of fork being worked on, but when there are variations and alternate procedures are provided, by reading all the alternate procedures and examining the features on the fork, it should be possible to determine which alternate procedure is appropriate.

TOOLS

Marzocchi makes five tools for servicing these forks, two of which are specifically for bushing and seal removal and installation. These are the Slider Protector #536003AB and the Seal Press #R5068. The third Marzocchi tool is a Seal Guide #R5082CD, which is used in servicing the adjustable-damper models. The fourth tool, pump #R4002, is essential for inflating models with front or top air valves. The fifth tool, Stanchion Cap Puller #R5008BZ, is used to remove unthreaded stanchion caps.

In addition, two sizes of sockets are needed for the top caps. Due to the low profile of the wrench flats on the top caps, it is necessary to custom grind the ends of the sockets to eliminate any internal bevel. The socket sizes are 21mm and 26mm.

RockShox Dropout Vise Blocks #70107 are very useful for securing the sliders in the vise with minimal chance of cosmetic or structural damage. The dropout vise blocks only work on models that fit a standard quick-release hub. An alternative is to put a dummy axle set into the dropouts, clamp the axle set directly into the vise jaws, then attach the fork to the axle set. One more alternative is to use a fork mount such as those used for securing a bike in the bed of a pickup truck.

FULL FORK SERVICE

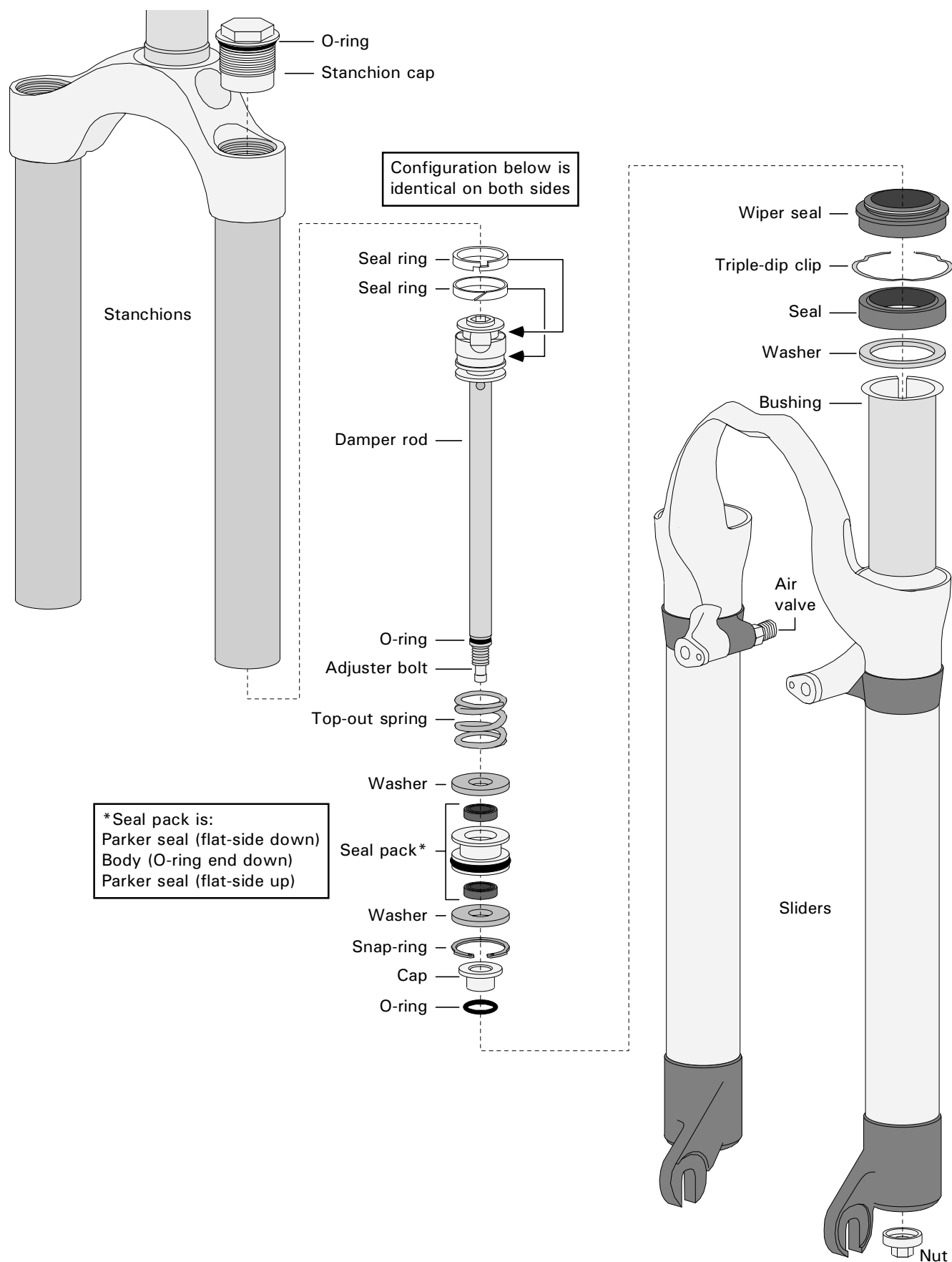
Top-cap and oil removal

- [] Remove brake calipers and cable system from fork.
- [] Find and uncap air valves. Deflate fork completely.
- [] **Removable stanchion models with threaded stanchion caps:** Remove circlips from stanchion caps, unthread crown bolts, remove stanchions from crown, then clamp each stanchion in bike-stand clamp to hold while unthreading stanchion caps with custom 26mm socket.
Removable stanchion models with unthreaded stanchion caps: Depress stanchion caps several millimeters, pry out circlips from stanchions, thread cap puller onto valve threads, then pull on tool to remove cap(s).
Integral stanchion models: Use custom 21mm socket to unthread stanchion caps from stanchions.
- [] Carefully drain old oil into waste receptacles, pumping stanchions to drain out oil.

Slider and damper removal

- [] **Adjustable-damper models:** Find 2.5mm Allen fitting inside 10mm nut in bottom end of sliders, then turn fully counterclockwise, counting turns:
_____ turns counterclockwise on right
_____ turns counterclockwise on left
- [] **'99 Z5 Alloy only:** Use 17mm socket on extension to break loose bolts inside access hole in bottom of slider.
Adjustable-damper models: Use 10mm socket on extension to break loose nuts inside access hole in bottom of slider.
Non-adjustable-damper models: Use 15mm socket on extension to break loose nuts inside access hole in bottom of slider.
- [] While pulling continuously on slider, continue to loosen nuts or bolts until sliders separate from stanchions.

38 – SUSPENSION FORKS AND REAR SHOCKS



38.11 Marzocchi '00 Z2 X-Fly fork typical of air-sprung types.

8. [] *Adjustable-damper models:* Remove caps from ends of plunger rods. If caps are not on rods, push rods from below out tops of sliders.
Non-adjustable-damper models: Remove foot valves from ends of plunger rods.
9. [] *Adjustable-damper models only:* Inspect caps for external O-rings. If O-rings are missing, inspect inside sliders and remove O-rings.
10. [] *Adjustable-damper models:* Remove snap-rings from bottoms of stanchions, then carefully pull out plunger-rod assemblies.
Non-adjustable-damper models: Remove damper assemblies from tops of stanchions.
11. [] *Adjustable-damper models:* Remove washer, seal pack, washer, then top-out springs from shafts.
Non-adjustable-damper models: Remove top-out springs from bottoms of shafts.
12. [] Remove split rings from piston heads on plunger shafts.

Seal and bushing removal

NOTE: Do not proceed with further disassembly unless inspection or symptoms have indicated need for seal replacement or bushing replacement. If either item is removed, it must be replaced with a new one.

13. [] Clamp slider in RockShox dropout vise blocks so top end of slider is accessible.
14. [] Pry out dust seals, then use screwdriver or seal pick to pry out triple-dip clip that retains seal in slider.
15. [] Place slider protector over top of slider, and use large flat screwdriver to pry out seal (be careful not to get screwdriver under washer that is just below seal, pry as though you were trying to lift seal through slot in protector).
16. [] Lift large washer out of slider.
17. [] Using seal pick with 90° bend, lift bushing out by catching tip of seal pick under lip of bushing at slot in bushing.

Cleaning and inspection

18. [] Using mild detergent, thoroughly clean and dry all parts, making sure there is no cleanser or lint left on parts.
19. [] Inspect all O-rings and seals for nicks and tears.
20. [] If air pressure has been leaking, remove and replace seals in seal pack and O-rings on top caps and air valves.

Bushing and seal installation

NOTE: If bushings and seals were not removed, skip to step 29.

21. [] Grease all O-rings, seals, and plastic split rings.

22. [] With slider clamped upright in dropout vise blocks, carefully slide thoroughly-oiled bushing into slider so that slot in bushing ends up on side of slider.
23. [] Place large steel washer over bushing.
24. [] Place thoroughly greased seal (lip side up) onto seal installer then tap seal into slider until bottomed.
25. [] Place triple-dip clip into slot above seal.
26. [] Check carefully that triple-dip clip is fully seated in groove inside slider.
27. [] Repeat steps 22–26 for other side.
28. [] Place dust seal(s) onto seal installer and install into slider(s).

Damper assembly and installation

29. [] *Adjustable-damper models only:* With 3mm Allen wrench engaged to head of adjuster rod (through top of piston), use 2.5mm Allen wrench to check that bolt on bottom end of adjuster rod is secure. If not, remove bolt and reinstall with Loctite 242.
30. [] Install split rings into grooves in piston heads on top ends of plunger rods. *Note:* On adjustable-damper models, stepped-split ring goes in top groove and diagonal-split ring goes in next groove.
31. [] *Adjustable-damper models:* Install onto plunger rods in order: short top-out springs, washer, seal-guide tool #R5028CD, seal pack (O-ring-end last), then second washer. Remove seal-guide tool.
Non-adjustable-damper models: Install top-out springs onto bottoms of shafts.
32. [] *Adjustable-damper models:* Insert plunger assemblies into stanchions, then install snap-rings into stanchions (sharp-edged-face out).
Non-adjustable-damper models: Install damper shafts through tops of stanchions, then install foot valves on ends of shafts.
33. [] *Adjustable-damper models only:* Install caps onto shafts, then install O-rings onto caps.

Slider installation

34. [] Install boots (if any) onto stanchions, then carefully push slider assembly onto stanchions only 2-3".
35. [] *Adjustable-damper models:* Turn fork upside down, then inject 7cc of 7.5wt oil into each hole in bottoms of sliders, then push slider assembly further onto stanchions until shafts protrude from holes.
Non-adjustable damper models: Turn fork upside down, then push sliders on until ends of shaft assemblies contact ends of sliders.

38 – SUSPENSION FORKS AND REAR SHOCKS

36. [] *Adjustable-damper models:* Use dowel or similar tool through tops of stanchions to seat shaft assemblies fully, insert 10mm nut in socket on extension, then engage nut to shaft protruding from hole in bottom of slider. Repeat for other side.

Non-adjustable damper models: Use dowel or similar tool through tops of stanchions to maintain pressure on tops of damper assemblies, then place nut/bolt in socket on extension and engage nut/bolt to ends of shafts.

37. [] *Adjustable-damper models:* Torque 10mm nuts to 105in-lbs. If necessary, use 8mm bit socket on extension from top of stanchion to keep shaft(s) from turning.

'99 Z5 Alloy only: Torque 17mm bolts to 80in-lbs. If necessary, use dowel through top of stanchion to keep shaft(s) from turning.

Non-adjustable-damper models: Torque 15mm nuts to 105in-lbs. If necessary, use dowel through top of stanchion to keep shaft(s) from turning.

Oil filling and final setup

38. [] *Adjustable-damper models only:* Use 2.5mm Allen wrench to loosen adjuster in bottom of each slider fully counterclockwise.

39. [] Turn fork over, push sliders fully down, then fill each stanchion with an appropriate volume of 7.5wt non-foaming oil.

Model	Volume
'99 Z2 Superfly	50cc
'99 Z5 Alloy	65cc
'00 Z2 X Fly & X Fly QR 20	60cc
'00 Z1 X Fly	75cc
'00 Z4 Flylight Air	85cc
'00 Z3 Flylight 100	100cc
'00 Z5 QR 20 & Z5 Flylight Air	110cc

40. [] *Threaded stanchion-cap models:* If non-integral stanchions, clamp stanchion(s) into bike-stand clamp. All: Thread in stanchion caps and secure to 105in-lbs.

Unthreaded stanchion-cap models: Press stanchion caps in until several millimeters below circlip grooves inside stanchions, seat circlips into grooves, then use cap puller to pull stanchion caps up to circlips.

41. [] Use pump to pressurize each leg to 35–45psi (factory standard). Install valve caps.
42. [] *Adjustable-damper models only:* Restore damping adjuster settings recorded in step 5.

NOTE: When tightening a pair of clamp bolts, always go back and forth between bolts until both are stationary at the recommended torque!

43. [] *Non-integral stanchion models:* Secure stanchion-clamp bolts to 70in-lbs.

44. [] Check for clamp bolts at base of fork column. Secure to 70in-lbs if two-bolt type.

TUNING OPTIONS

Sag adjustment

These forks have air springs, and sag is adjusted by changing the air pressure. Depending on the model, the factory standard pressure is 35–45psi. There is no factory guidelines for desired sag, so use a general guideline of pressurizing the fork so that the sag is 10–20% of the total travel. More sag creates higher comfort, and less sag creates higher performance for competitive riding.

Damping adjustments, adjustable models

A 2.5mm Allen wrench is inserted into a fitting accessed through the bottom of the slider. Clockwise adjustment increases rebound damping. The only way to change compression damping is by changing oil weight. The stock oil is 7.5wt non-foaming oil. Changing the oil weight also changes the potential amount of rebound damping.

Non-adjustable models damping models

These forks do not have adjustable damping. The non-adjustable oil dampers are rebound dampers only. The only way to change the rebound damping response is by changing the oil weight. As always, using heavier-weight oil increases damping, and lighter-weight oil reduces damping. The standard weight for these forks is 7.5wt. The design of the damping units makes it critical that a non-foaming suspension fluid is used.

RISSE ASTRO-5 REAR SHOCK

ABOUT THIS SECTION

This section is specifically about the Risse Astro-5 rear shock. It is similar to the earlier Genesis models, with the exception of an external hydraulic damper that has been added.

TOOLS

Four specialized Risse tools are required:

Combo Bearing Wrench	#20621
1-1/8" Shaft Clamp	#20224
1-1/8" Bullet Tool	#20355
1-1/8" Blowout Body	#20659

FULL SHOCK SERVICE

Shock removal

1. [] Use Schrader-valve pressure gauge to record pressure in shock: ____ psi.
2. [] Depress plunger in valve, put weight on bike to fully compress shock, then release valve plunger.
3. [] Remove shafts through body eyelet and shaft eyelet, then remove shock.

Shaft removal

4. [] Place 5/16" steel rod horizontally in vise, then place body eyelet on rod.
5. [] Orient shock so that shaft points up, then use Combo Bearing Wrench to unthread seal-head from end of shock body.
6. [] Place 3/8" steel rod into shaft eyelet; while holding body upright with one hand, pull upward on rod to remove shaft assembly (oil may spill).
7. [] Remove body from 5/16" shaft, then pour oil into empty waste receptacle to be properly recycled later.
8. [] Test viscosity of oil from waste receptacle using test from OIL-VISCOSITY TESTING (page 38-5). Approximate weight of fluid is: _____

NOTE: If changing fluid only, proceed to step 52.

Shaft-eyelet and seal-head removal

9. [] Clean piston-end of shaft with alcohol, then place 1–1/8" Shaft Clamp around cleaned portion of shaft.
10. [] Secure 1–1/8" Shaft Clamp in vise, so that eyelet end of shaft is up.
11. [] Use rod (diameter should match eyelet hole) to turn shaft eyelet counterclockwise. (If removal is very difficult, heat shaft with propane torch, applying constant pressure while applying heat, and moving heat to avoid concentration.)
12. [] Clean eyelet threads of any old Loctite.

Valve disassembly and floating-piston removal

13. [] Turn shaft/Shaft-Clamp assembly over in vise, so that piston-end of shaft is up.
14. [] With 17mm wrench, remove nut on end of piston.

15. [] Maintaining order and orientation, remove rebound shims from top side of piston and record their dimensions here:

I.D.	O.D.	Thickness
_____	_____	_____
_____	_____	_____
_____	_____	_____

(stock configuration below)

12.7mm	28.1mm	.16mm

12.7mm	28.1mm	.16mm

16. [] Noting orientation, remove piston.

17. [] Maintaining order and orientation, remove compression shims from below piston and record their dimensions here:

I.D.	O.D.	Thickness
_____	_____	_____
_____	_____	_____
_____	_____	_____

(stock configuration below)

12.7mm	28.1mm	.16mm

12.7mm	17.8mm	.30mm.

18. [] Push seal head fully to piston end of shaft, then thread Blowout Body onto seal head. Inflate Blowout Body to eject floating piston.
19. [] Remove Blowout Body, then remove seal-head from shaft.
20. [] Remove O-ring from shaft.

Removal of adjustable damper

21. [] Use 2mm Allen to unscrew 8 bolts that hold adjustable damper to body.
22. [] Watching carefully for the spring/bearing détente mechanism that is under the "R" end of the assembly, lift the assembly off the shock cylinder.
23. [] Remove détente spring from hole in cylinder, remove O-rings from oval grooves in cylinder, remove 3/32" détente bearing from bottom face of "R" end of damper unit, pull both ends of damper unit off shaft, then remove O-rings from both end pieces of damper unit.

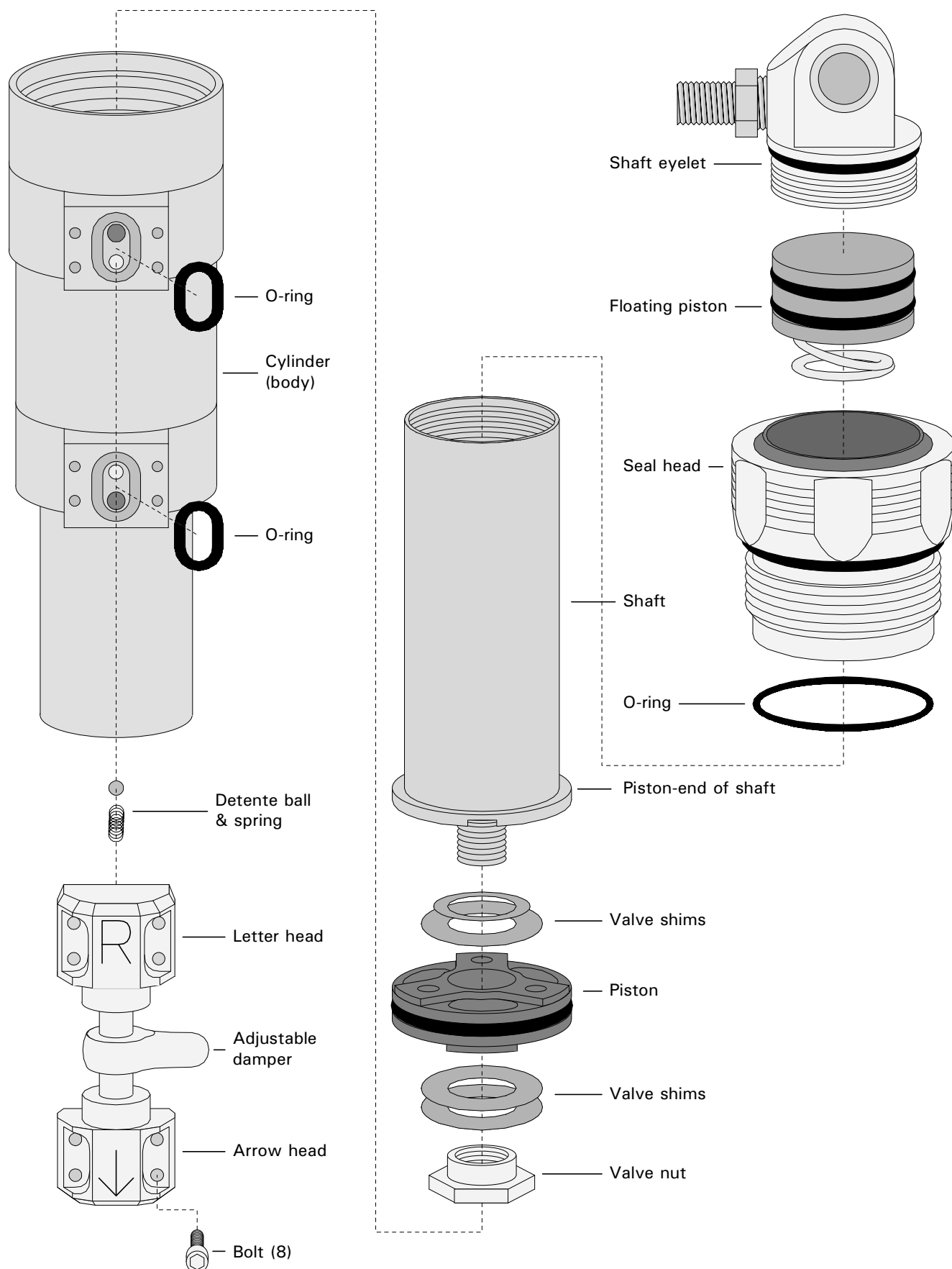
O-ring and seal removal

24. [] Remove O-ring from inside and outside of seal-head.
25. [] Remove wiper seal from end of seal-head.
26. [] Remove O-ring from shaft eyelet.
27. [] Remove O-rings from floating piston.

Cleaning and inspection

28. [] Clean all parts with mild detergent and water, then dry thoroughly with compressed air. *Avoid leaving solvents or lint from rags on, or in, any part!*
29. [] Inspect valve shims (thin washers) for chipping or cracks
30. [] Inspect O-rings and seals for tears, nicks, and cracks.

38 – SUSPENSION FORKS AND REAR SHOCKS



38.12 Risse Astro-5 rear shock.

O-ring installation and floating-piston assembly

31. [] Grease all O-rings and wiper seal.
32. [] Install wiper seal (conical-lip out), in end of seal-head.
33. [] Install O-rings on floating piston, and inside and outside of seal-head.

Shaft assembly

34. [] Put 1–1/8" Shaft Clamp around piston-end of shaft, then clamp radius blocks into vise with piston end pointing up.
35. [] Install shim stack that was below piston onto end of shaft in reverse order of removal.
36. [] Install piston (face with bigger 3-leg protrusion facing up).
37. [] Install shim stack that was above piston onto end of shaft.
38. [] Apply Loctite #242 to threads of nut, then thread nut onto stud (slightly snug).
39. [] Hold piston stationary and rotate nut until flats on nut align centered to legs on top face of piston.
40. [] Torque nut to 70–80in-lbs, making sure nut flats maintain orientation to piston legs.
41. [] Turn shaft/Shaft-Clamp assembly over in vise, then clamp securely.
42. [] Insert air piston (spring-end first) fully into piston shaft.
43. [] Install 1–1/8" Bullet Tool in end of shaft.
44. [] Install remaining O-ring over tool and onto shaft.
45. [] Install seal-head (threaded-end first) over tool and onto shaft, then remove tool.
46. [] Apply Loctite 242 on threads of shaft eyelet, then secure shaft eyelet to 100in-lbs.

Damper adjuster assembly

47. [] Install O-rings into adjuster-rod damper blocks, and O-rings into oval grooves in shock cylinder.
48. [] Insert orifice-end of adjuster rod into "R" block.
49. [] Insert détente bearing and spring into small hole in back face of "R" block.
50. [] Holding damper unit with bottom face facing up, position shock body over damper unit with open end of body pointing the same way as R-block end of damper unit, then mate together so détente spring inserts into spring hole (smaller hole) in mounting surface for damper unit.
51. [] Insert and tighten eight bolts that hold damper to shock cylinder.

Oil filling and assembly

52. [] Attach pump to air valve, then pressurize to pressure recorded in step 1.
53. [] Remove shaft assembly from vise (if appropriate).
54. [] Push O-rings and seal-head to piston-end of shaft assembly.
55. [] Place shock body upright in vise, and fill with 5wt oil.
56. [] Manually thread seal-head as far as possible into shock body.
57. [] Place 5/16" steel rod horizontally in vise, then place body eyelet onto rod.
58. [] Check that O-ring under seal-head flange has disappeared inside shock body.
59. [] Use Combo Bearing Wrench to secure seal-head into to end of shock body to torque of 240in-lbs (24lbs@10").
60. [] Install shock into bike.
61. [] Test shock by sitting in saddle and bouncing. Rear suspension should have damping. No sound of air in valving should be present. Listen for unusual noises, such as "gurgling" or "sucking" noise, which would indicate presence of air.

TUNING OPTIONS

Air pressure

Typical pressure is from 150–200psi. Increasing air pressure increases spring stiffness, which reduces rate of compression and increases rate of rebound while decreasing air pressure decreases spring stiffness, which increases rate of compression and decreases rate of rebound. Air pressure should be adjusted to create the desired amount of static sag. With the rider on the bike, the shock should compress 5%–20% of its total compression for cross-country riding, or 30%–40% for downhill riding.

Damping adjustment

Turning the damper-adjusting lever switches the damper unit through five progressive orifices settings. The rebound and compression damping are both simultaneously affected.

**RISSE TERMINATOR
REAR SHOCK**

ABOUT THIS SECTION

This section is specifically about the Risse Terminator rear shock.

TOOLS

Four specialized Risse tools are required:

Combo Bearing Wrench	#20621
1-1/2" Shaft Clamp	#20222
1-1/2" Bullet Tool	#20242
1-1/2" Blowoff Body	#20658

FULL SHOCK SERVICE

Shock removal

- 1. [] Use Schrader valve pressure gauge to record pressure in shock: ____ psi.
- 2. [] Depress plunger in valve, put weight on bike to fully compress shock, then release valve plunger.
- 3. [] Remove shafts through body eyelet and shaft eyelet, then remove shock.

Shaft removal

- 4. [] Carefully grasp body eyelets in soft jaws in vise, with rag to protect finish.
- 5. [] Use Combo Bearing Wrench to unthread seal-head from end of shock body.
- 6. [] Place 3/8" steel rod into shaft eyelet and pull upward on rod to remove shaft assembly (oil may spill).
- 7. [] Remove body from vise, then pour oil into empty waste receptacle to be properly recycled later.
- 8. [] Test viscosity of oil from waste receptacle using test from OIL-VISCOSITY TESTING (page 38-5). Approximate weight of fluid is: _____

NOTE: If changing fluid only, proceed to step 52.

Shaft-eyelet and seal-head removal

- 9. [] Clean piston-end of shaft with alcohol, then place 1-1/2" Shaft Clamp around cleaned portion of shaft.
- 10. [] Secure Shaft Clamp in vise, so that eyelet end of shaft is up.

- 11. [] Use rod (diameter should match eyelet hole) to turn shaft eyelet counterclockwise. (If removal is very difficult, heat shaft with propane torch, applying constant pressure while applying heat, and moving heat to avoid concentration.)
- 12. [] Clean eyelet threads of any old Loctite.

***Valve disassembly
and floating-piston removal***

- 13. [] Turn shaft/ Shaft-Clamp assembly over in vise, so that piston-end of shaft is up.
- 14. [] With 17mm wrench, remove nut on end of piston.
- 15. [] Maintaining order and orientation, remove rebound shims from top side of piston and record their dimensions here:

I.D.	O.D.	Thickness
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

(stock configuration below)

12.7mm	27.9mm	.30mm
12.7mm	34.3mm	.20mm
12.7mm	34.3mm	.20mm
12.7mm	34.3mm	.20mm

- 16. [] Noting orientation, remove piston.
- 17. [] Maintaining order and orientation, remove compression shims from below piston and record their dimensions here:

I.D.	O.D.	Thickness
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

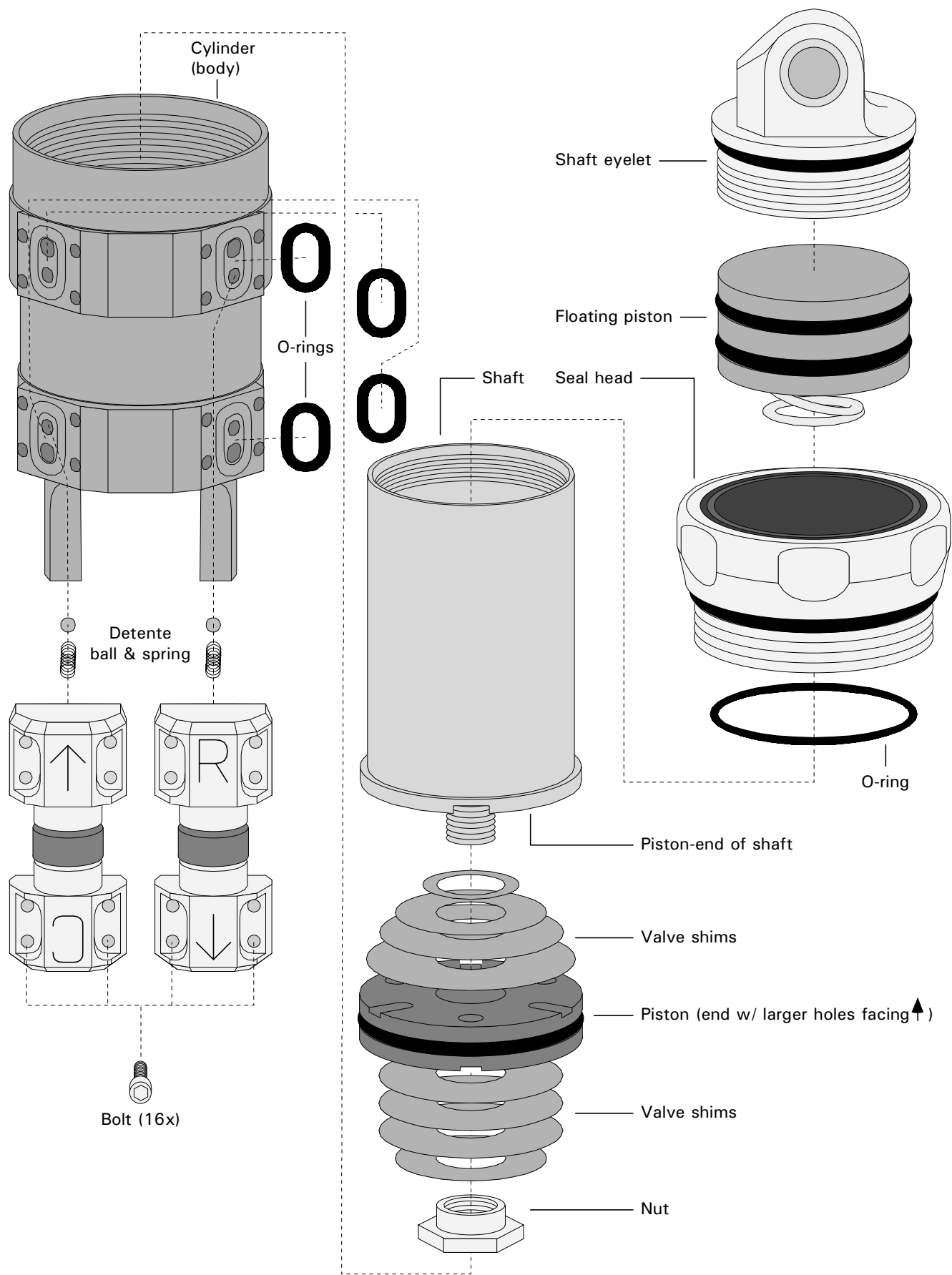
(stock configuration below)

12.7mm	38.7mm	.25mm
12.7mm	34.3mm	.16mm
12.7mm	27.9mm	.16mm
12.7mm	17.8mm	.30mm

- 18. [] Push seal head fully to piston end of shaft, then thread Blowout Body onto seal head. Inflate Blowout Body to eject floating piston.
- 19. [] Remove Blowout Body, then remove seal-head from shaft.
- 20. [] Remove O-ring from shaft.

Removal of adjustable dampers

- 21. [] Use 2mm Allen to unscrew 8 bolts that hold rebound adjustable damper (marked "R") to body, noting R end points to open end of body, then repeat for compression adjustable damper (marked "C"), noting that C end points to closed end of body.



38.13 Risse Terminator rear shock.

38 – SUSPENSION FORKS AND REAR SHOCKS

- 22. [] Watching carefully for the spring/bearing détente mechanism that is under the R or C end of the assembly, lift the assembly off the shock cylinder.
- 23. [] Remove détente springs from holes in cylinder, remove O-rings from oval grooves in cylinder, remove 3/32" détente bearing from bottom face of R and C ends of damper units, pull both ends of damper units off adjustment shafts, then remove O-rings from both end pieces of damper units. Remove 3/16" ball bearing and spring from inside the blocks with the engraved arrow.

O-ring and seal removal

- 24. [] Remove O-ring from inside and outside of seal-head.
- 25. [] Remove wiper seal from end of seal-head.
- 26. [] Remove O-ring from shaft eyelet.
- 27. [] Remove O-rings from floating piston.

Cleaning and inspection

- 28. [] Clean all parts with mild detergent and water, then dry thoroughly with compressed air. *Avoid leaving solvents or lint from rags on, or in, any part!*
- 29. [] Inspect valve shims (thin washers) for chipping or cracks
- 30. [] Inspect O-rings and seals for tears, nicks, and cracks.

O-ring installation and floating-piston assembly

- 31. [] Grease all O-rings and wiper seal.
- 32. [] Install wiper seal (conical-lip out) in end of seal-head.
- 33. [] Install O-rings on floating piston, and inside and outside of seal-head.

Shaft assembly

- 34. [] Put Shaft Clamp around piston-end of shaft, then clamp tool into vise with piston end pointing up.
- 35. [] Install shim stack that was below piston onto end of shaft in reverse order of removal.
- 36. [] Install piston. Side with smaller-diameter valve holes in flat surface faces up.
- 37. [] Install shim stack that was above piston onto end of shaft.
- 38. [] Apply Loctite #242 to threads of nut, then thread nut onto stud (slightly snug).
- 39. [] Torque nut to 70–80in-lbs (12–13lbs@6").
- 40. [] Turn shaft/ Shaft-Clamp assembly over in vise, then clamp securely.
- 41. [] Insert air piston, spring-end first, fully into piston shaft.
- 42. [] Install 1–1/2" Bullet Tool in end of shaft.

- 43. [] Install remaining O-ring over tool and onto shaft.
- 44. [] Install seal-head (threaded-end first) over tool and onto shaft, then remove tool.
- 45. [] Apply Loctite 242 on threads of shaft eyelet, then secure shaft eyelet to 100in-lbs (17lbs@6").

Damper-adjuster assembly

During normal disassembly, there is no reason to remove or loosen the adjusting rings on the adjusting rods. If the rings have been loosened, then it is possible the numbers on the rings are not in correspondence with the correct-size orifices. When the adjuster ring is correctly positioned and you are seeing the "1," you should simultaneously be seeing the smallest orifice through the next-to-largest orifice.

- 46. [] Install O-rings into adjuster-rod damper blocks, and O-rings into oval grooves in shock cylinder.
- 47. [] Insert orifice-end of adjuster rods into R and C blocks, insert spring and 3/16" ball bearing into each "arrow" block, then insert remaining end of each adjuster rod into each arrow block.
- 48. [] Insert détente bearings and springs into small holes in back faces of R and C blocks.

The Terminator shock has a rebound damper and a compression damper. Either can be installed facing either way, but only one way allows the dampers to function in the correct way. When correctly installed, the arrow on the rebound damper points toward the body eyelet and the arrow on the compression damper points away from the body eyelet. Simply put, the arrows point the way the body moves during rebound and compression strokes.

- 49. [] Holding damper unit with bottom face facing up, position shock body over damper unit with eyelet end of body pointing the same way as arrow end of "R" damper unit, then mate together so détente spring inserts into spring hole (smaller hole) in mounting surface for damper unit.
- 50. [] Insert and tighten eight bolts that hold damper to shock cylinder.
- 51. [] Repeat previous two steps for compression damper unit, but install so arrow end points away from eyelet end of body.

Oil filling and assembly

- 52. [] Attach pump to air valve, then pressurize to pressure recorded in step 1.
- 53. [] Remove shaft assembly from vise (if appropriate).
- 54. [] Push O-rings and seal-head to piston-end of shaft assembly.

55. [] Place shock body upright in vise, and fill with 5wt oil.
56. [] Manually thread seal-head as far as possible into shock body.
57. [] Check that O-ring under seal-head flange has disappeared inside shock body.
58. [] Use Combo Bearing Wrench to secure seal-head into to end of shock body to torque of 240in-lbs (24lbs@10").
59. [] Install shock into bike.
60. [] Test shock by sitting in saddle and bouncing. Rear suspension should have damping. No sound of air in valving should be present. Listen for unusual noises, such as "gurgling" or "sucking" noise, which would indicate presence of air.

TUNING OPTIONS

Air pressure

Typical pressure is from 150–200psi. Increasing air pressure increases spring stiffness, which reduces rate of compression and increases rate of rebound while decreasing air pressure decreases spring stiffness, which increases rate of compression and decreases rate of rebound. Air pressure should be adjusted to create the desired amount of static sag. With the rider on the bike, the shock should compress 5%–20% of its total compression for cross-country riding, or 30%–40% for downhill riding.

Damping adjustment

Turning each numbered damper-adjusting ring adjusts the damper unit through five progressive orifice settings, corresponding to the numbers on the rings. The rebound and compression damping are completely independent.

ROCKSHOX '97–'99 INDY & JETT FORKS

ABOUT THIS SECTION

This section covers RockShox Indy model forks from 1997 and 1998, including the S, C, SL, and XC models. In addition, the 1999 RockShox Jett C, 1999 Jett T2, and 2000 Jett XC can be serviced using these instructions. These are all similar to each other and are described with one procedure, with notes regarding the minor differences.

TOOL CHOICES

See table 38–3 for tool requirements. All the tools in the table are required for the job.

INDY & JETT FORK TOOLS

(table 38-3)	
Tool	Fits and considerations
6mm Allen bit socket	minimum 4" bit length
Ratchet extension	6" may be adequate, longer is recommended
RockShox 70096	Judy/Quadra/Indy bushing remover
RockShox 70098	Quadra/Indy/Jett bushing installer
UBT AL-11912B	22mm socket custom ground for optimal purchase

FULL SERVICE

Spring-stack removal

1. [] Leave fork in bike, but release front brake cable from brake lever.
2. [] Count number of turns require to loosen spring pre-load knobs fully counterclockwise and record here: left _____ right _____
3. [] Use 22mm socket to unthread plastic caps in tops of stanchions, then remove cap/spring-stack assemblies. ('99 Indy C and '00 Jett XC have spring stack only in right side.)

Slider removal

4. [] Compress fork completely.
5. [] Use ratchet drive, extension, and 6mm bit socket to unthread plunger bolts down in bottom of stanchions.
6. [] Remove wheel from fork.
7. [] Slide slider assembly off bottom of stanchion tubes.
8. [] Pour oil from sliders into waste receptacle.
9. [] Attach small O-rings or rubber bands to plunger bolts exposed below bottoms of plungers, so that bolts cannot escape into plungers.

Friction-damper removal (SL model only)

10. [] Use snap-ring pliers to remove internal snap rings at bottoms of stanchions.
11. [] Use extension with bit socket to push or tap plunger assemblies out bottoms of stanchions.
12. [] Remove friction dampers from ends of plungers.
13. [] Remove O-rings from friction dampers.

38 – SUSPENSION FORKS AND REAR SHOCKS

Seal and bushing removal

14. [] Remove boots and wiper seals from tops of slider tubes (insert screwdriver through seal and pry up on inside bottom edge of seal).
- NOTE: Before removing lower bushings, it is recommended to measure depth from top of slider to top edge of lower bushing.*
15. [] Place upright on top of slightly open vise jaws RockShox Seal Separator (large-end up), and place sleeve from RockShox Bushing Remover (small-end up) on top of Seal Separator.
16. [] Holding slider upside down, insert RockShox Bushing Remover with 28mm-long extractor plate up into one side of slider and engage plate against back of first bushing.
17. [] With tool still engaged to bushing, drop end of tool through sleeve, Seal Separator, and vise jaws until slider seats on sleeve, then firmly secure vise on Bushing Remover handle.
18. [] Hold one cylinder of Seal Separator stationary and rotate other cylinder to pull bushing out.
19. [] Repeat previous three previous steps for other bushing, then repeat for both bushings in other side.
20. [] Using a spoke or seal pick, fish bottom-out bumpers out of sliders.

Cleaning and inspection

21. [] Clean all parts with mild detergent and thoroughly dry with compressed air and/or lint-free rag.
22. [] Inspect wiper seals for nicks or tears.
23. [] Inspect and replace all elastomer and coil springs that do not meet RockShox specifications.

Seal and bushing installation

24. [] Install bottom-out bumpers in sliders so conical ends face down.
25. [] Thoroughly grease all replacement bushings with Judy Butter or equivalent non-lithium grease.
26. [] Place in order on Bushing Installer: 25mm sleeve, 85mm sleeve #110-02265-00 marked "98 Indy," and lower (smaller O.D.) bushing. Note: '97 Indy uses 78mm sleeve #70196 instead of 85mm sleeve.
27. [] Insert assembly into fork and tap with plastic mallet until assembly is fully bottomed, then remove tools.

28. [] Place in order on Bushing Installer: 25mm sleeve and upper bushing.
29. [] Insert assembly into fork and tap with plastic mallet until assembly is fully bottomed, then remove tools.
30. [] Repeat steps 26–29 for other side.
31. [] Grease wiper seals, then place wiper seals in top ends of sliders and tap into place with plastic mallet.

Friction-damper installation (SL model only)

32. [] Grease and install O-rings into friction dampers.
33. [] Slide top-out bumpers half-way down plunger shafts if bumpers have been forced over flange-ends of plungers.
34. [] Install friction dampers onto ends of plungers so that end of damper with groove in outer perimeter goes on first.
35. [] Wiggle and push plungers into stanchions.
36. [] Use 15mm socket or 7/8" PVC pipe to seat friction dampers just beyond snap-ring grooves.
37. [] Use snap-ring pliers to install internal snap-rings (sharp-edged-face out) into bottoms of stanchions.

Slider assembly

38. [] Remove rubber bands or O-rings from plunger bolts, then prep plunger-bolt threads with Loctite 242.
39. [] Check alignment of conical bottom-out bumpers in bottoms of sliders, then use spoke to align flat as necessary (conical-side down).
40. [] Put 5wt oil in each slider (15cc in XC, or 10cc in S, C, SL, and Jett T2).
41. [] Grease bushings, and fill pockets in wiper seals with Judy Butter or similar grease.
42. [] Use fingers to check if wiper seals are deformed at bottom edge, and pull wiper seals out just enough to eliminate deformity (if found).
43. [] Place slider assembly onto stanchions and compress fully.
44. [] Use extension and bit socket to engage plunger bolts into sliders.
45. [] Use torque wrench to tighten plunger bolts to 80in-lbs.
46. [] Pull sliders down fully, then engage bottoms of dust boots to wiper seals.

Spring-stack installation

47. [] Grease elastomer and/or coil springs.
48. [] Insert cap/spring-stacks into stanchions, and secure caps to 30in-lbs. ('99 Indy C and '00 Jett XC have spring stack only in right side.)
49. [] Restore pre-load settings.
50. [] Install wheel in fork.
51. [] Connect brake cable.

Crown-bolt security

52. [] Check crown bolt torque (if any). RockShox recommended torque is 60in-lbs.

TUNING OPTIONS

Sag and pre-load adjustment

RockShox recommends 7–10mm of sag for 72mm-travel models, 5–8mm of sag for 60mm-travel models, 3–5mm for 48mm-travel models. Adjust the pre-load adjusters (up to 5 full turns from loosest to tightest) to achieve sag in the recommended range. Check sag by measuring the change in distance from the top of the slider tube to the bottom of the crown after the rider

gets on the bike. If it is not possible to achieve the recommended sag with the existing springs, then consider changing springs.

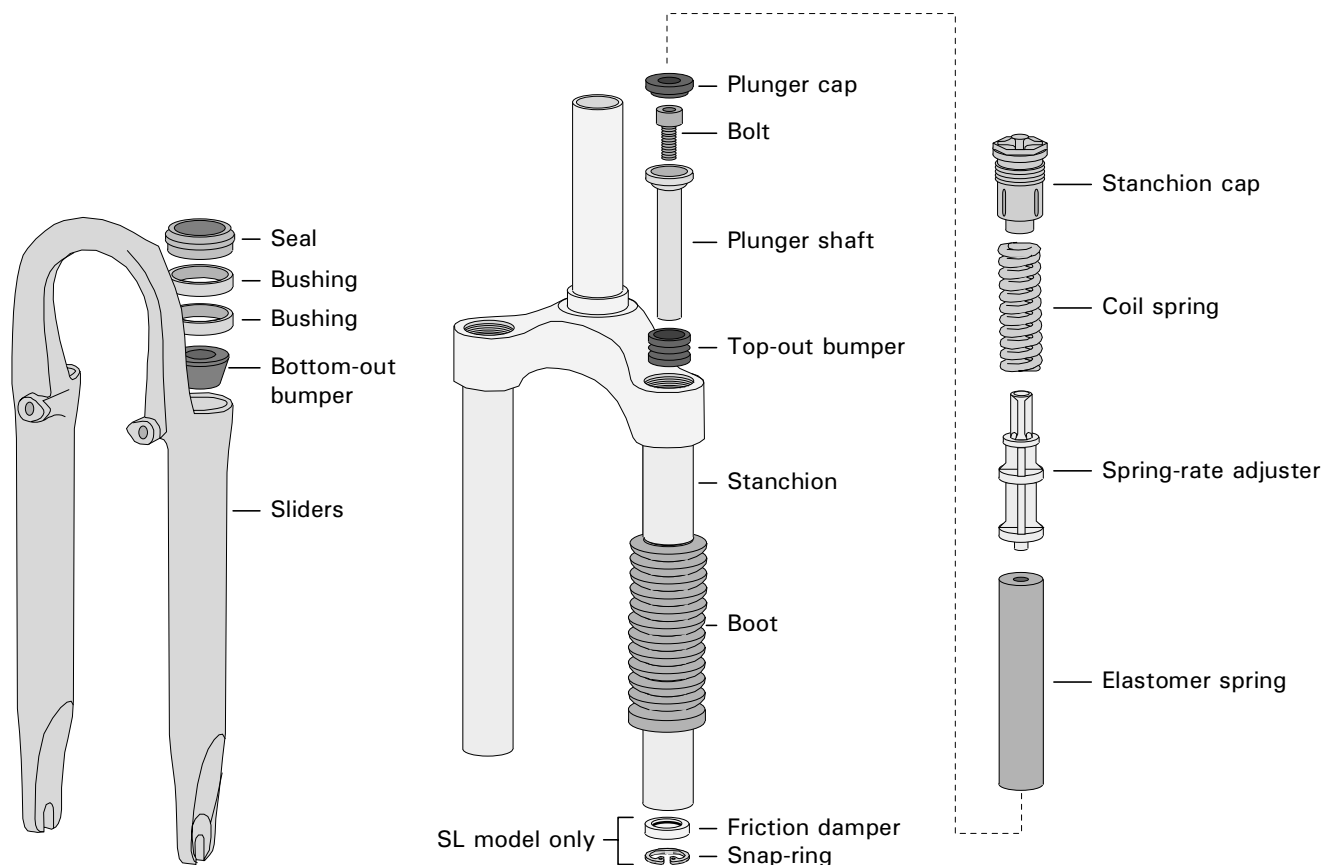
Spring-rate adjustment

Spring rate can be changed two ways. The spring-rate adjusters can be changed, and the coil springs can be changed. The spring-rate adjuster is the plastic stud that inserts into the coil spring. When the length of the stud is changed, the point at which the coil spring is fully compressed is changed. This, in turn, changes the point of fork compression when only the elastomer part of the spring set continues to compress. The spring-rate adjuster kit (#59136) contains different-length adjusters. A shorter length of stud makes the spring system softer, and a longer length of stud makes the spring system stiffer.

Coil springs are available in four degrees of firmness. These are soft (red, #110-000591-00), medium (yellow, #110-000592-00), firm (green, #59141), and extra firm (purple, #59139).

Travel adjustment

Travel kit #59123 converts '97-'98 Indy XC/SL and '98 Indy C to 75mm of travel.



ROCKSHOX '99-'00 JETT HYDRACOIL FORKS

ABOUT THIS SECTION

This section covers service of several 1999 and 2000 Jett forks including '99 Jett XC, '00 Jett Race, and '00 Jett SL models. The '99 Jett C, '99 Jett T2 and '00 Jett XC models are comparable to the 1998 Indy model for service purposes (see page 38-37). The '00 Jett is completely different from other Jett models, but is briefly covered at the end of this section (page 38-42). Complete service techniques, including bushing replacement, are included. RockShox recommends an oil change, complete cleaning, and lubrication every 100 hours of use or one year, whichever comes first. Bushing replacement should be done when the fork develops obvious play between the stanchions and sliders.

TOOL CHOICES

For all services other than bushing replacement, the following specialized tools are required:

- United Bicycle Tool AL-11912B (22mm socket already custom ground for optimal purchase)
- 24mm socket (must be custom ground to eliminate internal bevel for optimal purchase).
- 6mm Allen bit socket with >6" bit length

It may be difficult to find an appropriate 6mm bit socket. A Proto 4990-6MXL is slightly too short, but the bit can be replaced with a 160mm section cut from an extra-long Allen wrench, such as a Bondhus T-handle 6mm.

For bushing replacement, specialized tools from RockShox are required. The same tools work on numerous other models of RockShox forks. The required tools are:

- Bushing Remover #70096
- Bushing Installer #70098
- Seal Separator #70113

FULL SERVICE

Spring-stack removal

1. [] Turn spring adjuster fully counterclockwise, counting number of turns on each side:
No. of turns on right: _____
No. of turns on left: _____
2. [] Use 22mm or 24mm socket to unthread spring caps on each side, then remove caps.

3. [] Remove plastic spring spacer and spring from each side, then turn fork over to remove plastic spring retainer. Note: Oil will pour out, and fork may need to be tapped with plastic mallet before spring retainers will drop out.

Slider and plunger/damper removal

4. [] Use 6mm Allen bit on 8" ratchet extension to unthread bolts in bottoms of stanchions.
5. [] Pull slider and boots off stanchions.
6. [] Turn fork over to remove plunger assembly and damper assembly from each stanchion.

Seal and bushing removal

7. [] Remove boots and wiper seals from tops of slider tubes (insert screwdriver through seal and pry up on inside bottom edge of seal).

NOTE: Before removing lower bushings, it is recommended to measure depth from top of slider to top edge of lower bushing.

8. [] Place upright on top of slightly open vise jaws RockShox Seal Separator (large-end up), and place sleeve from RockShox Bushing Remover (small-end up) on top of Seal Separator.
9. [] Holding slider upside down, insert RockShox Bushing Remover with 28mm long remover plate up into one side of slider and engage plate against back of first bushing.
10. [] With tool still engaged to bushing, drop end of tool through sleeve, Seal Separator, and vise jaws until slider seats on sleeve, then firmly secure vise on Bushing Remover handle.
11. [] Hold one cylinder of Seal Separator stationary and rotate other cylinder to pull bushing out.
12. [] Repeat previous three previous steps for other bushing, then both bushings in other side.
13. [] Using a spoke or seal pick, fish bottom-out bumpers out of sliders.

Cleaning and inspection

14. [] Clean all parts with mild detergent and thoroughly dry with compressed air and/or lint-free rag.
15. [] Inspect wiper seals and damper-shaft glide ring for nicks or tears.
16. [] Measure coil springs and replace if length is 156mm or less.
17. [] Measure top-out springs and replace if length is 22mm or less.

Seal and bushing installation

18. [] Install bottom-out bumpers in sliders so conical ends face down.

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19. [] Thoroughly grease all replacement bushings with Judy Butter or equivalent grease.
20. [] Place in order on Bushing Installer: 25mm sleeve, 85mm sleeve (#110-02265-00 marked "98 Indy"), and lower (smaller O.D.) bushing.
21. [] Insert assembly into fork and tap with plastic mallet until assembly is fully bottomed, then remove tools.
22. [] Place in order on Bushing Installer: 25mm sleeve and upper bushing.
23. [] Insert assembly into fork and tap with plastic mallet until assembly is fully bottomed, then remove tools.
24. [] Repeat steps 20–23 for other side.
25. [] Grease wiper seals, then place wiper seals in top ends of sliders and tap into place with plastic mallet.

Slider and plunger/damper installation

26. [] Slide boots onto stanchions
27. [] Grease bushings, and fill pockets in wiper seals with Judy Butter or similar grease.
28. [] Guide slider assembly onto stanchions.

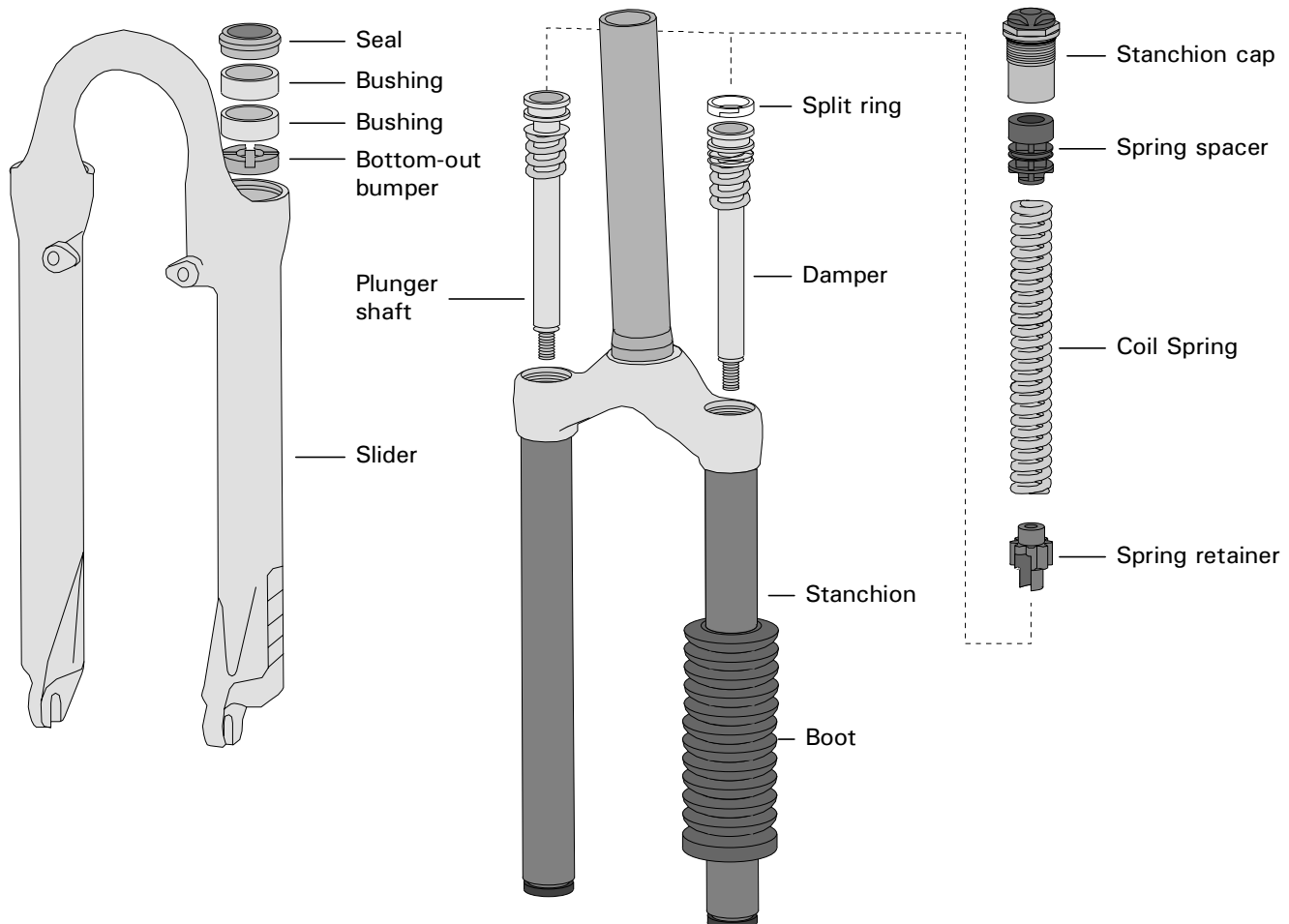
29. [] Put a drop of Loctite 242 on threads of bolts at bottom of damper shaft and plunger shaft.
30. [] Drop damper shaft into left stanchion and plunger rod into other stanchion.
31. [] Secure both bolts to 80in-lbs.
32. [] Attach boots to wiper seals.

Spring-stack installation

33. [] Install spring retainers into each stanchion (short-end up).
34. [] Pour 85cc's of RockShox Extra Light (5wt) oil into each stanchion.
35. [] Grease spring coils thoroughly and install in stanchions.
36. [] Install spring spacers in stanchions (large-diameter-ends up).
37. [] Thread top caps into stanchions and torque to 30in-lbs.
38. [] Reset spring preload on each top-cap adjuster.

Crown-bolt security

39. [] Check crown bolt torque (if any). RockShox recommended torque is 60in-lbs.



TUNING OPTIONS

Sag and pre-load adjustment

RockShox recommends 12–16mm of sag for 63mm travel models, and 14–18mm of sag for 75mm travel models. Adjust the pre-load adjusters (up to 5 full turns from loosest to tightest) to achieve sag in the recommended range. Check sag by measuring the change in distance from the top of the slider tube to the bottom of the crown after the rider gets on the bike. If it is not possible to achieve the recommended sag with the existing springs, then consider changing springs. The soft (yellow), medium (red), and firm (black) springs can be used in various mixtures to achieve the desired spring rate. RockShox recommends a progression of soft-soft (100–150lb. rider), soft-medium (125–175lb. rider), medium-medium (150–200lb. rider), medium-firm (175–225lb. rider), and firm-firm (200–250lb. rider). For hard riding on extreme terrain, consider the rider to be of a higher weight classification.

Rebound damping

The damping valve of this fork affects rebound only. The valving is not intended to be adjusted, but RockShox recommends switching to 15wt oil if rebound damping is insufficient.

Travel adjustment

Travel kits are available to convert between 63mm and 75mm travel ranges. The travel kit includes plungers, springs, and spring spacers.

'00 JETT

The '00 Jett can be distinguished by the fact that it has forward-offset dropouts just like other 2000 Jett models, but unlike these other models there are no pre-load adjusters on top of the legs, and there are small bolts on the bottoms of the legs.

The fork is an extremely basic OEM model, and the only service possible is to disassemble it and clean it. Unthreading the 24mm top caps enables the springs to be removed, cleaned, and greased. Unthreading the bottom bolts enables removal of the slider assembly, so that the bushings and stan- chions can be cleaned and greased.

ROCKSHOX '97-'99 JUDY CARTRIDGE FORKS

ABOUT THIS SECTION

This section covers a variety of models and years of RockShox Judy forks, including:

1997 C, XC, DH, SL

1998 T2, XC, SL, XL

1999 SL, XL

The model names can be found on the forks, but not the years. Depending on the model year, slightly different procedures are required. Observing decal styles can help identify the model year. The 1997 models have a 6" tall decal that wraps almost all the way around each slider tube and extends from just below the swell to just above the start of the dropout. All wording is horizontal. The 1998 models have a similar decal, but it is shorter (3.5") and stops about halfway down to the start of the dropouts. The 1999 models have decals that do not wrap around the slider tubes, but are on the outer face of the sliders only, with the model name written vertically on the decal.

Several levels of service of this fork are possible, including only replacement of the spring stacks, only replacement of the damper cartridge, complete cleaning and lubrication, or complete overhaul including bushing replacement. The following procedure is written for a complete overhaul, including bushing replacement, but by skipping unnecessary steps. As written, the procedure can be used for any lesser degree of service.

TOOL CHOICES

Several specialized or customized tools are required to service these forks. With the exception of the tools listed for overhauling the 1997 damper cartridge, all the tools work on virtually all of the models.

Tool	Considerations and fit
UBT AL-11912B	22mm socket custom ground for optimal purchase
20cc syringe	Oral type, available at pet stores
RockShox 70096	Judy/Quadra/Indy bushing remover
RockShox 70113	Seal Separator
RockShox 70119	Judy Bushing Installer Kit
RockShox 70142	1997 Cartridge Tool Kit

FORK SERVICE

The fork can be serviced while installed on the bike, but the brake calipers or disc brake need to be removed from the slider assembly.

Spring-stack removal

1. [] Turn pre-load adjusters fully counterclockwise and record number of turns here:
Right side: _____ turns
Left side: _____ turns
 2. [] Carefully use 22mm socket to unthread top caps from tops of stanchions. *Note: customized socket required in addition to careful maintenance of alignment of socket to avoid damaging flats of soft plastic top cap!*
- In the next step, the spring stacks are removed. The various configurations of the spring stacks constitute one of the two big difference areas between all of these models. All 1997 models and the 1998 T2 have (from top down) a coil spring, a plastic spacer(s), and an elastomer spring. The remaining 1998 models and the 1999 SL model have (from top down) a short coil spring, a plastic spacer (or connector), then a longer coil spring. The 1998 XL has an additional aluminum spacer rod (with two plastic end plates) below the spring stacks. The 1999 SL and XL have (from top down) a plastic spacer and then one very long coil spring.
3. [] Turn fork upside down to remove spring stacks, or spring stacks and spacer rods.

Slider removal

4. [] Pull out plastic adjuster knob (if any) from bottom end of one slider. *Note: 1999 XL and SL have a metal adjuster knob retained by a Phillips screw. Remove screw and knob at this time.*
5. [] Unthread both bolts at bottoms of sliders about three full turns. *Note: 1999 XL and SL have a nut instead of a bolt – unthread just until shaft protruding from nut no longer protrudes.*
6. [] Turn fork upright and position over receptacle for waste oils (no oil in 1997 models).
7. [] Use plastic mallet to tap on both bolts (or bolt and nut) until heads are back against sliders, then finish unthreading bolts (or nut).
7. [] Pull sliders downward about one inch to allow oil to drain, then remove sliders and boots from stanchions.
8. [] Separate boots from sliders, then turn sliders upside down to allow rest of oil to drain.

Neutral-shaft removal and disassembly

9. [] Depending on model, remove conical bumper from one or both shafts extending from bottoms of stanchions.
10. [] Operate both shafts extending from bottoms of stanchions to determine which is the neutral shaft (it offers no resistance) and which is damper (resistance is felt). *Note: T2 has two neutral shafts and DH has two dampers!*
11. [] Remove snap-ring from bottom of stanchion with neutral shaft (both on T2). *Note: On some models, watch for wavy washer that comes out when snap-ring is removed.*
12. [] Insert 7/8" dowel or similar shaft through top of stanchion to push out neutral-shaft assembly.
13. [] *1997 and 1998 models only:* Remove plastic end plate from the top of neutral-shaft assembly and then remove upper shaft guide.
14. [] *1997 and 1998 models:* From bottom of neutral shaft, remove: lower shaft guide, conical bumper, then washer(s). *1999 models:* From bottom of neutral shaft, remove: shaft guide, shaft-guide retaining ring, top-out spring (elastomer), top-out spring guide, upper shaft guide (with O-ring), then pin.

Cartridge removal

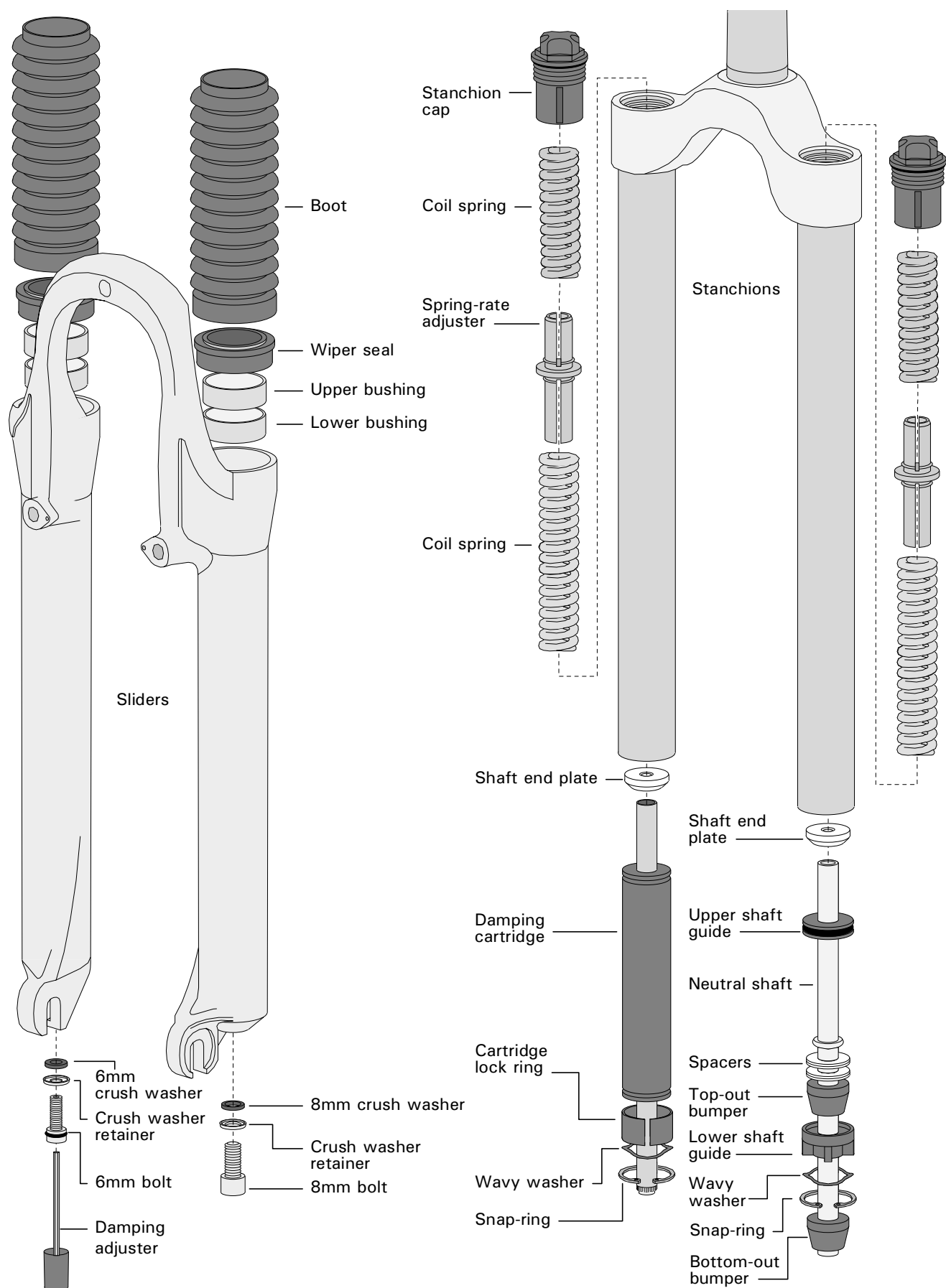
15. [] Remove snap-ring from bottom of stanchion, then remove wavy washer (if any).
16. [] Pull on cartridge shaft to remove cartridge from stanchion.
17. [] Remove shaft end plate from top end of cartridge shaft.
18. [] *1997 models:* Remove cartridge washer from bottom end of cartridge shaft.

Seal and upper-bushing removal

Bushing wear can be determined in two ways. After removing the seals in step #19, insert the stanchions into the sliders again and check for any fore-and-aft play. Obvious looseness is caused by worn bushings. Alternatively, before removing the bushings, clean them thoroughly and inspect their condition with the aid of a flashlight. Good bushings have a gray coating. Worn bushings have a metallic gold or bronze appearance where the coating has worn away.

19. [] Insert screwdriver into seal on top of slider, then pry seal out. *Note: 1997 models, also remove seal spacers positioned on top of upper bushings.*
20. [] Place Seal Separator upright on slightly open vise jaws with large-diameter end up.

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38.16 RockShox '98 Judy (cartridge type).

21. [] Install 30mm-long extractor plate onto extractor tool, push slider onto end of extractor tool until upper bushing clears extractor plate, then pull out on slider until extractor plate catches on edge of upper bushing.
22. [] Guide handle of extractor down through Seal Separator and vise jaws until top of slider tube rests on Seal Separator, then firmly secure extractor handle in vise. *Note: Vise may need to be repositioned to enable end of tool to clear bench.*
23. [] Hold large cylinder of Seal Separator stationary and rotate other cylinder to pull bushing out.
24. [] Remove slider, then pull extractor tool out of Seal Separator and retrieve bushing.
25. [] Repeat procedure for upper bushing in other slider tube.

Lower bushing removal

26. [] On top of slightly open vise jaws, place RockShox Seal Separator (large-end up), and place sleeve from RockShox Bushing Remover (small-end up) on top of Seal Separator.
27. [] Holding slider upside down, insert RockShox Bushing Remover with 30mm-long remover plate up into one side of slider and engage plate against back of first bushing.
28. [] With tool still engaged to bushing, drop end of tool through sleeve, Seal Separator, and vise jaws until slider seats on sleeve, then firmly secure vise on Bushing Remover handle.
29. [] Hold one cylinder of Seal Separator stationary and rotate other cylinder to pull bushing out.
30. [] Repeat previous three previous steps for other lower bushing.
31. [] Using a spoke or seal pick, fish bottom-out bumpers out of sliders.

Cartridge overhaul or replacement

Only the 1997 forks came with a cartridge that can be overhauled. It is possible that a 1997 fork has already had the cartridge replaced with a newer model that cannot be overhauled. Look at both ends of the cartridge body for an internal snap-ring, which indicates it is a 1997 cartridge.

With all 1998 and 1999 cartridges, replacement is the only option. It may also be more economical to replace the 1997 cartridge instead of overhauling it. Check with RockShox technical support for upgrade options to newer improved cartridges.

32. [] Push cartridge shaft to limit both ways and inspect both ends of shaft for wear marks that indicated need of replacement.

33. [] While pushing and pulling cartridge shaft, listen for gurgling sounds that indicate air in cartridge, which is reason for replacement or overhaul.
34. [] Thoroughly clean outside of cartridge, then pump shaft repeatedly. Look for oil seepage at both ends of cartridge, indicating need of replacement or overhaul.

Cartridge-service procedure

NOTE: Skip this procedure if cartridge is being replaced or there are no problems indicated in steps 32-34.

35. [] Firmly grasping shaft with fingers, use Allen key (3mm, occasionally 2mm) to turn adjuster rod (if any) in lower end of shaft fully clockwise (counting turns), and record number of turns here: _____.
36. [] Unthread adjuster rod (if any) from shaft.
37. [] If adjuster rod has been removed, point lower end of shaft into waste-oil receptacle and pump damper unit repeatedly until oil has been pumped out.
38. [] Place Cartridge-Body Fixture on bench (small-I.D.-end up) then place lower end of cartridge body centered on end of fixture.
39. [] Gently tap on shaft with plastic mallet to ease seal out end of cartridge body. Increase effort gradually if light tapping is insufficient.
40. [] Remove cartridge body from top of Cartridge-Body Fixture, then carefully drain remaining oil into receptacle while withdrawing shaft assembly from cartridge body.
41. [] Remove seal, aluminum washer, and top-out O-ring from lower end of shaft.
42. [] Remove internal snap-ring from end of cartridge body.
43. [] Place cartridge body into large-I.D. end of Cartridge-Body Fixture, then support other end of fixture on bench.
44. [] Insert Upper-Seal Installer tool into cartridge body, then tap vigorously on tool to drive out plastic shaft guide and upper seal.
45. [] Inspect shaft for nicks and scratches (replace if any).
46. [] Inspect glide ring on piston for nicks and scratches (replace if any). Inspect that glide ring floats freely.
47. [] Clean all parts with a lint-free rag.
48. [] Install internal snap-ring in groove in upper end of cartridge body, making sure face of snap-ring with sharp edges faces out of cartridge body.
49. [] Coat new upper seal with Judy Butter (or non-lithium Teflon grease) inside and out.
50. [] Place seal (cavity-side first) onto shaft of Upper-Seal Installer tool.

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- 51. [] Place plastic shaft guide (cavity side, if any, first) onto shaft of Upper-Seal Installer tool.
- 52. [] Coat inside of cartridge body with light coating of hydraulic oil that will be used to fill damper unit.
- 53. [] With Upper-Seal Installer tool standing up on bench, slide cartridge body over seal/tool assembly.
- 54. [] Place Cartridge-Body Fixture over cartridge body, then tap on end of fixture with plastic mallet to seat seal and plastic shaft guide into cartridge body.
- 55. [] Remove tools from cartridge body, then install Shaft-Guide tool through seal so small end of tool is inside cartridge body.
- 56. [] Place Cartridge-Body Fixture on bench (large-I.D.-end up) then place cartridge body into fixture.
- 57. [] Fill cartridge body halfway with oil.
- 58. [] Insert shaft assembly (end with no internal thread) into cartridge body until end of shaft engages end of Shaft-Guide tool.
- 59. [] Press shaft assembly into cartridge until Shaft-Guide tool is heard to drop to bench. Then seat shaft assembly fully into cartridge.
- 60. [] Fill cartridge body two-thirds full with oil.
- 61. [] Taking care not to pull shaft out of seal, pump shaft up and down several times to work oil into, and air bubbles out of, valve mechanism.
- 62. [] Slide top-out O-ring, then aluminum washer, over end of shaft and submerge both into the oil.
- 63. [] Fill cartridge body with oil to within 5mm of the top and let sit undisturbed for five minutes so air can dissipate from oil.
- 64. [] Fill cavity side of new bottom seal with grease, and grease outside of seal.
- 65. [] If adjusting rod was not removed from shaft, place a short section of fishing line through hole in seal.
- 66. [] Place seal (cavity-side first) over end of shaft (making sure line, if any, stays in place), then engage seal to cartridge body (making sure line is not trapped between seal and cartridge body).
- 67. [] Place conical washer (conical-face out) over shaft and against face of seal.
- 68. [] Place cavity end of Lower-Seal Installer tool over washer and seal.
- 69. [] With tool covered with rag to catch excess oil that might spurt out, tap plastic mallet against Lower-Seal Installer tool to seat seal fully into cartridge body, then remove Lower-Seal Installer tool.
- 70. [] If adjuster rod has been removed, replace adjuster-rod O-ring with a new, greased O-ring.

- 71. [] If installing adjuster rod, fill shaft with oil.
- 72. [] If fishing line was used when installing seal, remove line now.
- 73. [] Grasping shaft firmly with fingers, thread adjusting rod into shaft until fully bottomed.
- 74. [] Turn adjusting rod out by number of turns recorded in step 35.

Bushing and seal installation

- 75. [] Secure Judy Bushing Installer base upright in vise, with vertical post positioned out past end of vise jaws.

The Judy Bushing Installer tool comes with four long sleeves of various lengths. Originally, these sleeves were intended for setting the correct lower-bushing height for different models. Because travel can be changed on any model, RockShox now recommends using the red (128mm) sleeve only, which sets the lower bushing at the correct height regardless of model or travel configuration.

- 76. [] Place red (128mm) sleeve on tool shaft, then place smaller-diameter bushing (O.D. 30.5mm) on tool shaft.
- 77. [] Place one slider tube over tool shaft, insert small end of driving tool into hole in end of slider, then tap on driving tool until bushing is fully seated.
- 78. [] Remove slider and repeat previous two steps for other slider tube.
- 79. [] Remove red sleeve and place short (10mm) sleeve on tool shaft, then place larger-diameter bushing (O.D. 31.0mm) on tool shaft.
- 80. [] Place one slider tube over tool shaft, insert small end of driving tool into hole in end of slider, then tap on driving tool until top edge of bushing is even with second shoulder from top of slider. *Note: It is possible to insert bushing too far, with top edge below second shoulder. During installation, stop and inspect depth repeatedly!*
- 81. [] Remove slider and repeat previous two steps for other slider tube.
- 82. [] Insert bottom-out bumpers into slider tubes and push both down until they are below lower bushings.
- 83. [] Insert seal spacers (1997 models only) and seals into top end of each slider tube, then tap with mallet until each is fully seated and level.
- 84. [] Thoroughly grease all bushings and pockets inside seals with Judy Butter grease.

Neutral-shaft installation

85. [] **1997 and 1998 models:** Install to bottom (threaded) end of neutral shaft in order: washer(s), conical bumper (large-end first), then lower shaft guide (cupped-face first). *Note: T2 model right-side neutral shaft order is: washer, conical bumper (fat-end first), then shaft guide (cupped-face last). T2 left side has no washer or conical bumper, but shaft guide goes cupped-face first.*
86. [] **1999 models:** Install to bottom (threaded) end of neutral shaft in order: pin, upper shaft guide (with O-ring), top-out spring (elastomer), top-out spring guide, shaft guide retaining ring, then shaft guide.
87. [] **Only 1997 and 1998 models:** Install upper shaft-guide assembly then plastic end plate to top of neutral-shaft.
88. [] Insert neutral-shaft assembly into left slider (right side if 1997 model), install wavy washer (only if model has two), then install snap-ring so face with sharp edges faces out. T2 model, repeat for second side.
89. [] **1998 models only:** Install conical bumper large-end first on neutral shaft.

Cartridge installation

90. [] Install end plate on top (unthreaded) end of shaft, then install conical cartridge washer (1997 only) flat-face first onto lower end of cartridge shaft.
91. [] Insert cartridge into stanchion, insert wavy washer (if any), then install snap-ring so face with sharp edges faces out. *Note: T2 and 1998 models with 63mm travel, install conical bumper large-end first on cartridge shaft.*

Slider installation

92. [] Pull both neutral shaft and damper shaft fully out of stanchions.
93. [] Place boots on stanchion tubes, then carefully push slider assembly partially onto stanchions, using gentle rocking motion until alignment is achieved and sliders move up easily. Stop before bottoms of sliders engage either shaft.
94. [] **1998 and 1999 models:** Position fork so bottoms of sliders are higher than fork crown, then pour 10cc of 5wt shock oil (non seal-swelling) into each slider tube through holes for bottom bolts.
95. [] Push sliders on just far enough to see ends of shafts engaging holes in bottoms of slider tubes. Use small tool to align shafts to holes, if necessary.

96. [] Install new crush washers to shaft bolts/nuts (except 1997 models), prepare bolt/nut threads with Loctite 242, then engage bolts/nuts to neutral and damper shafts.
97. [] Secure bolts/nuts to 50in-lbs.
98. [] **1998 only:** Insert adjuster knob through shaft bolt into damper shaft.
1999 only: Slide adjuster knob over shaft nut on damper shaft, then install small screw to retain knob.

Spring-stack and top-cap installation

99. [] Thoroughly grease springs, then insert into tops of stanchions in following orders:
1997 and T2: elastomer, spacers, then coil
1998: long coil, spacer, then short coil
1998 XL: spacer rod with end plates, long coil, spacer, then short coil.
1999: coil spring, then plastic spacer.
100. [] Carefully thread in top-cap assembly, then secure to 30in-lbs.
101. [] Restore pre-load setting from step 1.
102. [] Engage boots to seals on top of sliders.

TUNING OPTIONS**Pre-load adjustment**

One tuning option for this fork is to adjust the pre-load adjusting knobs to add or subtract pre-load on the springs. Greater pre-load on the springs makes the fork stiffer, which increases resistance to compression and increases rebound speed. Less pre-load on the springs makes the fork softer, reducing resistance to compression and decreasing rebound speed.

The fork should sag when the rider's weight is on it. Sag helps keep the tire in contact with the ground on rough terrain, when rolling over dips or holes. The pre-load should be adjusted to create the correct amount of sag, when the rider sits on the bike. RockShox's recommended sag amounts are:

- Fork with 100mm travel: 18–25mm sag
- Fork with 80mm travel: 13–20mm sag
- Fork with 63mm travel: 7–15mm sag

Changing springs

Springs should be changed if the sag cannot be set within the desired range by changing the pre-load adjustment. Even if sag can be set, if the fork bottoms out too frequently, stiffer springs are needed and if the fork never bottoms out on the most severe bumps, softer springs are needed.

38 – SUSPENSION FORKS AND REAR SHOCKS

There are three different spring systems used in these models: Type 2 springs (a combination of elastomer and coil springs), Type 3 springs (a combination of two coil springs), and Single Coil ('99 XL only).

Type 2 springs: The progressiveness of the spring can be modified by changing the Spring Rate Adjuster, which is a plastic stud that fits into the coil spring. Different lengths of studs affect how soon the coil spring compresses fully, which results in additional compression of the elastomer spring. The Spring Rate Adjusters are color-coded. They come as a kit (part #59136 for '97 models, and part #110-001414-00 for the '98 T2 model).

Soft: beige

Medium: black

Hard: gray

The coil springs are available in several varieties, which are:

Soft: red (#110-000591-00)

Medium: yellow (#110-00592-00)

Firm: green (#59141)

Extra firm: purple (#59139)

Type 3 springs: This spring type is a combination of two coil springs. All four coils can be independently changed to fine tune the overall spring strength. The shorter (top) spring is the primary spring, and the longer (bottom) spring is the secondary spring. In the following list for 63mm and 80mm travel models, the first part number is the primary spring, and the second part number is the secondary spring.

Xtra soft: silver (nos. 44460-01 & 44459-01)

Soft: yellow (nos. 44460-02 & 44459-02)

Medium: red (nos. 44460-03 & 44459-03)

Firm: black (nos. 44460-04 & 44459-04)

The following list for the 100mm travel '99 SL model has only one part number because there is only one spring length.

Xtra soft: silver (#110-000333-00)

Soft: yellow (#110-000333-01)

Medium: red (#110-000333-02)

Firm: black (#110-000333-03)

Single Coil springs: This variety of spring is found only in the '99 XL model. The following varieties of springs are available.

Soft: yellow (#510-001379-02)

Medium: red (#510-001379-03)

Firm: black (#510-001379-04)

Cartridge damping-rate adjustment

If the damper cartridge has adjustable compression damping, there will be a hollow bolt at the bottom end of one, or both, of the sliders. A 2mm Allen

wrench can be inserted through the hollow bolt to turn the adjuster. Always start by turning the adjuster fully clockwise (increases damping), counting turns. From this point, the adjustment can be turned up to two full turns counterclockwise (reducing damping). *Caution: Turning the adjuster rod too far counterclockwise will cause an oil-seal failure on some models!*

The DH fork that comes with two damping cartridges has adjustable compression damping (described above) in the left leg, and adjustable rebound damping in the right leg. There are four full turns of adjustment available from fully clockwise; clockwise increases damping, and counterclockwise reduces damping.

The models that come with the C3 cartridge will have a 23mm-long aluminum adjusting knob in the bottom of the right leg. With the knob pushed fully in, turning it clockwise increases rebound damping and counterclockwise reduces rebound damping. With the knob pulled fully out, turning it clockwise increases compression damping and counterclockwise reduces compression damping. Always return the knob to the pushed-in position after completing adjustment of the compression damping.

Oil viscosity

In the 1997 models with serviceable cartridges, RockShox recommends 5wt or 8wt oil. Lighter-weight oils reduce compression and rebound damping. Heavier-weight oils increase compression and rebound damping. It may also be preferable to use lighter oils in extremely cold conditions.

Travel adjustment

Changing travel requires a travel kit, which consists of a damper cartridge and different spacers for the springs. Due to extra stress on the fork crown, only XL and XLC models should be increased to 100mm of travel. There is no kit to reduce travel to 63mm. The following kits are available:

1997 Judy models: 80mm, #59126

1998 T2 model: 80mm, #110-000611-00

1998 XC/SL models: 80mm, #110-000607-00

1998 XL/XLC models: 100mm, #110-000608-00

1999 SL model: 80mm, #110-002062-00

ROCKSHOX '99-'00 JUDY HYDRACOIL FORKS

ABOUT THIS SECTION

This section covers service of several 1999 and 2000 Judy forks including '99 Judy C, XC, 100, and XLC and '00 Judy XC, SL, Race, and XL models. The '00 Judy XC, SL, Race, and XL are "All-Travel" models, which require slightly different procedures, which are specified at various points. This section does not cover the 1999 Judy XL and SL, which are covered in **ROCKSHOX '97-'99 JUDY CARTRIDGE FORKS** (page 38-42). Complete service techniques, including bushing replacement, are included. RockShox recommends an oil change, complete cleaning, and lubrication every 100 hours of use or one year, whichever comes first. Bushing replacement should be done when the fork develops obvious play between the stanchions and sliders.

TOOL CHOICES

For all services other than bushing replacement, the following specialized tools are required:

- United Bicycle Tool AL-11912B (22mm socket already custom ground for optimal purchase)
- 24mm socket (must be custom ground to eliminate internal bevel for optimal purchase).

FULL FORK SERVICE

Spring-stack removal

1. [] Turn spring adjuster fully counterclockwise, counting number of turns on each side:
No. of turns on right: _____
No. of turns on left: _____
2. [] Use 22mm or 24mm socket to unthread spring caps on each side, then remove caps.
3. [] Remove plastic spring spacer (if any) and spring from each side, then turn fork over to remove plastic spring retainers. Note: Oil will pour out, and fork may need to be tapped with plastic mallet before spring retainers will drop out.

Slider and plunger/damper removal

4. [] Use 5mm Allen wrench to partially unthread bolts in bottoms of sliders, tap on bolt heads with plastic mallet until heads are back against sliders, then remove bolts.
5. [] Pull slider and boots off stanchions.

6. [] *All except '00 SL, Race, and XL:* Turn fork over and push plunger and damper out tops of stanchions. Only '00 XC, remove plastic All-Travel spacers from shafts.
Only '00 SL, Race, and XL: Remove snap-rings from bottoms of stanchions and pull plunger and damper out bottoms of stanchions.
7. [] *Only '00 SL, Race, and XL:* Remove shaft guide (Homer Valve), brass washer, then plastic All-Travel spacers from bottoms of shafts.

Seal and bushing removal

Seal and bushing removal is identical to forks covered in **ROCKSHOX '97-'99 JUDY FORKS**. See page 38-43.

Cleaning and inspection

8. [] Clean all parts with mild detergent and thoroughly dry with compressed air and/or lint-free rag.
 9. [] Inspect wiper seals and damper-shaft guide ring for nicks or tears.
 10. [] Measure coil springs and replace if length is unacceptable (too short).
- | Models | Unacceptable |
|---------------------------|--------------|
| All-Travel models | ≤200mm |
| Other 63/80mm models | ≤156mm |
| Other 100mm travel models | ≤220mm |
| All negative springs | ≤22mm |

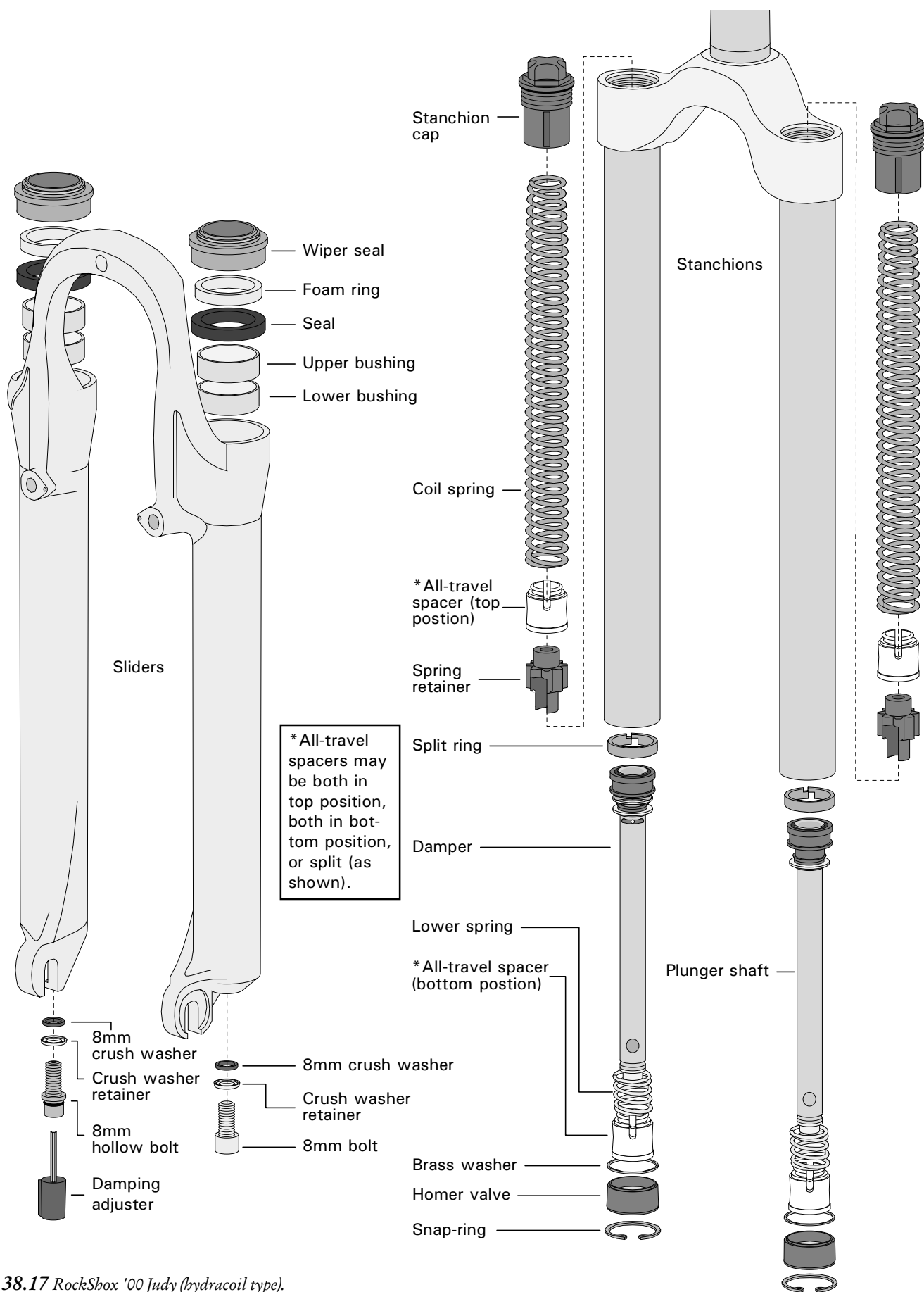
Seal and bushing installation

With the exception of models with All-Travel spacers, seal and bushing installation is identical to forks covered in **ROCKSHOX '97-'99 JUDY FORKS** (page 38-46). With those models that use All-Travel spacers, the only difference is the sleeve used to set the depth of the lower bushing. For All-Travel models, use sleeve 140-002860-00 (131mm) instead of the red sleeve recommended in the procedure.

Slider and plunger/damper installation

11. [] *All-Travel models only:* Install All-Travel spacers on damper and plunger shafts with small-diameter ends up. Use following guide to create desired amount of travel.
63mm travel: two spacers per shaft
80mm travel: one spacer per shaft
100mm travel: no spacers on shafts
Note: Any remaining spacers go on bottoms of main springs!
12. [] *Only '00 SL, Race, and XL:* Install brass washer, then Homer Valve (cupped-end first) onto damper and plunger shafts.

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38.17 RockShox '00 Judy (hydraulic type).

13. [] *All except '00 SL, Race, and XL:* Drop damper shaft into right stanchion and plunger shaft into other stanchion. Shafts should protrude from stanchions.
Only '00 SL, Race, and XL: Insert damper-shaft assembly in bottom of right stanchion and plunger-shaft assembly in left stanchion, then install snap-rings (sharp-edged-face out) into each stanchion.
14. [] Slide boots onto stanchions
15. [] Grease bushings, and fill pockets in wiper seals with Judy Butter or similar non-lithium grease.
16. [] Guide slider assembly onto stanchions.
17. [] Replace crush washers on bottom bolts.
18. [] Put drop of Loctite 242 on threads of bolts, insert bolts into bottoms of sliders (hollow bolt, if any, on right), then thread bolts into shafts.
19. [] Secure both bolts to 60in-lbs.
20. [] Install adjuster knob (if any) into right-side bottom bolt, turn fully clockwise (1/4 turn range of motion possible), then remove knob and re-install so indicator points at “+” on decal.
21. [] Attach boots to wiper seals.

Spring-stack installation

22. [] Pour correct amount of RockShox Extra Light (5wt) oil into each stanchion. Recommended oil volumes are:

Judy models	Volume
'99 C	115cc
'99 XC and 100	110cc
'00 SL, Race, and XL	120cc
'99 & '00 XLC	130cc
23. [] Install spring retainers into each stanchion (short-end up).
24. [] *All-Travel models only:* Install correct number of spacers to bottoms of springs. Use following guide to create desired amount of travel.
 - 63mm travel: no spacers on springs
 - 80mm travel: one spacer per spring
 - 100mm travel: two spacers on springs

Note: There should be no remaining spacers!
25. [] Grease spring coils thoroughly and install in stanchions.
26. [] Install spring spacers (if any) in stanchions (large-diameter ends up).
27. [] Thread top caps into stanchions and torque plastic caps to 40in-lbs, or aluminum caps to 50in-lbs.
28. [] Reset spring pre-load on each top-cap adjuster.

Crown-bolt security

29. [] Check crown-bolt torque (if any). RockShox recommended torque is 90in-lbs.

TUNING OPTIONS

Sag and pre-load adjustment

RockShox recommends the following amounts of sag, depending on the maximum travel of the fork.

63mm travel	7–15mm sag
80mm travel	13–20mm sag
100mm travel	18–25mm sag

Adjust the pre-load adjusters (up to 5 full turns from loosest to tightest) to achieve sag in the recommended range. Check sag by measuring the change in distance from the top of the slider tube to the bottom of the crown after the rider gets on the bike. If it is not possible to achieve the recommended sag with the existing springs, then consider changing springs. The extra soft (silver), soft (yellow), medium (red), and firm (black) springs can be used in various mixtures to achieve the desired spring rate. RockShox recommends these combinations: soft-soft (for 100–150lb. rider), soft-medium (for 125–175lb. rider), medium-medium (for 150–200lb. rider), medium-firm (for 175–225lb. rider), and firm-firm (for 200–250lb. rider). For hard riding on extreme terrain, consider the rider to be of a higher-weight classification.

Changing spring rates

Springs with different firmness are available for '99 and '00 HydraCoil Judy forks. For the '99 Judy C and XC models, three spring kits are available: soft (yellow, #110-002056-01), medium (red, #110-002056-03), and firm (black, #110-002056-05). For the '99 Judy 100, 100mm XL, and XLC models, three spring kits are available: soft (yellow, #110-002056-02), medium (red, #110-002056-04), and firm (black, #110-002056-06). For the '00 Judy models, four spring kits are available: extra-soft, (silver, #100-004473-00), soft (yellow, #100-004774-00), medium (red, #100-004775-00), and extra-firm (black, #100-004776-00).

Rebound damping

All except '00 SL, Race, and XL: The damping valve of these model forks affects rebound only. The valving is not intended to be adjusted, but RockShox recommends switching to 15wt oil if rebound damping is inadequate.

Only '00 SL, Race, and XL: The damping valve of these model forks affects rebound only. The valving is adjustable by means of the knob on the bottom of the right leg, which has a range of adjustment of slightly less than 90°. Turn the knob towards the “+” mark to increase rebound damping. RockShox recommends switching to 15wt oil if rebound damping is insufficient with the knob turned all the way to the “+” mark.

Travel adjustment

All-Travel models only (2000): As described in the procedure in this section, these models can be set up as 63mm, 80mm, or 100mm travel, depending on the location of the All-Travel spacers. There are two spacers in each leg, which can be switched between being on the shafts below the top-out springs, or being positioned below the main springs. The correct spacer locations are:

- 63mm travel two below each top-out spring
- 80mm travel one below each spring
- 100mm travel two below each main spring

All other models (1999): Travel kits are available to convert from 63mm to 80mm, and from 80mm to 100mm. The XLC is the only model that can be set up with 100mm travel. The travel kit includes plunger and damper shafts, springs, and spring spacers.

ROCKSHOX '98 SID FORKS

ABOUT THIS SECTION

This section covers RockShox 1998 SID fork service, including bushing removal and replacement. The 1998 SID forks can be distinguished by looking at the RockShox decals. If the decals have a black background, the fork is a 1998 model. If the decals are missing, inspect the bolt heads at the bottom of the slider tubes. If the bolt heads are titanium and have six 2mm diameter holes drilled in each head, the fork is a 1998 SID. If neither the decals or bolt heads confirm the SID fork is a 1998 model, then the fork is a later model, in which case see **ROCKSHOX '99-'00 SID FORKS** (page 38-56).

TOOL CHOICES

This fork requires several tools that are used to service other RockShox forks, but no tools that are unique to servicing only the SID fork. For bushing replacement, the same tools are required that are used with Judy forks. This includes the Universal Bushing Removal Tool #70096, the Judy Bushing Installer #70119, and the RockShox Seal Separator #70113.

FULL FORK SERVICE

Top-cap and slider-assembly removal

1. [] Remove front wheel, and disconnect brake cable from brake lever.

2. [] Remove Phillips screws in stanchion caps (note small O-rings under screw heads).
 3. [] Grease RockShox inflation needle, and insert into stanchion caps to release air pressure from both sides of fork.
 4. [] Use 22mm socket or adjustable wrench to unthread stanchion caps (note O-rings under cap flanges).
 5. [] Turn fork over to drain oil out tops of stanchions.
- NOTE:** *Observe Allen fittings accessible inside each stanchion tube. The 8mm Allen fitting adjusts spring rate. 2mm Allen fitting inside the 8mm Allen fitting adjusts damping.*
6. [] Use 8mm Allen to unthread titanium bolts at bottoms of sliders 4 full turns.
 7. [] Gently tap on bolt heads until heads are seated against sliders again, then finish removing bolts.
 8. [] Turn fork over and drain oil out bottoms of sliders.
 9. [] Pull sliders off stanchion tubes, then remove boots from stanchion tubes.

Cartridge and neutral-shaft removal

10. [] Remove internal snap-rings from bottom ends of stanchions, then remove wavy washers.
11. [] Thread bolts back into damper shaft and neutral shaft.

NOTE: *Remove neutral shaft for cleaning and lubrication, negative-spring adjustment, replacement of piston rings if air pressure is being lost, or to change top-out bumper spacers.*

NOTE: *Remove damper cartridge for cleaning and lubrication of piston rings, replacement of piston rings, adjustment of negative spring, or replacement of damper cartridge.*

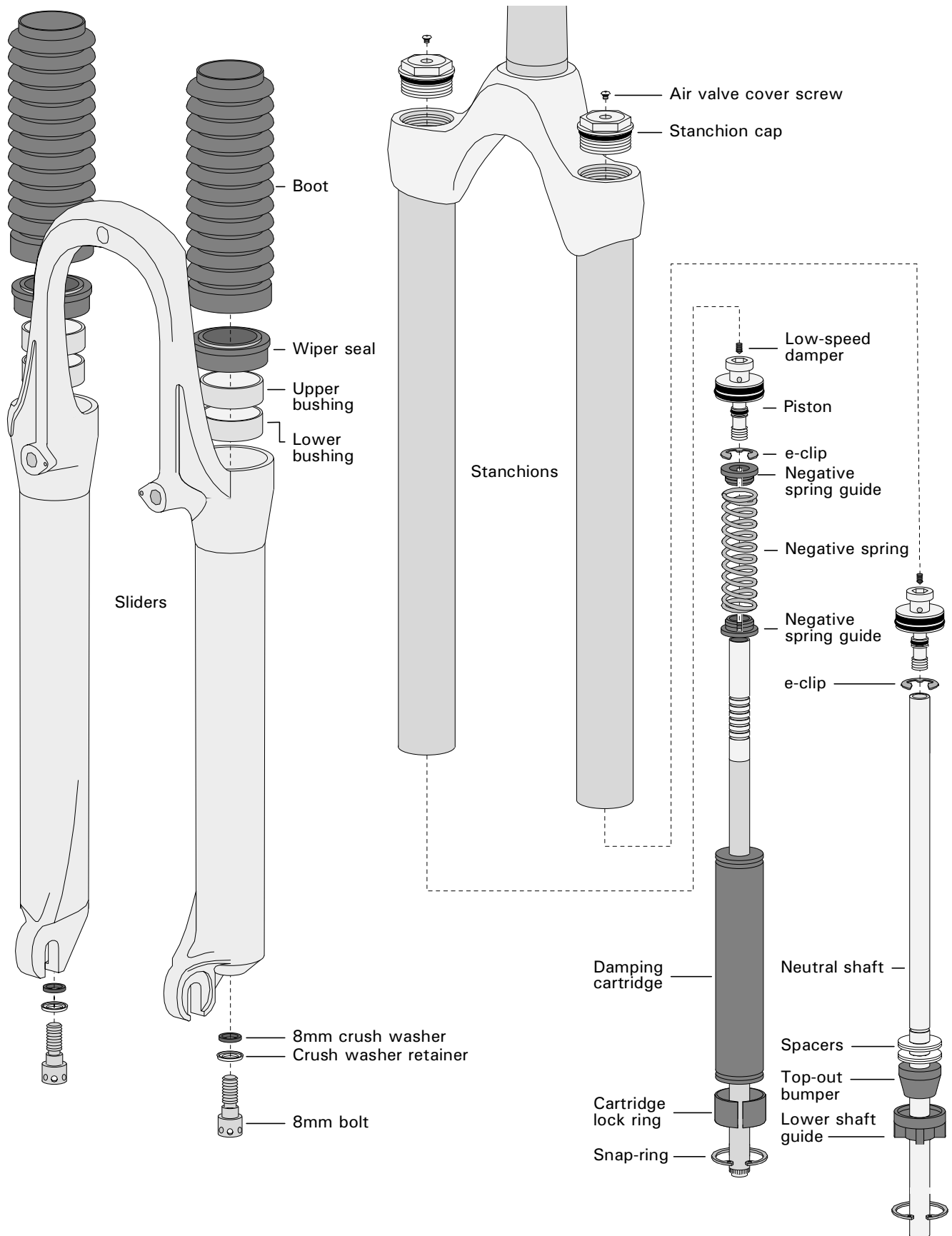
12. [] Insert spoke through holes in bolt heads, and pull on spoke to remove damper cartridge and/or neutral shaft assembly from stanchion tubes.
13. [] If adjusting negative spring, move e-clip on damper shaft down to increase negative-spring force, or up to reduce. (Negative spring can be removed entirely by unthreading piston, then removing e-clip and spring.)
14. [] With 8mm Allen, remove pistons from tops of shafts. Remove shaft guide, bumper, and washers from bottom of neutral shaft.

NOTE: *If not servicing bushings, go to step 27.*

Seal and upper-bushing removal

Bushing wear can be determined in two ways. After removing the seals in step #15, insert the stanchions into the sliders again and check for any fore-and-aft play. Obvious looseness is caused by worn bushings. Alternatively, before removing the bushings, clean

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them thoroughly and inspect their condition with the aid of a flashlight. Good bushings have a gray coating. Worn bushings are metallic gold or bronze in appearance where the coating has worn away.

15. [] Insert screwdriver into seal on top of slider, then pry seal out.
16. [] Place Seal Separator upright on slightly open vise jaws with large-diameter end up.
17. [] Install 30mm-long extractor plate onto extractor tool, push slider onto end of extractor tool until upper bushing clears extractor plate, then pull out on slider until extractor plate catches on edge of upper bushing.
18. [] Guide handle of extractor down through Seal Separator and vise jaws until top of slider tube rests on Seal Separator, then firmly secure extractor handle in vise. *Note: Vise may need to be repositioned to enable end of tool to clear bench.*
19. [] Hold large cylinder of Seal Separator stationary and rotate other cylinder to pull bushing.
20. [] Remove slider, then pull extractor tool out of Seal Separator and retrieve bushing.
21. [] Repeat procedure for upper bushing in other slider tube.

Lower-bushing removal

22. [] Place RockShox Seal Separator (large-end up) on top of slightly open vise jaws then place sleeve from RockShox Bushing Remover (small-end up) on top of Seal Separator.
23. [] Holding slider upside down, insert RockShox Bushing Remover with 30mm-long remover plate up into one side of slider and engage plate against back of first bushing.
24. [] With tool still engaged to bushing, drop end of tool through sleeve, Seal Separator, and vise jaws until slider seats on sleeve, then firmly secure vise on Bushing Remover handle.
25. [] Hold one cylinder of Seal Separator stationary and rotate other cylinder to pull bushing.
26. [] Repeat previous three previous steps for other lower bushing out.

Cleaning and inspection

1998 damper cartridges cannot be overhauled. Replacement is the only option.

27. [] Use mild detergent to thoroughly clean all parts. Dry with lint-free rag and/or compressed air. Avoid solvents, which may damage seals and other non-metallic parts.
28. [] Inspect all rubber O-rings and glide rings for nicks and tears, and replace as necessary.
29. [] Replace crush washer on each shaft bolt.

30. [] Push cartridge shaft to limit both ways and inspect both ends of shaft for wear marks that indicated need of replacement.
31. [] While pushing and pulling cartridge shaft, listen for gurgling sounds that indicate air in cartridge, which is reason for replacement.
32. [] Thoroughly clean outside of cartridge, then pump shaft repeatedly. Look for oil seepage at both ends of cartridge, indicating need of replacement.
33. [] Inspect stanchion tubes for bends, scratches, or heavy wear.
34. [] Inspect fork crown for cracks.

Bushing and seal installation

35. [] Secure Judy Bushing Installer base upright in vise, with vertical post positioned out past end of vise jaws.

The Judy Bushing Installer tool comes with four long sleeves of various lengths. Originally, these sleeves were intended for setting the correct lower-bushing height for different models. Because travel can be changed on any model, RockShox now recommends using the red (128mm) sleeve only, which sets the lower bushing at the correct height regardless of model or travel configuration.

36. [] Place red (128mm) sleeve on tool shaft, then place smaller-diameter bushing (O.D. 30.5mm) on tool shaft.
37. [] Place one slider tube over tool shaft, insert small end of driving tool into hole in end of slider, then tap on driving tool until bushing is fully seated.
38. [] Remove slider and repeat previous two steps for other slider tube.
39. [] Remove red sleeve and place short (10mm) sleeve on tool shaft, then place larger-diameter bushing (O.D. 31.0mm) on tool shaft.
40. [] Place one slider tube over tool shaft, insert small end of driving tool into hole in end of slider, then tap on driving tool until top edge of bushing is even with second shoulder from top of slider. *Note: It is possible to insert bushing too far, with top edge below second shoulder. During installation, stop and inspect depth repeatedly!*
41. [] Remove slider and repeat previous two steps for other slider tube.
42. [] Insert bottom-out bumpers into slider tubes and push both down until they are below lower bushings.
43. [] Insert seals into top end of each slider tube, then tap with mallet until each is fully seated and level.
44. [] Thoroughly grease all bushings and pockets inside seals with Judy Butter grease.

Cartridge and neutral-shaft installation

45. [] Replace worn or damaged O-rings, glide rings (on pistons), or seals.
46. [] Thread pistons fully into tops of shafts, but do not secure.
47. [] Install in order onto bottom of neutral shaft: plastic washers, conical bumper (large-diameter-end first), then shaft guide (cupped-face first).
48. [] Grease shaft and piston of damper cartridge assembly, then slide piston-end first into right-side stanchion.
49. [] Use 7/8" O.D. PVC pipe or similar cylinder to gently seat cartridge body just beyond snapping groove, then install snap-ring.
50. [] Pull damper shaft out as far as negative spring will allow.
51. [] Grease neutral shaft piston rings and top-out bumper.
52. [] Slide neutral shaft into left leg, engage snap-ring, then pull shaft out until even with damper shaft.

Slider assembly and top-cap installation

53. [] Install boots on stanchions.
54. [] Use Judy Butter or equivalent grease to grease stanchion tubes, bushings in sliders, and pockets in inner perimeters of wiper seals.
55. [] With bike/fork upright, put 5cc of oil in each stanchion tube, then install top caps to 35–40in-lbs each.
56. [] Put 5cc of oil in each slider tube and swirl around to coat inside of tubes.
57. [] Place sliders onto stanchions until just short of point shafts will be compressed.
58. [] Invert fork/bike, then pour 15cc of oil into bolt hole at bottom of each slider.
59. [] Treat both bottom bolts with Loctite 242.
60. [] Press sliders on fully, then engage bolts through holes in bottoms of sliders into neutral shaft and damper shaft and torque to 50in-lbs.
61. [] Use pump with RockShox inflation needle to pressurize both stanchions to desired pressure.
62. [] Install Phillips screws in stanchion caps.
63. [] Install wheel and reattach brake cable.

TUNING OPTIONS***Air-spring pressure***

The fork should sag when the rider's weight is on it. Sag helps keep the tire in contact with the ground on rough terrain, when rolling over dips or holes. The air pressure should be adjusted to create the correct amount of sag, when the rider sits on the bike. The recommended sag for this fork is between 3mm and

8mm. The air pressure should be adjusted to create this amount of sag. RockShox recommends the following depending on rider weight:

< 130lbs	40psi
120–150lbs	50psi
140–170lbs	60psi
160–190lbs	70psi
> 180lbs	80psi

The rider's style affects the necessary pressure, as well. This is why the weight ranges in the list overlap somewhat. For example, a less aggressive 165lb rider might do best with the 60psi recommendation, but a more aggressive 165lb rider might do best with the 70psi recommendation. If air pressure cannot be maintained, seals may need replacement, or there may be a problem with the low-speed damping adjusters. See the following section ***Low-speed-damping adjustment***.

Changing air-spring volume

The air springs get more progressive if the volume is reduced. A more progressive spring gets more resistant to compression at a given point in the travel than a less progressive spring. To adjust the volume, the springs must be depressurized and the top caps removed. A long 8mm Allen wrench can be used to adjust the piston height at the bottom of the air chamber. First, turn the wrench clockwise, counting the number of turns until it stops, to determine the current position. From the fully bottomed position, the pistons can be turned up to five full turns counterclockwise. It is critical to start by finding the bottom, because there is no stop to prevent loosening the pistons more than five full turns, which will cause the air chamber to not maintain pressure.

The pistons do not have to be adjusted equally, so maximum volume is with both turned fully clockwise. A medium adjustment is with both up 2.5 turns, or with one fully down and the other up five full turns. A minimum volume is with both turned five full turns up (counterclockwise).

Cartridge damping-rate adjustment

The damping cartridge is not adjustable, but three damping cartridges are available: soft (#20882-001), medium (#20882-002), and firm (#20882-003). RockShox recommends switching to the firm cartridge if 70psi or more is the best air pressure for the rider, but the fork acts too quick (too lightly damped) at this pressure. Conversely, the soft cartridge is recommended if the correct pressure for the rider is 50psi or less, but at that pressure the fork seems too heavily damped (sluggish).

Low-speed-damping adjustment

RockShox no longer feels the low-speed damping adjustment is effective, and may be a source of air-pressure leaks. RockShox recommends installing the low-speed damping screws with Loctite 242 and tightening each fully. If pressure loss continues, remove the piston heads from the neutral and damper shafts and seal the holes in the threaded studs on the bottom ends of the pistons. Alternatively, put rubber plugs under the low-speed damping adjuster screws.

Negative-spring adjustments

There are two possible adjustments to the negative spring. The negative-spring pre-load can be adjusted, and there are two strengths of springs available.

The negative spring serves to counteract the inherently high main-spring pre-load that exists with air-sprung forks. With the fork pre-load too high, the fork tends to not react to small bumps. Increasing negative-spring pre-load decreases the fork pre-load.

The negative-spring is on the damper shaft. When the damper is removed, the e-clip on top of the negative spring can be moved into one of several grooves. The fork has the most pre-load when the spring is removed, and the least pre-load when the e-clip is in the lowest groove. Each groove changes the spring rate by 4 lb-in.

The stock spring is the light spring. Light riders (under 130lbs) may need the heavy spring (#510-00689-00).

ROCKSHOX '99-'00 SID CARTRIDGE FORKS

ABOUT THIS SECTION

This section is specific to RockShox SID forks made in 1999 and 2000. For the 2000 models, this section only applies to the Race, SL, and XL models. The 2000 SID XC and 100 are a different design and are not available at the time of this writing. The 1999 and 2000 models this section does apply to are distinguished by the C3 cartridge adjuster knob on the bottom of the left leg. This 23mm-long aluminum knob can be pulled down another few millimeters to change between compression and rebound damping adjustment. Decals that say “C3 Dual Adjust” further identify the models this section applies to. See ***ROCKSHOX '98 SID FORK*** (page 38-52) for the 1998 model, which is signifi-

cantly different. The lack of the adjuster knob and the large RockShox decals with a black background distinguish 1998 models.

TOOLS

Servicing this fork requires one specialized tool that is unique to this model, the RockShox Cartridge Sleeve Retainer Tool #140-001905-00. For sake of brevity, the following procedure will refer to this tool simply as the “cartridge driver.” This fork needs one other tool common to several RockShox forks for removing the caps at the tops of the legs, the United Bicycle Tool AL-11912B (custom-ground 22mm socket for fitting low-profile wrench flats). The standard RockShox pump is adequate for inflation, with the addition of a 1999 Sid valve adapter.

For bushing replacement, the same tools are required that are used with Judy forks. This includes the Universal Bushing Removal Tool #70096, the Judy Bushing Installer #70119, and the RockShox Seal Separator #70113.

FULL FORK SERVICE

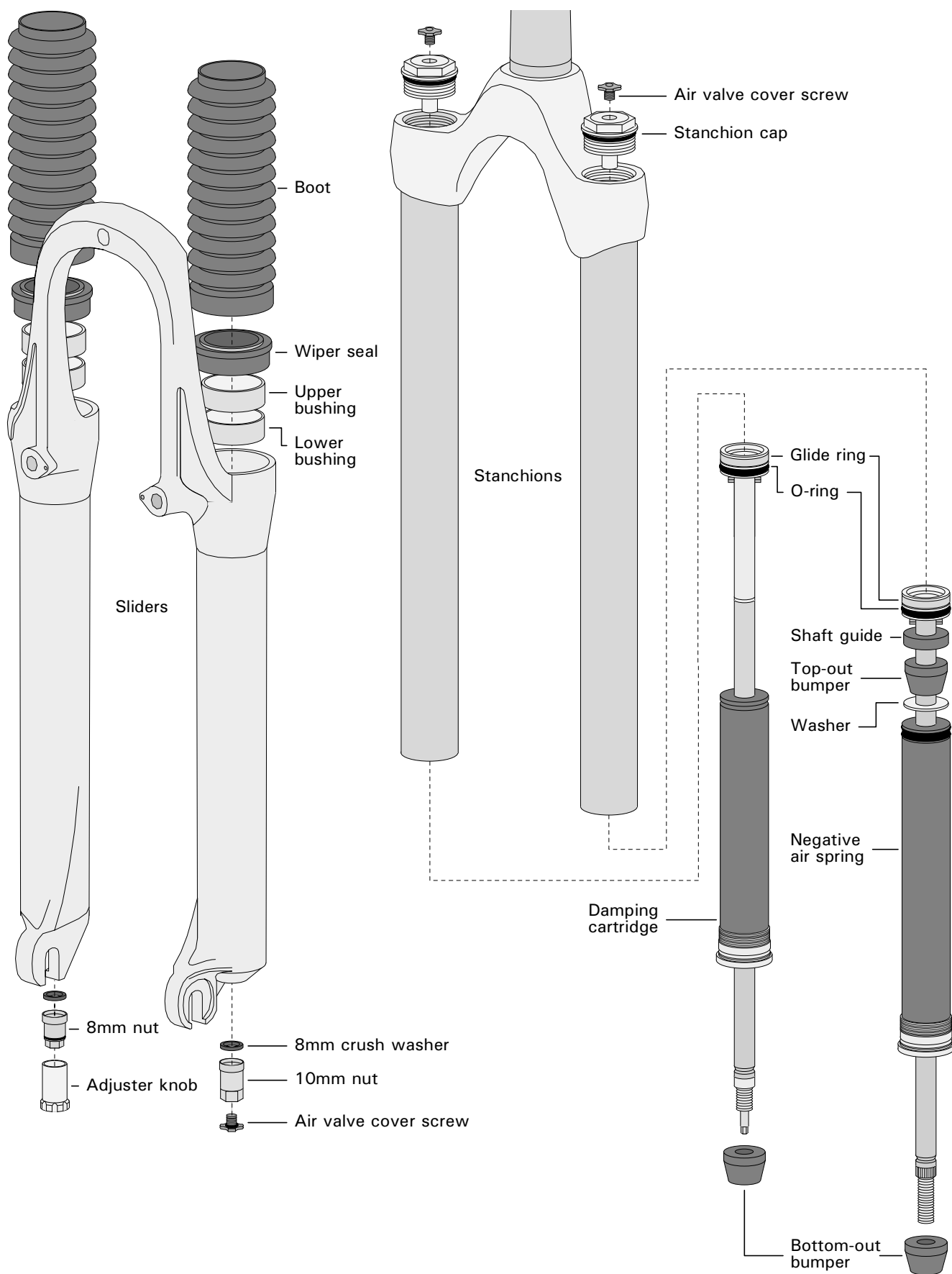
Slider removal

1. [] Remove plastic valve caps from top and bottom of left leg and top of right leg.
2. [] Push in adjuster knob on bottom of right leg, unscrew Phillips screw, then remove adjuster knob.
3. [] Depressurize air valve in bottom of left leg.
4. [] Unthread 8mm nut on bottom of right leg just until hex-shaped adjuster rod no longer protrudes.
5. [] Unthread 10mm nut on bottom of left leg about 5mm.
6. [] Depressurize both air valves at tops of legs.
7. [] Use 22mm socket to remove both air cap assemblies from tops of legs.
8. [] Tap on nuts at bottoms of legs with plastic mallet until nuts are against sliders, then unthread both nuts completely. *Note: Be prepared for oil to drain out holes at bottoms of sliders!*
9. [] Pull slider assembly of bottoms of stanchions, then remove boots. Drain remaining oil from sliders.

Cartridge and negative spring disassembly

There are two cartridges in the stanchions of the fork. The left cartridge is a negative air spring and the right cartridge is a hydraulic damper. The damper car-

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tridge is non-serviceable, but is removed for cleaning, inspection, and replacement of the glide ring and O-ring at the top of the damper shaft.

10. [] Pull conical bottom-out bumpers off cartridge shafts.
11. [] Push both cartridge shafts fully in. It is necessary to open air valve in left shaft to release air pressure.
12. [] Use cartridge driver to turn both cartridges clockwise until completely unthreaded, then pull on cartridge shafts to remove cartridges.
13. [] Carefully remove blue glide ring and black O-ring from top end of each cartridge shaft.
14. [] Pull cylinder off bottom of negative-spring assembly, then remove washer, conical top-out bumper, and plastic plate.

Seal and upper-bushing removal

Bushing wear can be determined in two ways. After removing the seals in step #15, insert the stanchions into the sliders again and check for any fore-and-aft play. Obvious looseness is caused by worn bushings. Alternatively, before removing the bushings, clean them thoroughly and inspect their condition with the aid of a flashlight. Good bushings have a gray coating. Worn bushings have a metallic gold or bronze appearance where the coating has worn away.

15. [] Insert screwdriver into seal on top of slider, then pry seal out.
16. [] Place Seal Separator upright on slightly open vise jaws with large-diameter end up.
17. [] Install 30mm-long extractor plate onto extractor tool, push slider onto end of extractor tool until upper bushing clears extractor plate, then pull out on slider until extractor plate catches on edge of upper bushing.
18. [] Guide handle of extractor down through Seal Separator and vise jaws until top of slider tube rests on Seal Separator, then firmly secure extractor handle in vise. *Note: Vise may need to be repositioned to enable end of tool to clear bench.*
19. [] Hold large cylinder of Seal Separator stationary and rotate other cylinder to pull bushing out.
20. [] Remove slider, then pull extractor tool out of Seal Separator and retrieve bushing.
21. [] Repeat procedure for upper bushing in other slider tube.

Lower bushing removal

22. [] Place RockShox Seal Separator (large-end up on top of slightly open vise jaws then place sleeve from RockShox Bushing Remover (small-end up) on top of Seal Separator.

23. [] Holding slider upside down, insert RockShox Bushing Remover with 30mm-long remover plate up into one side of slider and engage plate against back of first bushing.
24. [] With tool still engaged to bushing, drop end of tool through sleeve, Seal Separator, and vise jaws until slider seats on sleeve, then firmly secure vise on Bushing Remover handle.
25. [] Hold one cylinder of Seal Separator stationary and rotate other cylinder to pull bushing.
26. [] Repeat previous three previous steps for other lower bushing.

Cleaning and inspection

1999 and 2000 damper cartridges cannot be overhauled. Replacement is the only option.

27. [] Use mild detergent to thoroughly clean all parts. Dry with lint-free rag and/or compressed air. Avoid solvents, which may damage seals and other non-metallic parts.
28. [] Inspect all rubber O-rings and glide rings for nicks and tears, and replace as necessary.
29. [] Replace crush washer on each shaft nut.
30. [] Push cartridge shaft to limit both ways and inspect both ends of shaft for wear marks that indicated need of replacement.
31. [] While pushing and pulling cartridge shaft, listen for gurgling sounds that indicate air in cartridge, which is reason for replacement.
32. [] Thoroughly clean outside of cartridge, then pump shaft repeatedly. Look for oil seepage at both ends of cartridge, indicating need of replacement.
33. [] Inspect stanchion tubes for bends, scratches, or heavy wear.
34. [] Inspect fork crown for cracks.

Bushing and seal installation

35. [] Secure Judy Bushing Installer base upright in vise, with vertical post positioned out past end of vise jaws.

The Judy Bushing Installer tool comes with four long sleeves of various lengths. Originally, these sleeves were intended for setting the correct lower-bushing height for different models. Because travel can be changed on any model, RockShox now recommends using the red (128mm) sleeve only, which sets the lower bushing at the correct height regardless of model or travel configuration.

36. [] Place red (128mm) sleeve on tool shaft, then place smaller-diameter bushing (O.D. 30.5mm) on tool shaft.
37. [] Place one slider tube over tool shaft, insert small end of driving tool into hole in end of slider, then tap on driving tool until bushing is fully seated.

38. [] Remove slider and repeat previous two steps for other slider tube.
39. [] Remove red sleeve and place short (10mm) sleeve on tool shaft, then place larger-diameter bushing (O.D. 31.0mm) on tool shaft.
40. [] Place one slider tube over tool shaft, insert small end of driving tool into hole in end of slider, then tap on driving tool until top edge of bushing is even with second shoulder from top of slider. *Note: It is possible to insert bushing too far, with top edge below second shoulder. During installation, stop and inspect depth repeatedly!*
41. [] Remove slider and repeat previous two steps for other slider tube.
42. [] Insert bottom-out bumpers into slider tubes and push both down until they are below lower bushings.
43. [] Insert seals into top end of each slider tube, then tap with mallet until each is fully seated and level.
44. [] Thoroughly grease all bushings and pockets inside seals with Judy Butter grease.

Cartridge assembly and installation

45. [] Install O-Ring then blue glide ring in grooves in pistons at tops of each cartridge shaft.
46. [] Install plastic plate, conical bumper (large-end first), washer, then negative-spring cylinder (unthreaded-end first) onto negative-spring shaft. Leave cylinder at bottom end of shaft.
47. [] Grease piston assemblies with Judy Butter grease.
48. [] Carefully insert damper cartridge into right stanchion tube, then engage cartridge threads counterclockwise to stanchion-tube threads. Secure cartridge with cartridge driver to 20in-lbs.
49. [] Carefully insert negative-spring assembly into left stanchion tube, then engage cartridge threads counterclockwise to stanchion-tube threads. Secure cartridge with cartridge driver to 20in-lbs.
50. [] Pull shafts fully out of cartridges. Air valve in neutral spring needs to be opened while pulling on neutral shaft.
51. [] Install conical bumpers onto shafts (large-diameter-ends first).
52. [] Install top-cap assemblies into tops of stanchions and secure to 35–40in-lbs.

In the next step, the main springs are inflated to 100psi each. This is the maximum recommended pressure. Individual riders will usually use a lower pressure. The 100psi pressure is to test the pressure integ-

rity of the main springs, and to provide resistance to the cartridge shafts, which facilitates securing the nuts to the bottoms of the cartridge shafts.

53. [] Install RockShox SID pump in each top cap and inflate to 100psi.

Slider installation

54. [] Place boots on stanchion tubes, then carefully push slider assembly partially onto stanchions, using gentle rocking motion until alignment is achieved and sliders move up easily. Stop before bottoms of sliders engage either shaft.
55. [] Position fork so bottoms of sliders are higher than fork crown, then pour 10cc of 15wt shock oil (non seal-swelling) into each slider tube through holes for bottom bolts.
56. [] Push sliders on until shafts protrude through sliders.
57. [] Prepare nut threads with Loctite 242, then engage nuts to neutral and damper shafts.
58. [] Secure bolts/nuts to 50in-lbs.
59. [] Slide adjuster knob over shaft nut on damper shaft, then install small screw to retain knob.
60. [] Engage boots to seals on top of sliders.

Spring inflation

54. [] Refer to following table (or use rider preferences). First inflate main springs, then inflate negative spring to desired pressures.
55. [] Install valve caps in all three air-spring valves.

SID AIR-SPRING PRESSURES

Rider weight	Main	Negative-XC	Negative-racing
< 120lbs	30–40psi	30–40psi	25–30psi
120–140lbs	40–50psi	40–50psi	30–45psi
140–160lbs	50–60psi	50–60psi	40–55psi
160–180lbs	55–65psi	55–65psi	50–60psi
> 180lbs	65–75psi	65–75psi	55–65psi

Important: To prevent pressure loss, never exceed 100psi in main springs or negative spring!

TUNING OPTIONS

Damping adjustment

The damper has an adjusting knob at the bottom of the right leg. With the knob pushed fully in, turning it clockwise increases rebound damping and counterclockwise reduces rebound damping. With the knob pulled fully out, turning it clockwise increases compression damping and counterclockwise reduces compression damping. Always return the knob to the pushed-in position after completing adjustment of the compression damping.

Sag adjustment

RockShox recommends setting sag at 20% of total travel for cross-country riding (recreational) or 10% of total travel for racing. Sag is adjusted by balancing the main spring and negative-spring pressures. If the sag is correct, but the fork bottoms too easily on bumps, increase all pressures proportionally. If the sag is correct but the fork never bottoms on severe bumps, decrease all pressures proportionally. Changing negative-spring pressure independently of main-spring pressure will also affect responsiveness to small bumps. More negative-spring pressure increases responsiveness to small bumps.

Travel adjustment

On the 1999 models, travel can be adjusted only by replacing the cartridge. The 2000 models come with an All Spacer Kit, which are spacers that can be repositioned to change the travel.

Adjusting main-spring progressiveness

Changing the volume of the main-spring air chambers varies the progressiveness of the spring. Less volume creates more progressiveness. A more progressive spring gets more resistant to compression at the same amount of travel. RockShox has spacers available that are added to the bottoms of the top caps that reduce the volume of the main-spring air chamber.

ROCKSHOX DELUXE REAR SHOCK

This shock is a air/oil shock with an external coil spring. It is available in several lengths of travel and with several different spring ratings. Some versions have a floating piston that separates the air and oil in the shock body, but others have no piston for this purpose. The service of all these variations is so similar that the following procedure is adequate for all of them.

There is another model, called the Super Deluxe, that is significantly different. Instead of a uniform-diameter shock body, the Super Deluxe body gets substantially fatter at the end that is not inside the spring. There is a section called ***ROCKSHOX SUPER DELUXE REAR SHOCK*** (page 38-64) that should be used for servicing this type.

This procedure requires several tools that are included in the RockShox 70106 tool kit. The tool kit is designed for other models as well, so some tools in the kit will not be used in this procedure. In some cases, there may be two tools that are very similar,

except for slight differences in dimension. The individual tools are unmarked, so make sure that the tool you select seems dimensionally appropriate for the procedure being performed.

SHOCK AND SPRING REMOVAL

Shock removal

The compressed spring length needs to be measured, so that the customer's pre-load setting can be restored.

1. [] **Measure length of spring between red adjuster ring and silver stop plate: _____ mm**
2. [] **Turn red adjuster ring fully away from spring, until spring moves easily between plates.**

The shock unit may mount to the frame in a variety of ways, depending on the design of the frame. Usually, there will be a bolt and nut through the shock eyelets, or their will be a stud with retaining clips on each end.

3. [] **Remove shafts that go through both shock eyes, then remove shock from bike.**

Spring removal

1. [] **Thread red spring-adjuster ring off end of shock.**
2. [] **Slide spring off shock unit.**

OIL CHANGE/SHOCK DISASSEMBLY

NOTE: Perform complete SHOCK AND SPRING REMOVAL procedures before proceeding further.

Body-eyelet-bushing removal

There is an air valve hidden by the bushing located inside the eyelet on the end of the shock body. The bushing must be removed to depressurize the shock.

1. [] **Place flat face of body eyelet on top of vise, with vise jaws open enough to permit eyelet bushing to clear.**

The bushing tool used in the next step is a cylinder with different diameter reductions at each end.

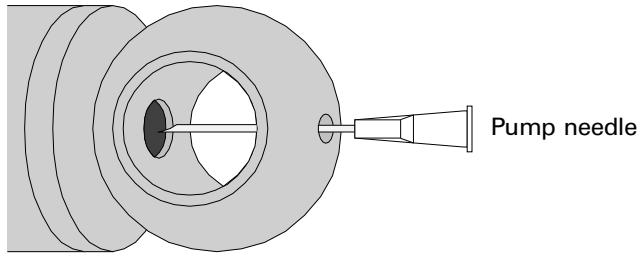
2. [] **Place large-diameter end of bushing tool against bushing, then tap on bushing tool with plastic mallet to drive out bushing.**

Depressurization

1. [] **Remove needle from pump, by unscrewing first brass fitting at base of needle.**

The pump needle needs to be removed from the pump for depressurization. The needle has a sharp tip that punctures the air valve (the puncture self seals when the needle is removed). Goggles are needed because hydraulic fluid can spray out the end of the needle at high speed.

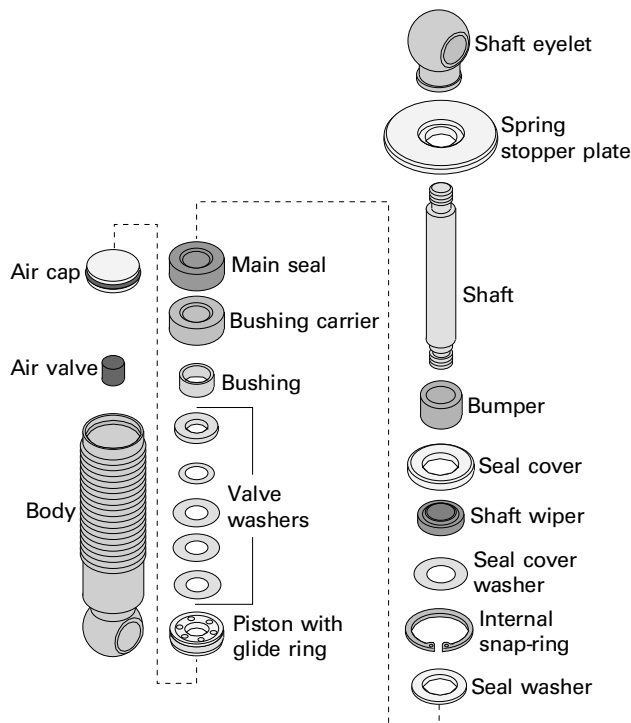
2. [] Wearing safety goggles to prevent getting hydraulic fluid in your eyes, insert needle through small hole in end of body eyelet, then into air valve that was covered by eyelet bushing.



38.20 Depressurizing the shock.

3. [] Remove needle.

Shaft-assembly removal, and oil draining



38.21 Blow-up of Deluxe shock.

4. [] Clamp faces of body eyelet in vise soft jaws.
5. [] Hold drift or screwdriver against bottom edge of seal cover (on top end of body), then tap on tool with hammer to remove seal cover from body.
6. [] Place shaft-clamping blocks around shaft, then firmly secure shaft-clamping blocks in vise.

7. [] Place rag over flats of shaft eyelet to protect finish.
8. [] Grasp flats of eyelet securely in large adjustable-wrench jaws.
9. [] Turn wrench counterclockwise to unthread eyelet from shaft.
10. [] Remove spring-stopper plate and bumper.
11. [] Remove shaft from shaft-clamping blocks.
12. [] Remove seal cover, shaft wiper, and seal-cover washer from end of shock.
13. [] Use snap-ring pliers to remove internal snap-ring from inside shock body.
14. [] Clamp body-eyelet flats in soft jaws in vise.
15. [] Thread shaft eyelet back onto shaft.
16. [] Wearing safety goggles, insert round bar through shaft eyelet; using rocking/pulling motion to pull shaft assembly out of shock body (oil will spill).
17. [] Remove shock body from vise, then carefully drain oil into waste receptacle for later recycling.

NOTE: *If performing oil change only, go to step 40.*

18. [] Inset 2mm spoke through small hole in end of body eyelet, then push air valve and floating piston (piston not in all models) out open end of body.
19. [] Remove seal washer and seal from shaft.
20. [] Remove bushing carrier and bushing from shaft.

NOTE: *Remaining parts on piston assembly are unnecessary to remove, except to change, add, or subtract washers.*

CLEANING AND INSPECTION

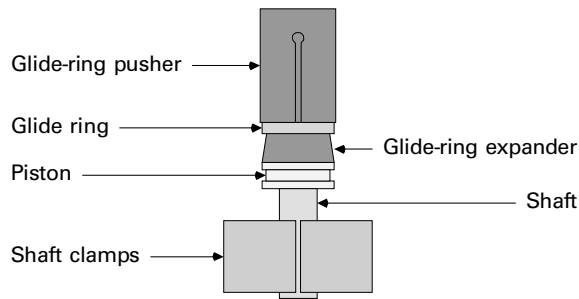
21. [] Clean all parts with mild detergent and water, then dry thoroughly with compressed air. ***Avoid leaving solvents or lint from rags on, or in, any part!***
22. [] Inspect shaft for scratches or nicks that will compromise oil seal.
23. [] Inspect inside of threaded tube for nicks or scratches that will compromise oil seal.
24. [] Inspect glide ring on piston for nicks or scratches, and remove now if damaged.
25. [] Inspect bushing in bushing carrier for wear, and check for loose fit between bushing and shaft (use large end of bushing tool to drive bushing out of carrier if bushing is worn).

38 – SUSPENSION FORKS AND REAR SHOCKS

ASSEMBLY

NOTE: If glide ring was not removed, go to step 30.

Glide-ring installation



38.22 Setup for glide-ring installation.

- 26. [] Place shaft (piston-end up) in shaft vise block, then clamp *very* securely in vise.
- 27. [] Install new glide ring onto piston.

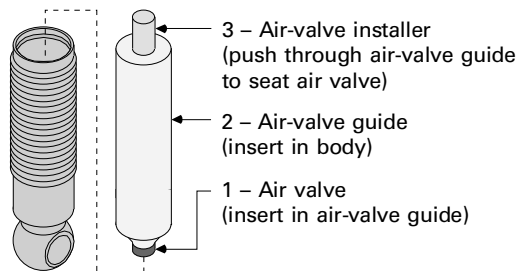
Bushing installation

NOTE: Go to step 30 if bushing was not removed from bushing carrier.

- 28. [] Place new bushing on small end of bushing tool.
- 29. [] Place bushing carrier on flat surface, position bushing and bushing tool over hole in bushing carrier, then use plastic mallet to drive in bushing.

Body assembly and preparation

- 30. [] Grease all O-rings and seals with light-weight, high-quality grease, then grease all seal-mounting points.
- 31. [] Insert lightly-greased air valve in recess in conical end of air-valve tool.
- 32. [] Place air-valve tool into shock body.
- 33. [] Insert rod into air-valve tool, then press on rod to install air valve (remove tools).



38.23 Setup for installing air valve.

NOTE: Models without floating piston, go to step 40.

- 34. [] Place O-ring on floating piston.

- 35. [] Insert inflation needle through end of body eyelet, then puncture air valve as close to center as possible.
- 36. [] Insert floating piston (cavity-side up) into body.
- 37. [] **Models with 1.25" travel only:** With fine marker, mark line on air valve installer 53.34–53.84mm from flat end of tool.
Models with 1.50" travel only: With fine marker, mark line on air valve installer 58.17–58.67mm from flat end of tool.
- 38. [] Insert flat end of air-valve tool into shock body until line is even with end of shock body.
- 39. [] Remove needle from air valve.
- 40. [] Fill body with oil until top of oil is between 24.13mm and 24.64mm below top of body.
- 41. [] Let bubbles rise and dissipate from oil for at least 5 minutes.

Shaft-unit and seal installation

- 42. [] Install bushing carrier and bushing over end of shaft.

In the next step, a tool called a glide-ring sizer is installed over the glide ring and left in place for at least one minute. The glide-ring sizer is a cylinder that slips over the glide ring and compresses it. The material the glide ring is made of has “short-term memory.” This memory allows the material to remain shrunk for a short while once the glide-ring sizer is removed. This enables the glide ring to fit more easily into the shock body. Once there, the glide-ring expands to fit closely along the inside of the shock.

The tool kit includes a glide-ring sizer for this shock, and a different one for the Super Deluxe model. The correct glide-ring sizer will fit somewhat snugly over the glide ring.

- 43. [] Install glide-ring-sizer tool over glide ring, and leave together at least 1 minute.
- 44. [] Remove glide-ring sizer from shaft assembly, then immediately insert piston-end of shaft assembly slowly into body, until top of piston is just below surface of oil (oil will spill).
- 45. [] Let bubbles rise and dissipate from oil for at least 5 minutes.
- 46. [] Grease seal inside and out.

In the next step, a tool called a bullet is used. The bullet is called a bullet because it looks just like a bullet. It enables the seal to slide onto the shaft without the soft inner lip of the seal catching on the sharp edge at the top of the shaft. The tool kit includes a bullet for this shock, and a different version for the Super Deluxe model. The correct bullet will closely match the diameter of the shaft.

47. [] Place bullet on end of shaft.

When installing the seal in the body, a small amount of air will end up trapped in the seal cavity. This has no effect on a shock that does not have a floating piston, but introduces air to the wrong side of the piston for those shocks that do have a floating piston. This unwanted air can be prevented by filling the seal cavity with a lightweight grease.

48. [] Install seal (cavity-side first) over bullet and onto shaft, then remove bullet.

49. [] Press bushing carrier and seal into body, using seal-press tool.

50. [] Install seal washer, then install seal-retaining clip (face of clip with sharper edges should face out of body).

51. [] Install seal-cover washer onto shaft.

52. [] Install shaft wiper and seal cover onto shaft.

53. [] Seat seal cover onto end of body with seal press (tap lightly with plastic mallet).

54. [] Install needle on pump, then insert needle into air valve.

55. [] Wearing safety glasses, pressurize to 175psi, then remove pump.

56. [] Inspect for leaks at all seams and seals.

Body eyelet bushing replacement

57. [] Place new bushing on small-diameter end of bushing tool.

58. [] Supporting eyelet face on flat surface, place bushing-tool/bushing on top face of eyelet, then use plastic mallet to tap bushing into eyelet.

Shaft eyelet installation

59. [] Place shaft vise blocks around shaft, then firmly secure shaft vise blocks in vise.

60. [] Install bottom-out bumper and silver spring-stopper plate onto end of shaft.

61. [] Put one drop of Loctite 271 in threads inside shaft eyelet.

62. [] Thread shaft eyelet onto shaft.

63. [] Place rag over shaft eyelet flats to protect finish.

64. [] Secure large adjustable wrench to shaft eyelet flats, then secure to 100in-lbs (17lbs@6").

SPRING AND SHOCK INSTALLATION

1. [] Slide spring over body end of shock.

2. [] Thread spring-adjuster ring onto shock body.

3. [] Install shock on bike.

4. [] Turn red spring-adjuster ring to restore measurement recorded in **SHOCK AND SPRING REMOVAL** (step 1), unless this requires more than 8 full turns after spring compression begins.

EYELET-BUSHING REPLACEMENT

1. [] Place flat face of eyelet on top of vise, with vise jaws open enough to permit eyelet bushing to clear.

2. [] Place large-diameter end of bushing tool against bushing, then tap on bushing tool with plastic mallet to drive out bushing.

3. [] Place new bushing on small-diameter end of bushing tool.

4. [] Supporting eyelet face on flat surface, place bushing-tool/bushing on top face of eyelet, then use plastic mallet to tap bushing into eyelet.

TUNING OPTIONS

Spring pre-load

RockShox recommends compressing spring length by no more than 8 full turns of the spring-adjuster ring. Compressing the spring increases the resistance to compression and increases the speed of rebounding. If the 8-full-turn adjustment does not stiffen the spring adequately, or if the spring is too stiff at the lowest pre-load setting, consider using a different spring.

Different springs

RockShox makes springs rated from 500 to 800 lbs. Higher ratings mean the spring is stiffer. Stiffer springs resist compression more, and rebound more quickly.

Air pressure and type of gas

The recommended gas pressure is 175psi.

Changing oil weight

RockShox recommends 5w oil, but anything from 2.5w to 15w may be used. The heavier-weight the oil, the more damping will occur.

Changing valving

The shim washers on top of the piston controls the rate of compression damping. Increasing the stack of washers will increase damping rate, while reducing the stack will reduce damping rate.

ROCKSHOX SUPER DELUXE REAR SHOCK

This shock is a air/oil shock with an external coil spring. It is available in several lengths of travel and with several different spring ratings. The service of all these variations is similar enough so that the following procedure applies to all of them.

Another model, the Deluxe, is significantly different. Instead of a shock body that gets substantially fatter at the end that is not inside the spring, the Deluxe body is a uniform diameter throughout. There is a section called **ROCKSHOX DELUXE REAR SHOCK** that should be used for servicing this type (page 38-60).

This procedure requires several tools that are included in the RockShox 70106 tool kit. The tool kit is designed for other models as well, so some tools in the kit will not be used in this procedure. In some cases, there may be two tools that are very similar except for slight differences in dimension. The individual tools are unmarked, so make sure that the tool you select seems dimensionally appropriate for the procedure being performed. On some versions, when the spring pre-load adjuster is loosened fully, there is enough slack to remove the spring keeper plate. On the shortest-travel model, however, an extra tool is needed to compress the spring further in order to remove the spring keeper plate.

SHOCK AND SPRING REMOVAL

Shock removal

The compressed spring length needs to be measured so that the customer's pre-load setting can be restored.

1. [] Measure length of spring between red adjuster ring and silver stop plate: _____ mm
2. [] Turn red adjuster ring fully away from spring.

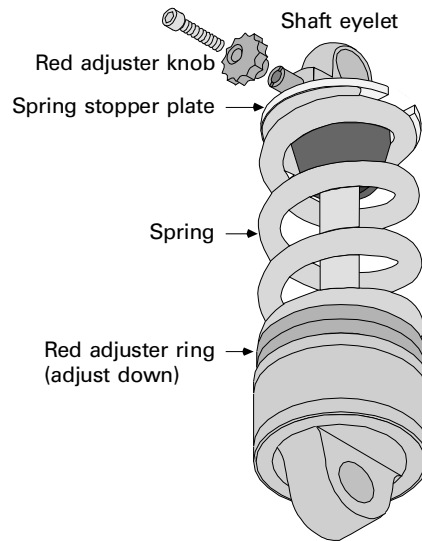
The shock unit may mount to the frame in a variety of ways, depending on the design of the frame. Usually, there will be a bolt and nut through the shock eyelets, or there will be a stud with retaining clips on each end.

3. [] Remove shafts that go through both shock eyes, then remove shock from bike.

Spring removal

4. [] Turn red damper-adjusting knob fully counterclockwise, counting turns: _____.
5. [] Holding red damper-adjusting knob stationary, use 2mm Allen wrench to unthread bolt from center of knob, then remove knob.
6. [] Use thin slotted screwdriver to turn damper-adjusting shaft fully clockwise (so spring will clear when removed).

7. [] Use spring-compression tool to compress spring (if spring does not develop slop when red adjusting ring is fully loosened).
8. [] Slip silver spring stop plate off shaft.
9. [] Slide spring off shock unit.
10. [] Use thin slotted screwdriver to turn damper-adjusting shaft fully counterclockwise (so damping will be reduced to make piston removal easier).
11. [] Thread ring off of threaded tube, leaving it in space between shaft eyelet & threaded tube.



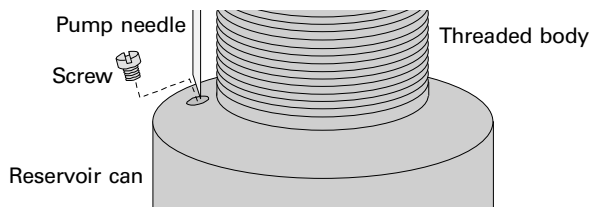
38.24 Spring removal on Super Deluxe shock.

OIL CHANGE/SHOCK DISASSEMBLY

NOTE: Perform complete SHOCK AND SPRING REMOVAL procedures before proceeding further.

Depressurization

The pump needle needs to be removed from the pump for depressurization. The needle has a sharp tip that punctures the air valve (the puncture self seals when the needle is removed). Goggles are needed because hydraulic fluid can spray out the end of the needle at high speed.



38.25 Wearing safety goggles, remove the screw and insert the pump needle through the air-valve rubber to depressurize the shock.

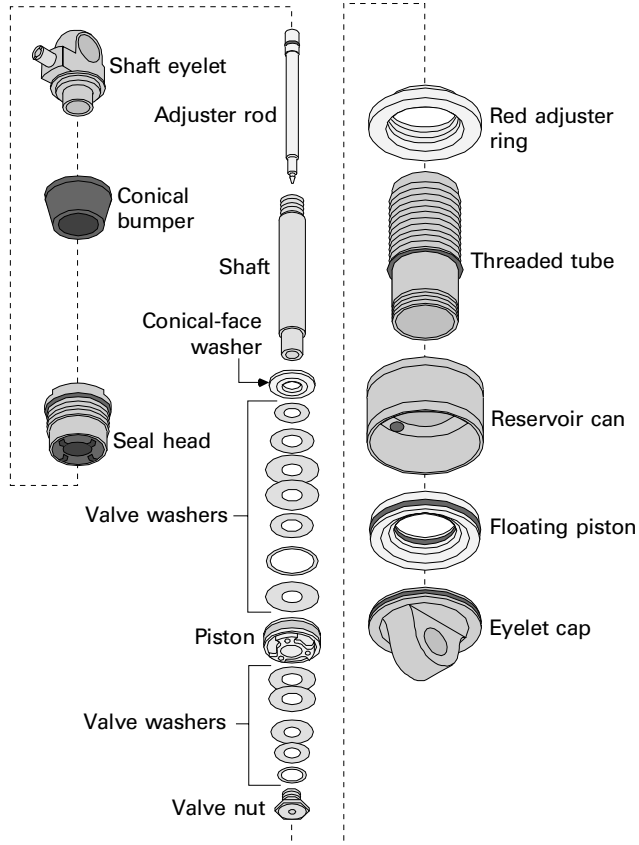
1. [] Remove needle from pump by unscrewing first brass fitting at base of needle.

2. [] Unthread slotted screw fitting in face of reservoir (near base of threaded tube that red ring was threaded on).
3. [] Wearing safety goggles to prevent getting hydraulic fluid in your eyes, insert needle through hole brass screw came out of, to depressurize reservoir.
4. [] Remove needle.

Shaft-assembly removal and oil draining

In the next step, and at several points throughout the remaining procedure, the shaft is placed in a pair of blocks with radius jaws that match the diameter of the shaft closely. The blocks are then placed in the vise, and the vise secured. The design of the shaft-clamping blocks ensures that the shaft will not be damaged by too much tightening of the vise, *but failure to tighten the vise enough will result in the shaft spinning in the vise clamping blocks, which could destroy the shaft!*

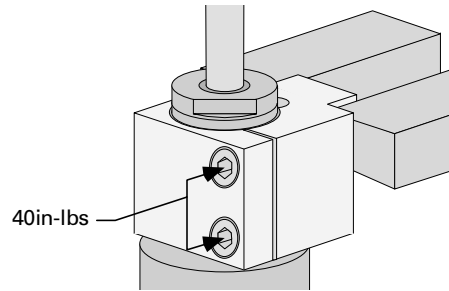
5. [] Grasp shaft securely in shaft-clamping blocks (in vise), eyelet end up.
6. [] Protect shaft eyelet flats with rag.
7. [] Grasp flats of eyelet securely in large adjustable-wrench jaws.
8. [] Turn wrench counterclockwise to unthread eyelet from shaft.
9. [] Remove conical bumper.



38.26 Blow-up of Super Deluxe shock.

10. [] Remove shaft from shaft-clamping blocks.
11. [] Thread red adjusting ring off threaded tube and slip adjusting ring off end of shaft.

In the next step, the threaded tube of the shock body is clamped in a special tool. Unlike the shaft-clamping tool, too much clamping force can cause damage. Too little clamping force can also cause damage. *It is strongly recommended to use a torque wrench!*



38.27 Clamp the threaded tube in the clamp, and the clamp into the vise.

12. [] Slide threaded-tube clamp over shaft and onto threaded tube, then secure bolts in clamp to 40in-lbs each. *Caution, too much or too little torque can destroy threaded tube!*
13. [] Secure tab of threaded-tube clamp in vise so that shaft points up.
14. [] Hand-thread shaft eyelet onto shaft.
15. [] Using 22mm open-end wrench (or well-snugged adjustable wrench), unthread seal-head (cap at end of threaded tube that has two wrench flats).
16. [] Once seal-head is unthreaded, insert non-metallic shaft through shaft eyelet, to pull shaft/seal-head assembly out of threaded tube.
17. [] Remove shaft eyelet from shaft.

Reservoir/body disassembly

18. [] Remove threaded-tube clamp from vise, then carefully drain oil into waste receptacle for later recycling.

NOTE: *If performing oil change only, go to step 71.*

19. [] Turn tube-clamp over so reservoir can is on top, insert clamp in side of vise jaws, then secure vise.
20. [] Place rag over flats of body eyelet to protect finish.
21. [] Grasp flats of body eyelet snugly in large adjustable-wrench jaws, then turn wrench counterclockwise to unthread eyelet cap from threaded tube.
22. [] *If can came off with can lid:* Hold reservoir can in one hand, then pull eyelet from end of can (pressure of O-ring keeps parts together).

38 – SUSPENSION FORKS AND REAR SHOCKS

23. [] *If can stayed on threaded tube:* Pull reservoir can carefully off threaded tube, being careful not do damage O-rings as they pull past threads on end of tube.
24. [] Pull the floating piston out the large-diameter end of the reservoir can.
25. [] Remove O-rings from inside and outside edges of floating piston.
26. [] Remove O-ring from edge of eyelet cap.
27. [] Remove O-ring from threaded tube.

Piston/valve disassembly

The disassembly procedure from this point forward assumes you have access to all seals, O-rings, and a replacement seal-head. It is not recommended to go further without the necessary parts on hand. It is also recommended to replace the seal-head, all the seals, and all the O-rings, each time a service is performed.

28. [] Slide seal head up against piston. Put shaft-clamping blocks around shaft, and secure clamping blocks in vise with high force; *it is critical that the shaft not spin in the clamping blocks in the next step!*
29. [] Use 10mm box wrench (or socket), to unthread nut on end of shaft.

In the next steps, a series of different washers (that were sandwiched between the just-removed bolt and the piston) need to be removed. The number and dimensions of the washers will vary, because these factors are what enable customization of the damping rate. There are several washers that are nearly identical. Critical variations might be as slight as .05mm. If unable to measure dimensions this precise (or if no valving changes will be made), carefully transfer the washers to a bundling tie, maintaining the order and orientation of the washers as they are removed. Keep them bundled together from the time of removal until the time of installation. There is a similar bundle of washers on the other side of the piston. It is critical to not confuse the two sets of washers.

30. [] Remove washers one at a time from above piston, measuring O.D. (outside diameter), thickness, and I.D. (inside diameter) of each washer as it comes off:

O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____

31. [] Remove piston only, noting which side faces up (if not symmetrical).

In the next steps, a different series of washers (below the piston location) need to be removed. The number and dimensions of the washers will vary, because these factors are what enable customization of the damping rate. There are several washers that are nearly identical. Critical variations might be as slight as .05mm. If unable to measure dimensions this precise (or if no valving changes will be made), carefully transfer the washers to a bundling tie, maintaining the order and orientation of the washers as they are removed. Keep them bundled together from the time of removal until the time of installation.

32. [] Remove washers and shims one at a time from below piston, measuring O.D., thickness, and I.D. of each washer as it comes off:

O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____
O.D. _____	Thickness _____	I.D. _____

33. [] Remove aluminum base-plate washer, noting which side faces up (if not symmetrical).
34. [] Inspect glide ring for nicks or scratches, and if damaged, remove glide-ring from outer perimeter of piston.

Damping-adjuster-rod removal

35. [] Push adjuster rod out end of shaft where eyelet was removed.
36. [] Remove O-ring from adjuster rod.

Seal-head removal and disassembly

Some early versions of RockShox service literature described disassembling the seal head. This is likely to damage the seal head, and is no longer recommended. If the bumper plate and washer (below the bumper plate) come out accidentally, it is not a problem. Removing the seal from the open end of the seal-head is when damage will occur.

37. [] Pull seal-head off end of shaft.
38. [] Note orientation of bumper plate, so that it can be reinstalled if it accidentally falls out.

NOTE: *If oil has been leaking from seal between seal head and shaft, RockShox requires replacing seal-head as a unit. Do not attempt further disassembly of seal-head.*

CLEANING AND INSPECTION

39. [] Clean all parts with mild detergent and water, then dry thoroughly with compressed air. *Avoid leaving solvents or lint from rags on, or in, any part!*
40. [] Inspect shaft for scratches or nicks that will compromise oil seal.
41. [] Inspect inside and outside of threaded tube for nicks or scratches that will compromise oil or gas seal.
42. [] Inspect inside of reservoir can for nicks or scratches that will compromise gas seal.
43. [] If no gas hissed out of needle during depressurization step, air seal is bad; pry air seal out of can, grease new air seal, then push air seal back into can (until flush).

ASSEMBLY

Damping-adjuster-rod assembly

44. [] Grease small O-ring, then install O-ring on adjuster rod.
45. [] Push adjuster rod into end of shaft where eyelet was removed.
46. [] Grasp shaft in shaft-clamping blocks in vise very securely (full-diameter end up).
47. [] Make sure red adjusting rod is threaded fully counterclockwise, then thread eyelet onto shaft.
48. [] Protect eyelet flats with rag.
49. [] Grasp eyelet flats snugly with adjustable wrench, then secure eyelet to shaft to 100in-lbs (17lbs@6").

Seal-head assembly

NOTE: Steps 51–52 are only required if bumper and bumper washer have accidentally come out of seal-head

50. [] Place seal-head assembly (flange-side down) on flat surface.
51. [] Install bumper washer into seal-head.
52. [] Install bumper (flat-face first) into seal-head.

Shaft-unit assembly

53. [] Place conical bumper on shaft (large-diameter end first) and fit onto eyelet, then clamp flats of shaft eyelet securely in soft jaws in vise (shaft pointing up).

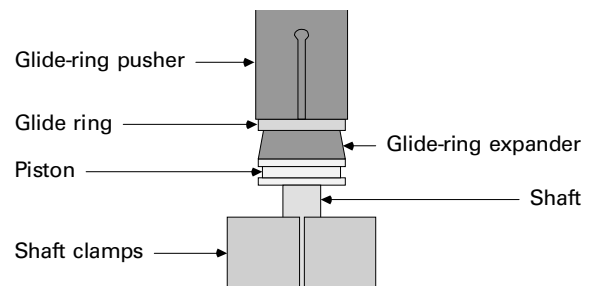
In the next step, a tool called a bullet is used. The bullet is called a bullet because it looks just like a bullet. It enables the seal to slide onto the shaft without the soft inner lip of the seal catching on the sharp edge at the top of the shaft. The tool kit includes a

bullet for this shock, and a different version for the Deluxe model. The correct bullet will closely match the diameter of the shaft.

54. [] Place shaft bullet on top of small-diameter end of shaft, then coat bullet & shaft with grease.
55. [] Place seal-head (flange-end first) over top of bullet.
56. [] Push seal-head assembly fully onto shaft.
57. [] Remove bullet from shaft.
58. [] Clean grease from outside and inside of shaft.
59. [] Install aluminum base-plate washer (conical-face, if any, up) on shaft.
60. [] Install washers listed in step 32 on shaft, in reverse order of list.
61. [] Install piston, 3-leg-protrusion face up.
62. [] Install washers listed in step 30 on shaft, in reverse order of list.
63. [] Treat shaft-bolt threads with one small drop of Loctite 242.
64. [] Thread shaft bolt into end of shaft, taking care to align shim washers so that shaft bolt inserts through all washers above piston.
65. [] Secure shaft bolt with 10mm box-end wrench or socket to 60in-lbs (20lbs@3").

NOTE: If glide ring was not removed, go to step 88.

Glide-ring installation



38.28 Installing the glide ring.

66. [] Place glide-ring expander on top of piston.
67. [] Install new glide ring onto tapered end of glide-ring expander.
68. [] Place large-I.D. end of glide-ring pusher over glide ring, then push glide ring down until glide ring snaps into groove in piston.
69. [] Remove glide-ring expander & glide-ring pusher.
70. [] Slide seal-head fully away from piston.
71. [] Pack top-out-bumper-end of seal head with light-weight grease to eliminate air pockets.

NOTE: If performing oil-change only, go to step 87.

In the next step, a tool called a glide-ring sizer is installed over the glide ring, then left in place for at least one minute. The glide-ring sizer is a cylinder that slips over the glide ring and compresses it. The material the glide ring is made of has “short-term memory.” This memory allows the material to remain shrunk

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for a short while, once the glide-ring sizer is removed. This enables the glide ring to fit more easily into the shock body. Once there, the glide-ring expands to fit closely along the inside of the shock.

The tool kit includes a glide-ring sizer for this shock, and a different one for the Deluxe model. The correct glide-ring sizer will fit somewhat snugly over the glide ring.

72. [] Place large-I.D. end of glide-ring sizer over glide ring fully, then leave in place until ready to install shaft into shock body.

73. [] Remove shaft assembly from vise.

Reservoir/body assembly

74. [] Grease all O-rings with light-weight, high-quality grease, then grease all seal-mounting points.

75. [] Carefully slide O-ring over end of threaded tube, then seat seal in groove.

76. [] Install O-rings in inside and outside edges of floating piston that fits inside reservoir can.

77. [] Install O-ring in outer perimeter of eyelet cap cap.

78. [] Clamp flat tab of threaded-tube clamping tool in end of vise, so that short-threaded end of tube points up.

79. [] Slide small-I.D. end of reservoir can over end of threaded tube, until can is seated against shoulder on threaded tube.

80. [] Slide floating piston (cavity-side first, conical-face up) carefully over end of threaded tube, just until it clears threads on threaded tube.

81. [] Clean grease off tube threads.

82. [] Apply drop of Loctite 271 to tube threads.

83. [] Thread body-eyelet cap onto tube.

84. [] Place rag over body-eyelet-cap flats to protect finish.

85. [] Grasp flats securely with large adjustable wrench, then secure to 100–120in-lbs (17–20lbs@6").

86. [] Loosen bolts and remove body from threaded-tube clamp. Remove clamp from vise.

Oil filling and final assembly

87. [] Grasp flats of body eyelet in soft jaws in vise.

88. [] Insert pump needle into air valve, then pressurize to 50psi (floating piston may seat with a "pop").

89. [] Thread red adjusting ring (flatter-face first) onto threaded tube.

90. [] Pour 5wt oil into threaded tube until oil level reaches bottom of threads inside threaded tube.

91. [] Let bubbles rise and dissipate from oil for at least 5 minutes.

92. [] Using thin slotted screwdriver, turn damping adjuster rod fully counterclockwise.

93. [] Remove glide-ring sizer from shaft assembly, then immediately insert piston-end of shaft assembly slowly into threaded tube, until top of piston is at least 1/2" below top of threaded tube (oil will spill). Stop before seal head reaches threaded tube.

94. [] Let bubbles rise and dissipate from oil for at least 5 minutes.

95. [] Holding piston/shaft assembly stationary, push seal-head down shaft and engage seal-head in threads of threaded tube (oil will spill).

96. [] Thread seal-head fully into threaded tube (oil will spill), then secure to 100–120in-lbs (17–20lbs@6").

97. [] Clean assembly of all excess oil.

98. [] Thread red adjuster ring off of threaded tube.

99. [] Insert needle in air valve and pressurize to 225psi (nitrogen preferred, air is acceptable).

100. [] Inspect for leaks at all seams and seals.

SPRING AND SHOCK INSTALLATION

1. [] Thread red adjusting ring back onto threaded tube, then thread fully-down.

2. [] Turn red damper-adjusting shaft fully clockwise with thin slotted screwdriver.

3. [] Slide spring over shaft-end of shock.

4. [] Compress spring (if necessary) with spring-compression tool, then install silver spring keeper plate (recessed side facing towards eyelet) onto shaft.

5. [] Apply Loctite 222 to Allen bolt that retains damper-adjusting knob.

6. [] Attach damper-adjusting knob to damper-adjusting shaft, and secure by threading in adjusting-knob retaining bolt.

7. [] Turn damper-adjusting knob fully counterclockwise.

8. [] Turn damper-adjusting knob in, number of turns recorded in SHOCK AND SPRING REMOVAL (step 4).

9. [] Install shock on bike.

10. [] Turn red spring adjusting ring out to restore measurement recorded in SHOCK AND SPRING REMOVAL (step 1), unless this requires more than 8 full turns.

EYELET-BUSHING REPLACEMENT

1. [] Place flat face of body eyelet or shaft eyelet on top of vise, with vise jaws open enough to permit shaft eyelet bushing to clear.

2. [] Use large-diameter end of bushing tool to drive bushing out of eyelet.

3. [] Place new bushing on small-diameter end of bushing tool.
4. [] Supporting eyelet face on flat surface, place bushing-tool/bushing on top face of eyelet, then use plastic mallet to tap bushing into eyelet.

TUNING OPTIONS

Spring pre-load

RockShox recommends compressing spring length by no more than 8 full turns of the spring-adjuster ring. Compressing the spring increases the resistance to compression and increases the speed of rebounding. If the 8-full-turn adjustment does not stiffen the spring adequately, or if the spring is too stiff at the lowest pre-load setting, consider using a different spring.

Different springs

RockShox makes springs rated from 500 to 800 lbs. Higher ratings mean the spring is stiffer. Stiffer springs resist compression more, and rebound more quickly.

Gas pressure and type of gas

The recommended gas pressure is 225psi. Nitrogen is recommended, but regular air can be used with only a small performance loss.

Changing damper setting

The damper adjustment affects compression and rebound damping. Turning the damper-adjusting knob clockwise increases damping while turning the adjuster knob counterclockwise reduces damping. Increased damping slows the rate of compression or rebound.

Changing oil weight

RockShox recommends 5w oil, but anything from 2.5w to 8w may be used. The heavier-weight the oil, the more damping will occur.

Changing valving

The shim washers on either side of the piston controls the rate of damping. The washers between the shaft nut and piston control the rebound damping rate; the washers between the piston and the conical washer control the compression damping. Increasing a stack of washers will increase damping rate and reducing the stack will reduce damping rate.

RST '98 MOZO FORKS

ABOUT THIS SECTION

This supplement covers full service of 1998 RST Mozo XL, Mozo Pro, and Mozo Comp forks, including bushing replacement.

TOOL CHOICES

RST provides a bushing remover and installer (Hot Karl tool) for remove bushings from the models that have pressed-in bushings.

FULL FORK SERVICE

Disassembly

1. [] Remove front wheel and front brake.
2. [] Remove slider brace from both sliders.
3. [] Turn pre-load adjusters on stanchion caps fully counterclockwise, noting number of turns: _____
4. [] Loosen stanchion clamp bolts slightly.
5. [] With fingers, unthread stanchion-cap/spring-assemblies from stanchion tubes.
6. [] Compress sliders completely.

NOTE: *Only the Mozo XL and Pro have air dampers in the stanchions. In all the following steps, models with no air-damper have a simple plunger shaft instead of a damper shaft with an air valve. For these models, substitute the word "plunger" for "damper," and ignore all references to the air valve.*

7. [] Insert 8mm Allen bit socket on 6" extension into 8mm fitting in top of damper shaft (inside stanchion).
8. [] Holding extension stationary with ratchet wrench, use 4mm Allen wrench to unthread bolt at bottom of each slider.
9. [] Pull sliders off bottom of stanchions.
10. [] Pull bottom-out bumpers from damper shafts that extend from bottoms of stanchions.
11. [] Remove internal snap-rings from bottom of stanchions.
12. [] Pull firmly on damper shafts to remove from stanchions.
13. [] Pull damper-shaft guides, then top-out bumpers from damper shafts.
14. [] Insert 8mm Allen in fitting in head of damper shaft(s) to hold shaft while unthreading air-valve nut.
15. [] Remove air valves from damper shafts.
16. [] Inspect all O-rings for nicks and tears, and replace if damaged.

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NOTE: *The remaining disassembly steps should only be performed if replacing the bushings. If not replacing bushings, skip to step 29.*

17. [] Carefully pry dust wipers from top of sliders.

NOTE: *On the Mozo XL model, the bushings retained by a circlip are not a press fit, and can be pulled out with a hooked seal pick or bent spoke, and inserted by hand. Use this hand technique for removal and installation, then skip to step 29.*

18. [] Unthread double-flatted plate from shaft of Hot Karl bushing remover, and drop plate into slider. It should pass through bushings and rest flat on top of spool spacer.

19. [] Unthread nut from tool shaft, then insert non-flatted end of shaft into slider and engage into threads of double-flatted plate. Make sure shaft is engaged with plate with threads to spare.

20. [] Slide large washer over tool shaft, then thread nut on until double-flatted plate snugs up against bottom of lower bushing.

21. [] Hold flats of tool shaft in soft jaws of vise. Tighten nut against washer while holding slider from rotating. After one inch of tightening against resistance, lower bushing will become loose, then several more inches of effortless tightening will be needed before tool begins to pull upper bushing out.

22. [] Remove tool, remove bushings from tool, then remove spool spacer from bottom of slider.

NOTE: *Repeat steps 18–22 for other slider.*

Assembly

23. [] Put spool spacers (cavity-end up) into bottom of each slider.

24. [] Place smaller-diameter bushing on fat end of Hot Karl bushing installer, and insert tool and bushing into slider.

25. [] Tap on tool with plastic mallet until line in middle of sticker on tool is even with top of slider. Repeat for other slider.

26. [] Place larger-diameter bushing over small-diameter end of Hot Karl bushing installer until it seats against fattest part of tool, then insert tool into slider until tool passes through lower bushing.

27. [] Tap on tool with plastic mallet until top of bushing is even with shoulder that is approximately 10mm down from top of slider. Repeat for other slider.

28. [] Press dust wipers into tops of stanchions.

29. [] Clean and dry all parts, making sure they end up lint and solvent free.

30. [] Grease threads on damper-shaft heads.

31. [] Grease O-rings on air valves, then slide air valves onto damper shafts so that face with large slots faces away from shaft-head. (Reversing orientation of valve will decrease rebound damping and increase compression damping).

32. [] Hold damper shaft with 8mm Allen, then secure valve nut on shaft. Repeat for other side.

33. [] Grease top-out bumpers (shorter ones), and slide onto damper shafts flat-face first.

34. [] Grease shaft guides and slide onto damper shafts cavity-face first.

35. [] Insert air-damper assemblies into stanchions head-ends first.

36. [] Install internal snap-rings into bottom ends of stanchions.

37. [] Grease and install bottom-out bumper onto damper shafts, round-ends first.

38. [] Place sliders onto thoroughly-greased stanchions, and engage boots to dust wipers. Compress sliders fully.

39. [] Treat slider-securing bolts with Loctite 242.

40. [] Use 8mm Allen bit socket on ratchet with extension to hold damper shaft(s) from turning, then install slider-securing bolt(s) in bottom of slider(s) to 40in-lbs.

41. [] Grease spring assemblies (steel coil and elastomer stacks) that are attached to stanchion caps.

42. [] Install stanchion-cap/spring-assemblies fully into stanchions, then secure with fingers.

43. [] Pull down on stanchions until stanchion-cap flanges are against fork crown.

44. [] Secure stanchion-clamp bolts to 80in-lbs.

45. [] Check that fork-column-clamp bolts are secured to 80in-lbs.

46. [] Treat slider-brace-bolt threads and brake-pivot-stud threads with Loctite 242.

47. [] Install slider brace, then secure slider-brace bolts to 90in-lbs and brake pivot studs to 115in-lbs.

48. [] Install front wheel and attach front brake.

WHITE BROTHERS FORKS

ABOUT THIS SECTION

This section specifically covers the '97-'99 White Brothers SC70, SC90, DC90, DC110 and DC118 models, but can be used as a general guideline for servicing other models.

TOOLS

White Brothers sells a tool kit (#97-713) for bushing replacement and cartridge overhaul. The tools are also available separately. The kit includes:

Cartridge Drift	97-707
Cartridge Bleed Tool	97-708
Cartridge Holder	97-700
Cartridge Bush & Seal Driver	97-709
Cartridge Upper Seal R&R Tool	97-710
Fork Bushing Install Tool	97-711
Fork Bushing Removal Tool	97-712

In the following procedure, the Cartridge Drift is called the “small drift,” the Cartridge Bush & Seal Driver is called the “medium drift,” and the Cartridge Upper Seal R&R Tool is called the “large drift.” Each of these tools is a cylinder with several steps in diameter. They also vary in length. The small drift is the short, skinny cylinder. The medium drift is the short, fat cylinder. The large drift is the long cylinder.

The Fork Bushing Removal Tool has a ring that is free to slide up and down the shaft of the tool (when a setscrew in its side is loosened). This ring is called the “depth ring” in the following procedure.

FULL FORK SERVICE

Slider removal

1. [] Remove brakes and front wheel.
2. [] Loosen bolts at bottoms of stanchions two full turns.
3. [] Tap on loosened bolts with plastic mallet until heads contact bottoms of sliders, then complete bolt removal.
4. [] Remove slider assembly.
5. [] Remove bolts from both ends of slider brace.

Top-cap and spring removal

6. [] Turn pre-load adjusters fully counterclockwise, counting number of turns and record here: right: _____ left: _____
7. [] Unthread top caps.
8. [] *SC70 only:* Remove plastic spacers and spring caps from tops of springs.

9. [] Remove springs from tops of stanchions.

Neutral-shaft and cartridge removal

10. [] Remove conical bumpers from shafts.
11. [] Unthread cartridge from bottom of left stanchion.
12. [] Turn stanchions upside down and remove neutral shaft.
13. [] Remove top caps from damper shaft and neutral shaft.
14. [] Remove top-out bumper from bottom end of neutral shaft.

Seal and bushing removal

15. [] Remove circular coil spring from lips of seals.
16. [] Insert screwdriver into each seal, catching tip under bottom edge of seal, then pry out seal.
17. [] Remove foam ring(s).
18. [] Turn right stanchion over and shake out bottom-out spacer (large plastic spool).
Bushings should be cleaned and inspected before removal. The appearance of brass flecks or solid-metallic areas on the surfaces of the bushings indicates need for bushing replacement. Do not remove bushings unless intending to replace them.
19. [] Assemble Bushing Removal Tool parts in following sequence onto threaded shaft:
Flat washer (conical-face first)
Rectangular plate (flat-face first)
Expander mechanism (large-end first)
20. [] Secure 1/3 of rectangular plate in vise so it sticks out end of vise and rest of tool hangs down past edge of bench.
21. [] Push slider onto bottom of tool until expander is heard or felt to snap clear of first bushing.
22. [] While holding onto slider, tighten tool shaft continuously until slider is free.
23. [] Remove expander and bushing from bottom of tool shaft and repeat bushing removal for lower bushing, then both in other slider.

Cartridge overhaul

24. [] Place Cartridge Holder in vise, then place cartridge in Holder so end of shaft with flats points up, but do not secure vise.
25. [] Remove circlip (older models) or snap-ring (newer models) from top end of cartridge body, then turn cartridge body over in Cartridge Holder.
26. [] Position Cartridge Holder so split end of tool is half way into vise jaws.
27. [] Position cartridge in Holder so bottom of body is flush with bottom of Holder, then secure vise.
28. [] Place receptacle for waste oil below cartridge.

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- 29. [] Place small end of Cartridge Drift (small drift) in top of shaft, then slowly tap on tool to drive parts out bottom of cartridge. Be prepared to catch cartridge shaft.
- 30. [] Place small end of Cartridge Upper Seal R&R Tool (large drift) on top of cartridge, then carefully tap parts out bottom end of cartridge. Be prepared to catch parts.
- 31. [] Use 2mm Allen wrench to unthread adjuster rod off end of cartridge shaft, then remove O-ring from needle end of adjuster rod.
- 32. [] Remove plastic washers and seal from cartridge shaft.
- 33. [] Remove split ring from shaft piston.

Cleaning and inspection

- 34. [] Clean all parts with mild detergent and dry with lint-free rag and/or compressed air.
- 35. [] Inspect stanchion tubes for heavy wear marks or scratches.
- 36. [] Inspect lips of slider-tube seals for tears.
- 37. [] Inspect cartridge shaft for heavy wear marks or scratches.
- 38. [] Inspect inside cartridge body for heavy wear marks or scratches.
- 39. [] Inspect cartridge-seal lips for nicks or tears.

Cartridge assembly

- 40. [] With Cartridge Holder loosely supported in vise, install cartridge body in vise so end with circlip/snap-ring is down.
- 41. [] Place Delrin conical-face washer into cartridge body (conical-face first), then drive it to bottom of cartridge body with large end of large drift.
- 42. [] Grease cartridge seal and install (cupped-face up) into cartridge body, then seat fully with large end of large drift.
- 43. [] Place 2mm flat Delrin washer into cartridge body, then seat fully with large end of large drift.
- 44. [] Remove cartridge body from Holder, insert small end of small drift into seal until large end of drift is flush with conical washer, then put cartridge body (closed-end down) back into Holder.
- 45. [] Put split ring into groove in piston, then place shaft (round-end down) carefully on top of drift.
- 46. [] Fill cartridge body with 2.5wt oil to 1/2" from top of body.
- 47. [] Carefully push shaft down fully into cartridge body, making sure split ring does not catch on top edge of cartridge body. Small drift will fall to floor.
- 48. [] Thread Bleed Tool into top end of shaft, then pump shaft 1/2" up and down repeatedly.

- 49. [] Remove Bleed Tool, then fill cartridge body to top with additional oil. Let sit five minutes or until bubbles are gone.
- 50. [] Fill pocket in seal with light grease and grease outer perimeter of seal.
- 51. [] Place 8mm Delrin washer onto shaft, then use long end of Cartridge Bush & Seal Driver (medium drift) to seat washer to 12mm depth.
- 52. [] Place seal (cupped-side first) onto shaft and use short end of medium drift to seat seal to 5mm depth.
- 53. [] Place conical washer (flat-face first) into cartridge body, then install circlip/snap-ring.
- 54. [] Insert shaft end of bleed tool fully into cartridge shaft to purge shaft of excess oil.
- 55. [] Install new O-ring over pointed end of adjuster rod.
- 56. [] Thread adjuster rod into cartridge shaft until it bottoms. Stock settings from this point are:

SC70	2 turns out
SC90 & DC90	3 turns out
DC110 & DC118	4 turns out
- 57. [] Wipe excess oil off cartridge.

Bushing installation

- 58. [] Secure dropout of slider into vise with RockShox dropout vise blocks, or other method that will not mar dropout.
- 59. [] Loosen set screw on depth ring of Bushing Install tool, then position and secure ring with setscrew in upper dimple in tool shaft.
- 60. [] Place bushing on bottom end of tool and insert tool into slider, then tap on top of tool until depth ring contacts top of slider.
- 61. [] Remove tool and repeat for other slider.
- 62. [] Remove tool and set depth ring with setscrew in lower dimple on tool shaft, then repeat procedure for both upper bushings.

Cartridge and neutral-shaft installation

- 63. [] Place plastic conical caps on top ends of cartridge shaft and neutral shaft.
- 64. [] Thread cartridge body into bottom end of left stanchion and secure.
- 65. [] Slide smallest conical bumper (conical-end first) onto bottom end of neutral shaft, then insert neutral shaft into top end of right stanchion.
- 66. [] Pull damper and neutral shafts fully down, then place larger conical bumpers (conical-ends first) onto shafts.

Spring and top-cap installation

- 67. [] Grease springs and install into stanchions.
- 68. [] *SC70 only:* Insert discs into stanchions, then insert plastic sleeves.
- 69. [] Thread in top caps fully, then turn pre-load adjusters fully clockwise.

Slider installation

70. [] Drop bottom-out spacer (large plastic spool) into right slider.
71. [] Place round coil springs over lips of seals.
72. [] Grease seals thoroughly (use non-lithium grease) and place onto stanchions (lip-face first), making sure lips do not fold in.
73. [] Grease foam rings and place onto stanchions.
74. [] Thoroughly grease bushings (non-lithium grease).
75. [] Carefully guide right slider onto right stanchion, then carefully guide left slider onto left stanchion.
76. [] Attach slider brace to sliders.
77. [] Prep slider-brace bolts (anti-seize if bolts are titanium), then secure bolts to 50in-lbs.
78. [] Treat bottom bolts with Loctite 242, then insert into holes in bottoms of sliders (hollow bolt, if any, in left) and thread into bottoms of shafts. *Note, it may be necessary to use small hooked tool such as head of spoke to align shafts with holes!*
79. [] Compress fork fully, then secure bolts to 60in-lbs. *Note: If bolts will not secure, remove top cap and spring on side not being secured, compress again and secure side with spring.*
80. [] Slide foam rings down into tops of sliders.
81. [] Slide seals down into tops of sliders and seat seals fully.
82. [] Install adjuster knob, if any, in bottom of right-side slider.
83. [] Turn pre-load adjusters fully counterclockwise, then clockwise number of turns recorded in step 6.

TUNING DATA REPORT

The following information should be recorded whenever servicing a suspension unit for a customer. All of the information does not apply in every case. The information is recorded during performance of service procedures, but does not occur at uniform points in each procedure, so no step numbers are provided for where the information can be found.

Original damper setting: _____ #/turns

Current damper setting: _____ #/turns

Original air pressure: _____ psi

Current air pressure: _____ psi

Original oil level: _____ mm

Current oil level: _____ mm

Approximate weight of original suspension oil:

2.5w, 5w, 7.5w, 10w, 15w, 20w,

other: _____

Brand and weight of current suspension oil:

Valving changes:

Spring pre-load YES NO Amt: _____ mm

Compression reed-valve washers:

added/subtracted number? _____

thickness change? _____

Rebound reed-valve washers:

added/subtracted number? _____

thickness change? _____

Travel added YES NO Amount: _____ mm

Original spring pre-load setting: _____ #/turns

Current spring pre-load setting: _____ #/turns

Original elastomers and/or coil-spring rate:

Current elastomers and/or coil-spring rate:

