Perform Pressure & Leak Test, Tubing & Piping

Module 12306
Instrumentation Trainee Task Module 12306

**PERFORM PRESSURE AND LEAK TEST, TUBING AND**

Objectives

*Upon completion of this module, the trainee will be able to:*

1. Discuss pressure and leak testing limitations for piping/tubing systems.
2. Discuss selection criteria for testing methods to be used for piping/tubing systems.
3. Discuss and describe various testing methods.
4. Discuss precautions associated with testing piping/tubing systems.
5. Discuss and perform pressure/leak test per approved procedure.
6. Discuss and prepare required documentation of test performance.

Required Trainee Materials

1. Trainee Module
2. Required Safety Equipment
COURSE MAP

This course map shows all of the *Wheels of Learning* task modules in the third level of the Instrumentation curricula. The suggested training order begins at the bottom and proceeds up. Skill levels increase as a trainee advances on the course map. The training order may be adjusted by the local Training Program Sponsor.

LEVEL 3 COMPLETE
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Trade Terms Introduced In This Module


ASME: American Society of Mechanical Engineers.


Design pressure: Maximum pressure a piping or tubing system can withstand prior to failure.

Demineralized water: Water that has had all natural minerals and added chemicals removed.

Hydrostatic testing: Testing a piping or tubing system by filling it with liquid, and then raising the pressure to check system integrity.


Pneumatic testing: Testing a piping or tubing system using a gas (usually air) to check system integrity.

Test medium: Substance that is used to perform a leak test (liquid or gas).

1.0.0 INTRODUCTION

Process piping and tubing systems are designed and constructed for the purpose of transporting fluids of varying temperatures and pressures throughout. The importance of system integrity cannot be overemphasized because of the obvious safety and operational considerations. Testing system tightness is required prior to, and at some point, during system service to ensure failure has not or will not occur under normal operating conditions. This module will introduce the trainee to the requirements for, and procedures associated with, pressure/leak testing of piping and tubing systems.

2.0.0 PRESSURE AND LEAK TESTING LIMITATIONS
Testing of piping and tubing systems will not be performed arbitrarily, that is; the limitations and requirements will conform to a specific set of guidelines imposed by a standardized code. The generally accepted standards for testing systems within the U.S. are set forth by the American Society of Mechanical Engineers (ASME). Additional organizations that provide guidelines for testing include: American National Standards Institute (ANSI); American Society of Testing and Materials (ASTM).

2.1.0 ANSI, ASME, AND ISO 9000 STANDARDS FOR PIPING SYSTEMS/TUBING SYSTEMS

With the opening of the European marketplace and the ending of the Cold War, the International Standards Organization (ISO) was formed to provide worldwide standardization of procedures for testing and acceptance. ANSI Q-90 is the equivalent of ISO 9000.

The vendor or supplier of components to be tested will also provide specific data to identify the test parameters and limitations.

The testing limitations for piping and tubing systems can be determined by referencing the applicable articles of the ASME codes. Temperature, pressure, and leakage limits are the parameters of concern for pressure/leak testing.

The minimum metal temperature for all components during a test shall be as specified in the applicable Mandatory Appendix of the related Code, or in the referencing Code section for the hydrostatic, hydropneumatic, or pneumatic test of the pressure component or parts. The minimum and maximum temperature during the test shall not exceed that temperature compatible with the leak testing method or technique used. The temperature of the test medium shall be that of the available source unless otherwise specified by the vendor. The test pressure shall not be applied until the system and the pressurizing medium are approximately at the same temperature. When conducting pressure tests at low metal temperatures, the possibility of brittle fracture shall be considered.

Unless specified in the applicable Mandatory Appendix of the chosen code, components that are to be pressure-leak tested shall not be tested at a pressure exceeding 25% of the Design Pressure.

Leakage limits for piping and tubing systems do not require any interpretation because the acceptance criteria is "zero leakage".

On occasion, standards set forth by the various organizational codes and vendor supplied limits may conflict. In this situation, the vendor data will be used as the specification.

3.0.0 SELECTION CRITERIA FOR TESTING METHODS

The proper selection of a test method is as important as any aspect of the test performance. Section V, Article 27 of the ASME Code provides guidance for the selection of pressure/leak testing methods. Table I is a simplified guide for the selection.
The correct choice of a leak testing method optimizes sensitivity, cost, and reliability of the test. One approach is to rank the various methods according to test system sensitivity.

The various testing methods must be individually examined to determine their suitability for the particular system being tested. Only then can the appropriate method be chosen.

Table 1. Guide for Selection of Leakage Testing Method

For example, radioactive gases are not generally employed as a tracer for leak location because of the hazards associated with their use. However, such gases are employed in leakage detection equipment when they can be safely added to, and removed from, a test chamber on a periodic basis.

It is important to distinguish between the sensitivity associated with the instrument employed to measure leakage and the sensitivity of the test system followed using the instrument. The sensitivity of the instrument influences the sensitivity that can be attained in a specific test. The range of temperatures or pressures, and the types of fluids involved, influence both the choice of instrument and the test system.

There are other items to be considered when determining which test method will be used. Contamination of a piping or tubing system may occur if the test medium is a substance that may not meet the cleanliness
requirements of that particular system. If the test medium could not be completely removed from the system the cleanliness could not be restored.

Vendor data and specifications, if provided, will be used to determine the correct test method. In most cases, the vendor information parallels or duplicates the accepted national codes and standards.

**4.0.0 DESCRIPTION OF TESTING METHODS**

This section will discuss the various testing methods used to perform pressure/leak testing of piping/tubing systems. Proper compliance to testing methods will ensure safety to plant personnel and prevent damage to the piping systems.

**4.1.0 INITIAL SERVICE TESTING**

An initial service test and examination is acceptable when other types of tests are not practical or when leak tightness is demonstratable due to the nature of the service. One example is piping where shut-off valves are not available for isolating a line and where temporary closures are impractical. Others may be systems where during the course of checking out of pumps, compressors, or other equipment, ample opportunity is afforded for examination for leakage prior to full scale operation. An initial service test is not applicable to boiler external piping.

When performing an initial service test, the piping system shall be gradually brought up to normal operating pressure and continuously held for a minimum time of 10 minutes. Examination for leakage shall be made of all joints and connections. The piping system exclusive of possible localized instances at pump or valve packing shall show no visual evidence of weeping or leaking.

**4.1.1 Pneumatic Leak Test**

A pneumatic leak test requires compressed gas or air for leak detection. *Pneumatic testing* can be performed with air that is oil and moisture-free or with another type of compressed gas. If air is used as a testing medium, it must be filtered to keep out unwanted matter. This clean air is applied to the tubing system by a compressor to build pressure in the system. Other types of compressed gases that can be used are nitrogen and argon. Any gas used must be nonflammable.

Before a pneumatic leak test is performed, certain requirements must be met. These requirements are:

- Installation of the system must be complete
- Test boundaries must be defined
- Valves not to be tested must be locked open
- Instrumentation gauges must be removed
- Tubing ends must be capped
• The system must be physically supported
• Test pressure gauges must be installed
• All test pressure gauges must be calibrated for proper readout

One method of pneumatic testing employs a device known as a bubbler leak tester. This unit is lightweight, rugged, and portable. The bubbler is installed in-line between the compressed air source and the system or components to be leak checked. System valves are shut in the section to be tested and air is supplied through the bubbler up to the shut valve. If a leak is present, flow will exist in that section of the system and be seen through the tester as bubbles in the bowl.

4.1.2 Hydrostatic Test

Hydrostatic leak testing requires water as a test medium. There are three grades of water that can be used for testing. These are:

• Grade A
• Grade B
• Grade C

The grade of water is determined by its purity. Grade A water is demineralized water. This is the purest water used for testing. Grade B water is returned condensate. This water has lost some of its composition; it is the second purest water. Grade C water is ordinary tap or well water. The type of water used is determined by the components and materials of the system to be tested. Plant engineering usually decides on the grade of water used.

All hydrostatic tests should be conducted at a temperature that minimizes brittle fracture. Brittle fracture is a crack in a metal (iron especially) tube or pipe. This occurs when the temperature of the test item is lower than the temperature of the testing medium. The water used for testing should be approximately the same temperature as the system components to be tested. A large variation in temperature also causes expansion and contraction of metal fittings and flanges resulting in leaks at joints.

Before a hydrostatic leak test is performed, certain requirements must be met as with pneumatic testing. Refer to the Section titled "Pneumatic Leak Test" for a list of requirements.

5.0.0 TESTING PRECAUTIONS

The precautions associated with pressure/leak testing of piping and tubing systems will vary based on the test method, pressure, temperature, and type of system.

Generally, these precautions provide protection for equipment and personnel.

Instrument devices will be isolated from test pressure source to prevent damage to delicate components. Block valves, bleed valves, and gage root
Valves will be shut prior to commencing the test. All open outlets of the piping system will be plugged so adjacent or connecting systems will not be inadvertently pressurized.

Personnel-related safety precautions will conform to those set forth by the Occupational Safety and Health Act (OSHA) for individuals working with high pressure/temperature fluids, gases, or possibly, hazardous materials. The written test procedure shall describe all personnel and equipment safety-related warnings.

**6.0.0 GENERAL TEST PROCEDURE**

Instrument systems can be leak tested in whole or part. If only a part of the entire system is to be tested, plugs or caps must be installed. These separate the part of the system being tested from the rest of the system. The type of test to be performed should be decided before the testing date. The following sections will explain:

- Performing a low pressure pneumatic leak test
- Performing a high pressure hydrostatic leak test
- Repairing leaks

**6.1.0 PERFORMING LOW PRESSURE PNEUMATIC LEAK TEST**

Follow these steps to perform a low pressure pneumatic leak test.

**Step 1**  Lock out the system as required by plant safety standards.

**Step 2**  Remove instruments from the system that may be damaged from increased air pressure.

**Step 3**  Cap the tubing ends or install pneumatic jumpers where instruments are removed to maintain continuity. *Figure 1* shows a pneumatic jumper installation.

**Step 4**  Connect the compressed air source to the system with tubing connections and install the test pressure gauges.
NOTE: Test pressure gauges should be installed according to plant requirements and standards.

Step 5 Apply system pressure and increase to test pressure in increments of 10 psi.

Step 6 Apply soapy water to all joints with a brush.

NOTE: If bubbles occur on any joints, leaks are present and they should be marked for repair.

Step 7 Release pressure after marking the leaks.

Step 8 Repair the leaks.

Step 9 Repeat Steps 5 through 8 until all leaks are corrected.

Step 10 Restore the system to operation.

6.1.1 Performing High Pressure Hydrostatic Leak Test

Hydrostatic leak testing requires pressurized water. Several types of hydrostatic test pumps are available for this purpose. Follow these steps to perform a high pressure hydrostatic leak test.

Step 1 Lock out the system as required by plant safety standards.

Step 2 Remove instruments from the system that maybe damaged from pressurized water.

Step 3 Cap the tubing ends or install jumpers where instruments are removed to maintain continuity.

Step 4 Apply water to the system using a hydrostatic test pump.
**NOTE:** Make sure the proper class of water is used. Refer to the Section titled "Hydrostatic Leak Test" for an explanation of water class.

**WARNING!** The temperature of the water being used as a test medium should be monitored and kept close to ambient to avoid brittle fracture of metal tubing.

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**Step 5** Pressurize the system to the desired test pressure.

**NOTE:** Test pressures are determined by material and application. Check with the supervisor for the correct test pressure.

**Step 6** Maintain the test pressure for the test period.

**Step 7** Look for dripping or flowing water from system components to inspect for leaks.

**Step 8** Mark the leaks for repair.

**Step 9** Release the pressure and repair the leaks.

**Step 10** Repeat Steps 4 through 9 until all leaks are repaired.

**Step 11** Restore the system to operation.

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6.1.2 Repairing Leaks

After leaks are detected, they must be properly repaired. If a leak occurs in an instrument, such as the bellows assembly, the instrument should be replaced and taken to the instrument shop for repair. Other locations in an instrument system where leaks are commonly detected and must be repaired are:

- Fittings and tubing
- Flanges
- Gaskets

**Fittings and Tubing**

Fittings and tubing are rarely repaired. They are generally tightened or replaced when leaks occur. Follow these steps for replacing fittings and tubing.

**Step 1** Lock out the system as required by plant safety standards.

**Step 2** Remove the faulty fittings and tubing by unscrewing the tube nut on the fitting as shown in *Figure 2.*
Step 3  Remove the remaining part of the fitting by unscrewing it from its mate as shown in Figure 3.

Step 4  Secure the new fitting of correct size and inspect for imperfections.

Step 5  Wrap a sealing tape or use a sealing compound around the male pipe thread portion of the fitting and screw the fitting into the outlet from which it was removed.
Step 6  Place the tube nut and ferrule on the tubing and connect to the fitting as shown in Figure 4.

![Figure 4. Connecting Tube Nut and Ferrule on Fitting](image)

Step 7  Screw the tube nut onto the fitting until finger tight.

Step 8  Tighten the tube nut using two wrenches. One wrench is used to hold the fitting and the other is used to tighten the tube nut.

**NOTE:** For tubing 1/4 inch, tighten the tube nut 3/4 of a turn. For tubing 3/8 inch and over, tighten the tube nut one turn.

Step 9  Check the connection for leaks.

Step 10  Restore the system to operation.

Follow these steps to reconnect an existing fitting.

**NOTE:** System should be locked out according to plant safety standards.

Step 1  Insert the tubing end into the tubing fitting.

**NOTE:** Make sure the tubing rests on the tubing stop inside the fitting.

Step 2  Turn the tube nut finger tight.

Step 3  Note the position of the tube nut by scribing a mark on the nut.

Step 4  Tighten the tube nut to a specified tightness while holding the fitting with a backup wrench.

**NOTE:** Specified tightness can be between 3/4- and 1-1/4 turns.

Step 5  Check connections for leaks.

Step 6  Restore the system to operation.

Flanges
Leaky flanges that are welded in place require new welds for repair. For large leaks, the flange is usually removed and replaced with a new flange and weld. Pinhole size leaks can be repaired with a filler weld.

When the flange leak is repaired, it should be tested to assure a leak-free connection.

Gaskets

Gaskets are used for installing control valves and orifice plates. If a good seal is not made between the gasket and the flange, a leak could easily occur. Figure 5 shows a control valve installation.

Figure 5. Control Valve Installation

Follow these steps for replacing gaskets in a control valve and orifice plate installation.

**Step 1** Lock out the system as required by plant safety standards.

**Step 2** Remove all flange bolts and nuts holding the control valve or orifice plate in place.

**Step 3** Remove the instrument and gaskets from the system.

**Step 4** Scrape the gasket off the instrument or flange connecting surface.

**Step 5** Secure the proper size gaskets and install between the instrument flanges and pipe flanges.

**Step 6** Align the flange holes of the pipe and instrument.
**Step 7** Insert the flange bolts and nuts and tighten as required.

**Step 8** Check the connection for leaks.

**Step 9** Restore the system to operation.

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**7.0.0 TESTING DOCUMENTATION**

When written procedures are required by the referencing Code Section, they shall include, as a minimum, the following information:

(a) extent of the examination;
(b) type of equipment to be used for detecting leaks or measuring leakage rates;
(c) surface cleanliness preparation and type of equipment used;
(d) method or technique of the test that will be performed;
(e) temperature, pressure, gas, and percent concentration to be used.

The test report shall contain, as a minimum, the following information as applicable to the method or technique:

(a) date of test;
(b) certification level and name of operator;
(c) test procedure (number) and revision number;
(d) test method or technique;
(e) test results;
(f) component identification;
(g) test instrument, standard leak, and material identification;
(h) test conditions, test pressure, and gas concentration;
(i) gage(s) - manufacturer, model, range, and identification number;
(j) temperature measuring device(s) and identification number(s);
(k) sketch showing method or technique setup.

The test report shall be maintained in accordance with the requirements of the referencing Code Section.
SUMMARY

Pressure/leak testing of piping and tubing systems is essential to ensure the integrity of these systems after initial fabrication and throughout their operational life. The stringent requirements associated with this type of Non-Destructive Testing should be thoroughly understood by all members of the testing crew prior to commencing the procedure. This module has briefly presented some of the information that you, the trainee, must understand and learn to be able to correctly coordinate and perform a pressure/leak test.
References

For advanced study of topics covered in this Task Module, the following works are suggested:

ASME Standards
ANSI 31.1 and 31.3
ISO 9000
ANSI Q-90

SELF-CHECK REVIEW / PRACTICE QUESTIONS

1. Unless specified, tubing or piping shall not be tested at pressure exceeding ________% of the design pressure.

2. When selecting a testing method, what is one criteria?
   a. Sensitivity.
   b. Cost.
   c. Reliability.
   d. All of the above.

3. What is the minimum time pressure shall be held continuously for an initial service test?
   a. One hour.
   b. 30 minutes.
   c. 10 minutes.
   d. 4 hours.

4. What test medium is normally used for hydrostatic testing?
   b. Air.
   c. Oil.
   d. Water.

5. Why should instrument devices be isolated from test pressure?
   a. Prevent damage to delicate components.
   b. Because they are inaccurate at high pressure.
   c. Because they will give false readings to test rig operator.
   d. May cause inadvertent operation of a safety device.
PERFORMANCE / LABORATORY EXERCISES

1. Given a "mock-up" of an instrument tubing system provided by instructor:
   Step 1 Write a test procedure to perform a pressure/leak test of the system.
   Step 2 Set up and perform the test.
   Step 3 Properly document test results.

2. Given a "mock-up" of an instrument piping system provided by instructor:
   Step 1 Write a test procedure to perform a pressure/leak test of the system.
   Step 2 Set up and perform the test.
   Step 3 Properly document test results.

ANSWERS TO SELF-CHECK REVIEW / PRACTICE QUESTIONS

1. 25%
2. d
3. c
4. d
5. a