LOAD BANK TESTING PROCEDURE
GENERATOR LOAD BANK TESTING
AND ENGINE TESTING

I. General

A. Provide all equipment, labor, materials and supervision necessary to test the stand-by diesel engine driven electric generator set specified. Tests shall be performed as installed on-site.

B. Acceptance testing of the installed generator set shall be conducted by a factory trained representative of the generator set manufacturer. An authorized representative of Anne Arundel County will also witness the acceptance tests. The test results shall be submitted to and approved by the County before the generator set is accepted. The contractor shall furnish all testing equipment, materials, fuel, etc., needed to demonstrate the set is in compliance with the specification. Any deficiencies brought to the attention of the contractor shall be corrected and if warranted or requested by the County, the test shall be re-performed prior to acceptance. Final Operations & Maintenance (O&M) manuals shall be submitted before the acceptance tests commence.

C. The acceptance tests shall be performed during a field test during which the manufacturers representative shall demonstrate that the system performs in complete compliance with the specifications. As a minimum, a load bank test performed in accordance with NFPA 110 section 5-13.2 (copy of which is included at the end of this section) as modified by the County shall be conducted. The load test shall use dry type load banks specifically utilized for this purpose. The load bank will be capable of definite and precise incremental loading and shall not be dependent on the generator control instrumentation to read voltage and amperage of each phase. The test instrumentation will serve as a check of the generator set meters. Salt water brine tank load banks are not acceptable for this purpose and are disallowed and will not be utilized for this test.

D. Load bank testing shall be performed for a period of four (4) hours at the full rated load of the generator, and witnessed by a County representative.

II. Generator Engine and Load Bank Testing Outline

A. Prechecks

1) Fuel, fluid levels, belts, hold-down bolts, etc.

2) Run generator long enough to establish proper operation and make sure all pumps, motors etc. are turning in the proper direction under emergency power.
3) Shut down generator and allow it to cool to "cold start" condition.

B. Perform NFPA 110 testing (as modified by the County) as follows:

1) "Cold-start" test (NFPA 110, 5-13.2 (a) through (g)) where a normal power failure is simulated and the maximum expected emergency load supplied. Record engine and generator performance data. Maximum emergency starting load will be supplied using facility load plus pump starting loads as detailed later in this section.

2) In lieu of NFPA 110 5-13.2.3 (h) & (i), hook up the dry-type load bank to generator and perform a stepped load test on the generator at 25%, 50%, 80% and 100% of the nameplate KW rating of the generator. Each step to last fifteen (15) minutes record engine and generator data as detailed later in this section.

IMPORTANT NOTES!

a) Depending on the sizing of the generator breaker, the load bank may be required to be tied into the line side of the breaker in order to test the generator at 100% load for extended period. In this case properly sized separate overcurrent protection shall be provided.

b) Set shall be loaded based on the KW amperage rating and not KVA amperage rating.

3) Return normal power to the station and record time delay on retransfer and time delay on prime mover cool down period and shut down (NFPA 110, 5-13.2.3 (j)).

4) Allow prime mover to cool down for five (5) minutes.

5) Perform a full-load (100% KW rating) test immediately after the cool down period in accordance with NFPA 11, 5-13.2.6. Record data listed in 5-13.2.3.(c) through (h) at 100% load acceptance.

6) Continue running generator at full-load for four (4) hours in lieu of the two (2) hours required by NFPA 110, 5-13.2.5. Record performance data every fifteen (15) minutes.

7) Test all engine protective devices for proper operation and set-point tolerances as detailed later in this section. Record final settings.

- END OF OUTLINE -
III. Test Parameters, Procedures and Tolerances

A. Perform the "cold-start" test and record data as required by NFPA 110, 5-13.2 by doing the following:

Sewage Pumping Stations

1) Trip normal power and put one pump in "hand" position simultaneously.
2) Engine starts under dry-transformer load and one pump starting load.
3) Ten (10) seconds later put second pump in hand. Engine now accepts dry-transformer load, one pump running load plus second pump stating load.

NOTE: During this test also observe and record the maximum voltage dip due to pump starting loads. The generator should pull both pumps (first one then the other) with no more than a 20% dip under the maximum station load conditions of ____KW.

Other Facilities

1) Apply load in steps used for generator sizing (design consultant specify).

B. Perform a stepped load-bank test. As a minimum, the following shall be observed and recorded at 25%, 50%, 80% and 100% stepped load during testing of diesel generators on-site:

1) Volts and amps on each phase - Voltage unbalance between phases shall not exceed ± 1% of rated voltage.
2) Frequency - Frequency regulation shall be 0% with isochronous governing and within 3% with speed droop governing.
3) KW
4) Oil pressure - shall not deviate more than 10% above the manufacturers recommended oil pressure at full load and operating temperature.
5) Water temperature shall not exceed 210°F at any time.
6) Hour meter readings.
7) Note and record color and appearance of exhaust after engine has stabilized at each step by simple description such as clear, little haze, white, bluish, gray, dark, etc. Except for normal engine warm-up and load
change stabilization, the stack should remain clear or with little haze over entire operating range.

NOTE: A sample form used by the County load bank testing program to document items (1) - (6) above is included as a guide at the end of this section. While taking readings, the engine should be running uniformly without unusual sounds, knocking or excessive vibration.

C. Perform a full-load test in accordance with 5-13.2.4-2.7 of NFPA 110 for four (4) hours in lieu of two (2) hours. In addition to the data required in paragraph B (1)-(7) above record cylinder exhaust temperatures using a hand-held contact pyrometer or other approved device. Cylinder exhaust temperatures should be within 50°F of each other to indicate loads are being divided equally among cylinders. This requirement will also necessitate that the proper absolute exhaust temperatures at 100% load be known and recorded for comparison between cylinders.

D. Test engine protection devices for proper operation and settings including shut-down for overcrank, overspeed, high coolant temperature and low oil pressure under simulated conditions. Check proper operation of status lights and resets. Performance tolerances:

1) Overcrank protection shall include a 10 second cranking cycle limited to 3-5 attempts before lockout. Record final field setting:
   - Overspeed setting shall be set at 15% above rated speed. Record final field setting.
   - High coolant temperature shut-down setting shall not exceed 210°F. Record final setting.
   - Low oil pressure shut-down shall not occur at less that 10 psi. Record final setting.

2) If engine fails to start or any safety devices operate while the engine is running, the engine shall stop immediately and starting controls locked out requiring manual resetting. All alarm indicators shall be checked for proper operation.

E. Test time delay on diesel cool-down period and shut-down shall not be less than five (5) minutes.

F. Test automatic starting, "Run-off-Auto" switch.

G. Check adjustment and operation of governor.
H. Check proper pump rotation and diesel ventilation fan (where installed) rotation under emergency power vs. normal power.

I. Check proper operation of ventilation louver devices.

J. Check operation of jacket water heater.

K. Perform vibration test (see Vibration Testing Section).

IV. Documentation

The following documentation is to be submitted to the County prior to acceptance:

A. Evidence of prototype testing

B. Results of factory tests of the generator set supplied

C. Installation certificates.

D. A final on-site performance and inspection report summarizing load bank test results, engine controls testing, observations and other information relative to standby generator testing. This data is to be included as part of the Operation and Maintenance (O&M) Manuals. All problems, findings or any corrective actions necessary to bring generators into compliance shall also be well documented.

E. Final O & M manuals.

F. Shop drawings.

A copy of section 5-13 of NFPA 110 Emergency and Standby Power System 1985 has been included at the end of this section.

END OF SECTION
An automatic dry chemical system shall not be used unless the manufacturers of the EPS certify that the dry chemical system will not damage the EPS system or hinder its operation or reduce its output. Where sprinkler protection is provided in the EPS equipment rooms or separate buildings, hoods or shields of noncombustible materials shall be installed to protect the critical equipment.

5-11.3 Where the EPS rooms or separate buildings are equipped with fire detection systems, the installation shall be in accordance with applicable standards. (See NFPA 72A, Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service; NFPA 72B, Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service; NFPA 72C, Standard for the Installation, Maintenance and Use of Remote Station-Protective Signaling Systems for Fire Alarm and Supervisory Service; NFPA 72D, Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems; and NFPA 72E, Standard on Automatic Fire Detectors.)

5-11.4 The EPS equipment shall be adequately protected from damage due to lightning.

5-11.5 In recognized seismic risk areas EPS components such as electrical distribution lines, water distribution lines, fuel distribution lines and others which serve the EPS shall be designed to minimize damage from earthquakes and to facilitate repairs should an earthquake occur.

5-11.6 In seismic-prone areas for Level 1 and 2 systems, EPS, transfer switches, distribution panels, circuit breakers and associated controls must be capable of performing their intended functional operation during and after being subjected to the anticipated seismic shock.

5-12 Distribution.

5-12.1 The distribution and wiring systems within EPS shall be installed in accordance with applicable standards. (See NFPA 70, National Electrical Code.)

5-12.2 Where applicable, in addition to the requirements of 5-12.1, distribution and wiring systems of level 1 EPS shall be installed in accordance with applicable standards. (See Chapter 8, Essential Electrical Systems in Health Care Facilities, of NFPA 99, Standard for Health Care Facilities.)

5-12.3 The wiring between the EPS output terminals and the first distribution overcurrent protection terminals within the EPS shall be located at a minimum distance to enhance system reliability and safety.

5-12.4 If the conduit attaching point to the EPS is on the forcing function side of the EPS's vibration isolation system, flexible conduit section(s) shall be installed between the EPS unit(s) and any of the following attached:

(a) The transfer switch.
(b) The control and annunciator wiring.
(c) Any accessory supply wiring such as jacket water heaters.

Stranded wire of adequate size shall be used to minimize breakage due to vibration. Bushings shall be installed to protect wiring from abrasion with conduit terminations.

5-12.5 All AC-powered support and accessory equipment necessary to the operation of the EPS shall be supplied from the load side of the automatic transfer switch(es), or the output terminals of the EPS, ahead of the main EPS overcurrent protection, as necessary to assure continuity of the EPS operation and performance.

5-12.6 The starting battery units shall be located as close as practicable to the prime mover starter to minimize voltage drop. Battery cables shall be sized to minimize voltage drop in accordance with the manufacturer's recommendations and accepted engineering practices.

5-12.7 The electrical distribution system of the EPSS shall be complete with properly sized overcurrent and fault current protective equipment. (See NFPA 70, National Electrical Code.)

5-13 Installation Acceptance.

5-13.1 Upon completion of the installation of the EPSS, the EPS shall be tested to ensure conformity to the requirements of the standard, both in power output and in function. The authority having jurisdiction shall be given advance notification of the time the final test will be performed in order that the authority may witness these tests.

5-13.2 An on-site acceptance test shall be conducted as a final approval test for all Emergency Power Supply Systems. For new Level 1 installations, the EPSS shall not be construed to meet this standard until the acceptance tests have been conducted and test requirements met.

5-13.2.1 The test shall be conducted after completion of the installation with all EPSS accessory and support equipment in place and operating.

5-13.2.2 Test Results. The EPSS shall perform within the limits specified in the standard.

5-13.2.3 The on-site installation test shall be conducted in the following manner:

(a) With prime mover in a “cold start” condition and emergency load at normal operating level, initiate a normal power failure by opening all switches or breakers supplying the normal power to the building or facility. Test load shall be that load which is served by the EPSS.

(b) Observe and record the time delay on start.
(c) Observe and record the cranking time until the prime mover starts and runs.
(d) Observe and record the time required to come up to operating speed.
APPENDIX G

EMERGENCY AND STANDBY POWER SYSTEMS

Chapter 6 Routine Maintenance and Operational Testing

6-1 General.

6-1.1 The continuing reliability and integrity of the EPSS is dependent on an established program of routine maintenance and operational testing. The routine maintenance and operational testing program shall be based upon the manufacturer's recommendations, instruction manuals, and the minimum requirements of this chapter and the authority having jurisdiction.

6-1.2 Consideration shall be given to temporarily providing a portable or temporary alternate source whenever the emergency generator is out of service.

6-2* Manuals, Special Tools and Spare Parts.

6-2.1 At least two sets of an instruction manual(s) for all major components of the EPSS shall be supplied by the manufacturer(s) of the EPSS and shall contain:

(a) A detailed explanation of the operation of the system.

(b) Instructions for routine maintenance.

(c) Detailed instructions for repair of the EPS and other major components of the EPSS.

(d) Pictorial parts list and part numbers.

(e) Pictorial and schematic electrical drawings of wiring systems, including operating and safety devices, control panels, instrumentation and annunciators.

6-2.2 For Level 1, one set of the instruction manual shall be kept in a secure, convenient location near the equipment. The other set shall be kept in a different source location.

6-2.3 Special tools and testing devices required for routine maintenance shall be available for use when needed.

6-2.4 Replacement for parts identified by experience as high mortality items shall be maintained in a secure location(s) on the premises. Consideration shall be given to stocking spare parts as recommended by the manufacturer.

6-3 Maintenance and Operational Testing.

6-3.1* The EPSS shall be maintained so as to provide reasonable assurance that the system will be capable of supplying service within the time specified in type and for the time duration specified in class.

6-3.2 Routine maintenance and operational testing program shall be initiated immediately after the EPSS has passed acceptance tests.

6-3.3 A written schedule for routine maintenance and operational testing of the EPSS shall be established.

6-3.4 A written record of inspections, tests, exercising, operation, and repairs of the EPSS shall be maintained on the premises. The written record shall include:

(e) Record voltage and frequency overshoot.

(f) Observe and record time required to achieve steady-state condition with all switches transferred to the emergency position.

(g) Record voltage, frequency, and amperes.

(h) Record prime mover oil pressure, water temperature where applicable, and battery charge rate at 5-minute intervals for the first 15 minutes, and at 15-minute intervals thereafter.

(i) Continue load test with building load for one hour, observing and recording load changes and the resultant effect on voltage and frequency.

(j) Return normal power to the building or facility, record the time delay on retransfer to normal for each switch (set for 15 minutes minimum) and the time delay on prime mover cooldown period and shutdown.

5-13.2.4 After completion of the test performed in 5-13.2.3, the prime mover shall be allowed to cool for 5 minutes.

5-13.2.5 Full-Load Test. A load shall be applied for a two-hour, full-load test. The building load can serve as part or all of the load, supplemented by a load bank of sufficient size to provide a load equal to 100 percent of the nameplate kW rating of the EPS, less applicable derating factors for site conditions. Unity power factor is acceptable for on-site testing, provided that rated load tests at rated power factor have been performed by the manufacturer of the EPSS prior to shipment.

5-13.2.6 A full-load test shall be initiated immediately after the cooling time allowed in 5-13.2.4 by any method which will start the prime mover and, immediately upon reaching rated rpm, pick up 100 percent of nameplate kW rating on one step, less applicable derating factors for site conditions. 

Exception: For gas turbines, the load can be applied in steps.

5-13.2.7 Record the data listed in 5-13.2.3(e), (d), (c), (f), (g), and (h) at first load acceptance and every 15 minutes thereafter until the completion of the two-hour test period.

5-13.2.8 Cycle Crank Test. Utilize any method recommended by the manufacturer to prevent the prime mover from running. Put the control switch into "run" to cause the prime mover to crank. Observe the complete crank/test cycle specified in 3-5.4.2 and 1able 3-5.4.

5-13.2.9 Test all safety specified in 3-5.5 and 3-5.6 as recommended by the manufacturer.

5-13.3 The following shall be made available to the authority having jurisdiction at the time of the acceptance test:

(a) Evidence of the prototype test of 3-2.1 (for Level 1).

(b) Certified analysis of 3-5.10.2.

(c) A letter of compliance specified in 3-5.10.5.
LOAD BANK TEST REPORT

FACILITY_____________________________ DATE_____________

NAMEPLATE DATA

KW__________________  KVA_______________  PF____________

VOLTS_______________  AMPS______________  HZ____________

<table>
<thead>
<tr>
<th>TIME</th>
<th>VOLTS</th>
<th>AMPS</th>
<th>HZ</th>
<th>HOURS</th>
<th>OIL PRESS</th>
<th>WATER TEMP</th>
<th>KW</th>
</tr>
</thead>
<tbody>
<tr>
<td>L G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LOAD RATE 25%__________  TESTED BY: ________________________
LOAD RATE 50%__________  OBSERVED BY: _____________________
LOAD RATE 80%__________  APPROVED BY: _____________________

FORM #113089/#1MXL

Published: 01/01  Revised:
EXHAUST SMOKE ANALYSIS

CHECK FOR

CHECKS TO BE MADE WITH ENGINE WATER OUTLET TEMPERATURE OF 165º F MINIMUM

BLACK OR GRAY
INCOMPLETELY BURNED FUEL

INSUFFICIENT
COMBUSTION AIR

HIGH EXHAUST BACK PRESSURE.
A. MEASURE WITH MANOMETER.
B. REMOVE MUFFLER.
C. REMOVE MANIFOLD.

RESTRICTED AIR INLET.
A. CYLINDER LINER PORTS CLOGGED.
B. AIR CLEANERS OR SILENCER CLOGGED BY DIRT OR DAMAGED.
C. EMERGENCY STOP NOT COMPLETELY OPEN OR RESTRICTED SCREEN.
D. INSPECT ENGINE ROOM FOR ADEQUATE AIR INLET.

INSUFFICIENT COMBUSTION AIR

EXCESS FUEL OR IRREGULAR FUEL DISTRIBUTION

IMPROPER SETTING OF INJECTOR RACKS.

IMPROPER TIMING OF INJECTORS.

FAULTY INJECTORS.
A. POP INDIVIDUAL INJECTORS WITH ENGINE STOPPED.
B. CUT OUT INDIVIDUAL INJECTORS WITH ENGINE RUNNING.

HEAVY FUEL DOES NOT COMPLETELY VAPORIZE
(IF SMOKE IS PRESENT WHILE WARMING UP AND IS OBJECTIONABLE, USE OF LIGHTER FUEL IS INDICATED) - RUN ENGINE ON NO. 1 FUEL OIL OR KEROSENE AND OBSERVE EXHAUST.

BLUE
FUEL OR LUBE OIL NOT BURNED IN CYLINDER, BLOWN THROUGH CYLINDER DURING SCAVENGING PERIOD

INTERNAL FUEL OR LUBE OIL LEAKS.
A. FOLLOW CHART ON HIGH OIL CONSUMPTION.
B. AIR HEATER LEAKING FUEL.

PULLOVER OF LUBE OIL FROM AIR CLEANER - CHECK OIL LEVEL IN CLEANER.

WHITE
MIS-FIRING CYLINDERS

FAULTY INJECTORS.
A. POP INDIVIDUAL INJECTORS WITH ENGINE STOPPED.
B. CUT OUT INDIVIDUAL INJECTORS WITH ENGINE RUNNING.

LOW COMPRESSION

LOW OCTANE FUEL, RUN ENGINE ON NO. 1 FUEL OR KEROSENE.