Load Bank Testing
Load Bank Testing

Whether required by code or as simply part of good building operations strategy, facility executives whose organizations own emergency generators must test them regularly to ensure they’re in good working order should disaster strike. The benefits of regular testing are many, but how, and how frequently, to do so for maximum benefit is often dependent on many variables. These include the building’s occupancy, its use, and the cost of business interruption, to name a few.

A recent Building Operating Management survey illustrated that most facility executives (76 percent) do have emergency power generation at their facilities, and most (72 percent of respondents) are familiar with load bank testing.

1. Do you have onsite emergency power generation in any of your facilities? R=992
   Yes  76%
   No  24%

2. Are you familiar with load banks, and the benefits they provide in regards to load testing? R= 992
   Yes  72%
   No  28%

A good place to start in developing testing plans is to know which codes or standards apply directly to a particular facility type, including whether it’s required to have emergency backup power for fire/life safety considerations. While hospitals have long been mandated to have and test emergency generators, facility executives responsible for other types of facilities may not be aware of the requirements they must meet. For example, the relatively new (created in 2005) NEC 708 includes language that may require some of types of facility — high schools or commercial office facilities with a banking component or data center — to have emergency generation. And if that’s the case, those generators will need to be tested.

Facility executives have two options when it comes to testing emergency power equipment. Load bank testing offers the main advantage that generators can be tested without shutting down a whole building to switch to generator power. The other option is building load testing, which means putting the full building load on the emergency generators during an off period.

Facility executives often combine load bank testing with an occasional building load test. Experts and facility executives experienced with both types of testing offer advice on when each type of testing might be most useful.
One critical strategy of emergency power testing in general, but load bank testing specifically, is keeping accurate records of when and how emergency generators were tested. This is true when the organization has its own load banks, as well as when facility executives are renting load banks or hiring a third-party company to do load bank testing for them. In the latter cases, facility executives need to work carefully with the load bank service company to ensure the accuracy of records and the validity of data being recorded.

Recordkeeping can help facility executives prove their equipment is up to date with testing and has been checked in accordance with industry best practices and/or local codes. Just as importantly, they can analyze testing data to see trends in performance, and take appropriate corrective action, if necessary.

Above all, load bank testing helps assure facilities executives that the backup generating systems will be there when the main electrical supply to their buildings goes out.

Benefits of Testing

Load bank testing provides facilities executives with numerous benefits. For new buildings, the load bank testing validates that the backup generation system is performing to design specifications. For existing structures, load bank testing makes sure that modifications or remodeling adjustments have not altered the backup generator’s operation. Or, if they have, load bank testing puts facility executives in a position to install additional or modified backup generator sets before any power failures occur.

Kurt Summers, president of Austin Generator Service and an expert for the Electrical Generating Systems Association (EGSA), points out that routine load bank testing “ensures generator set performance” during an emergency. Such testing means facilities executives may uncover system defects that may not be found otherwise until a power outage, according to Summers. Discovering them during testing allows any necessary repairs to be made before the facility has a critical need.

"Prior to building turnover, load bank testing helps insure that electrical generation systems support loads by maintaining voltages and frequencies that meet design criteria,” maintains Joshua Gepner, vice president of Environmental Systems Design, Inc. Endurance testing may last eight to 48 hours, depending on the criticality of the generators being tested, Gepner explains. “Generally, if they are going to fail, they will fail quickly.”

Testing also provides an opportunity to conduct an infrared (IR) scanning process, making sure all electrical connections are tight. This is particularly important in data centers, says Gepner.
When using IR thermal scanning, Michael Fluegeman, principal/manager of data center support systems for PlanNet, recommends easing up the load, beginning the scan, and then rescanning. He also suggests waiting at least 15 minutes after reaching design load. “Bad connections and other problems don’t always show up right away,” he notes.

Every electrical generator at Scottrade is load bank tested annually, according to Al Fowler, assistant vice president of building operations. The load bank places each generator under full load conditions for four hours. “Every 15 minutes readings are taken to see how that generator is handling the load,” explains Fowler. Once the load bank testing for that generator is completed, Fowler keeps both an electronic record and a hard copy of the results in a folder.

“As per National Fire Protection Association Standard 110 (NFPA 110), if you cannot achieve at least 30 percent load on a unit, you will build up carbon in the system,” maintains Stewart Allen, facility manager — Jacksonville at Citizens Property Insurance. “When you run the units at the higher load it creates greater temperatures and burns off any carbon that may have built up,” Allen explains.

Christopher Wade, national program director of critical environment operations, Newmark Grubb Knight Frank, agrees. “Running an engine with minimal load causes residual fuel buildup, which decreases the efficiency of the engine and reduces the useful life of critical parts,” says Wade.

Another advantage of load bank testing is that it allows verifying the performance of emergency backup generators without interrupting business operations.

When it comes to mission critical facilities such as data centers, Wade also notes a significant reduction in business risk. “Effective load testing could prevent or defer 60 percent of data center failures,” according to Wade.

Other load bank testing benefits include the ability to conduct an integrated systems test that double checks all HVAC and power systems loads. “A load bank generates heat as it produces electrical load, which allows the cooling system to be tested, adjusted and equalized,” observes Wade. “Furthermore, various system failure scenarios can be initiated for each and the resulting effects on the system can be documented for future reference.

“Load bank testing provides tangible proof that the system will support a full load in all modes of operation. A written report will be generated of all results and any work completed or recommended,” explains Wade.

A Round-Up of Code Requirements

In most cases, emergency power generating systems must comply with a number of different code requirements based on National Fire Protection Association (NFPA) 110, Joint Commission, Environmental Protection Agency (EPA) Tier regulations, and National Electrical Code (NEC) specifications. The Building Operating Management survey showed that many facility executives (46 percent) aren’t clear on which code or standard their emergency power generating systems comply with. Here is a rundown of the major industry standards and codes that cover emergency power generation and testing.

NFPA 110

Emergency Generator Testing Requirements sets safety standards to protect commercial building occupants by making sure generator-powered backup lighting will operate as expected. A monthly test is performed on generators whose failure could result in death or injury. Should a generator fail this monthly test, it should undergo load bank testing for two continuous hours annually, per Section 8.2.4.3. It is not mandatory to use load banks, but most buildings’ total load values are below the higher monthly testing requirements. Under the continuous test, the generator should be operated at 25 percent of the nameplate kilowatt rating for 30 minutes, at 50 percent of the kilowatt rating for 30 minutes and at 75 percent of the kilowatt rating for 60 minutes.

“If the connected load will not provide sufficient engine loading to hit the 30 percent minimum load level, one option is to connect a portable resistive load bank annually to meet the requirements of NFPA 110,” explains Wade. He also notes that if a generator set is paralleled with other generator sets — or if loads from other generators can be safely transferred to the under-loaded set — then simply switching the other sets off may be possible.

NFPA 700

Emergency Systems are legally required to receive an operating permit as determined by the local code enforcement authority. This electrical code requirement is essentially a people-oriented lifeline, ensuring that lighting and controls for occupant life safety loads take priority over other building loads. Should the main electrical power supply fail, backup emergency power for life safety systems must be available within 10 seconds.
Load Bank vs. Building Load Testing

“Load bank testing allows for performance testing of critical equipment from very light loads up to nameplate and/or design loads, which is normally not possible using live load,” says Fluegeman. Fifty-five percent of respondents to the Building Operating Management survey do use load banks to test their energy power systems.

3. Does your facility test the emergency power system using load banks? R=788

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<td>45%</td>
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Fluegeman says load bank testing is ideal for initial commissioning and for periodic component and subsystem maintenance testing. “For facilities where loads can be connected downstream of switchgear (at or near the critical load point) with minimal disruption, load banks are often preferred over live load.”

“UPS are considered critical to business continuity without which loads would not be able to operate during a power outage,” notes Wade. “Load bank testing is a way of validating the correct operational performance and battery autonomy of the UPS system. As a UPS battery set is only as strong as its weakest battery cell, load bank testing can also be used to determine the condition of UPS batteries and battery sets, or strings, to indicate if any individual cells are approaching the end of their working life and not holding a charge and about to fail.”

Summers notes, “Load bank testing focuses on the engine-generation set without putting the customer loads in jeopardy if the gen set fails to perform properly. Code compliance may require this test annually, which is also an interval recommended as a best practice maintenance interval.”

“A building load test is done to validate complete system performance, including the generator set and automatic transfer switches, with actual customer loads,” explains Summers. “Code compliance may require this test monthly, especially for life safety facilities.”

An advantage of building load testing is “it allows you to test your transfer gear and at the same time monitor your building loads under different conditions, such as air conditioning or heating,” says Allen. “This will help to forecast fuel usage and total run times.”

“Both tests are part of any good maintenance program,” says Summers.

Fluegeman agrees. “Live load sometimes presents a more challenging load profile than load banks for generators and uninterruptible power supply (UPS) systems.” The reason, says Fluegeman, is that dynamics of power factor, harmonics, etc., must be considered for live loads.

NEC 701

Legally Required Standby Systems are the next priority, after NEC 700. NEC 701 requires standby power to be available in 60 seconds or less after a power loss to certain legally required standby systems. Basically, NEC 700 is designed for people who are exiting the building, while NEC 701 responds to the needs of firefighters and other personnel responding to the emergency.

NEC 702

Optional Standby Systems apply to situations where standby generators are optional. In these cases, the systems may be put in place to protect economic loss or business interruptions. For instance, data centers may lose millions of dollars from lost power.

NEC 708

Critical Operations Power Systems (COPS) came into being through the U.S. Department of Homeland Security after 9-11, Hurricanes Katrina and Rita, and other disasters. This code requires a commissioning plan for on-site backup generation, baseline testing, and periodic witness testing, as well as a documented preventive maintenance program, written records of testing, and the way for testing all critical power systems during maximum anticipated load conditions.

Joint Commission requirements encourage hospitals, health centers, and nursing homes to go beyond local, state, and national electrical codes, thereby ensuring that emergency power systems provide patient safety and prevent loss of life. Periodic testing is required for all healthcare facilities, preferably under higher loads than the 30 percent minimum. At least once every three years, all healthcare facilities are required to exercise the power system under the facility’s actual load and full emergency conditions for at least four hours.

In 2014, the Joint Commission announced changes to monthly generator load testing, permitting it to be done anytime during the month, rather than the previous requirement of no less than 20 days and no more than 40 days from the previous monthly load test. However, this extended time allowance may clash with Centers for Medicare & Medicaid Services (CMS) Conditions of Participation requirements. Another concern is whether this new testing window applies to construction after March 2003 and/or to existing facilities.
Although data center standards currently may not require actual load testing, that may change in code and standard revisions. “Future standards may recommend actual load testing to ensure performance and safety,” observes Wade.

For UPS and generator systems, Gepner recommends a minimum of eight hours of load bank testing, to make sure “they are carrying their respective electrical loads in an acceptable fashion for extended time durations.” Power quality metering during this testing assures that the backup power systems are performing as specified and that waveforms produced are within tolerance ranges, explains Gepner. “During testing, we can slam a 100 percent load onto the generation system. We know there will be a voltage sag, but we can review the power quality metering data to determine how much it deviated from nominal and how fast the system recovered.”

4. Do you have a permanent load bank installed? R=434

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<tr>
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5. Do you rent a portable load bank? R=307

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<th>Yes</th>
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6. Do you hire a load bank testing service? R=316

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<th>Yes</th>
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<tr>
<td>No</td>
<td>6%</td>
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**EPA** Tier Level regulations apply to emissions from modern diesel generators, when operated at loads of more than 50 percent. Using load banks allows for simultaneously testing multiple units, thereby reducing the time required to perform and document mandatory testing to ensure the electronic engine and emissions controls are operating at the manufacturer’s recommended load levels and temperatures.

**ISO 8528** applies to test methods and criteria for measuring the alternating current of generation sets that are driven by reciprocating internal combustion engines in load bank testing. In part 6 of the standard, three performance classes, Grade 1, Grade 2 and Grade 3 are defined, along with their associated performance criteria. A fourth class, Grade 4, also is available but applies to customized performance criteria determined by the supplier and the customer. Grade 2 is the normal grade specified.

The performance criteria covers specific percentages for steady state frequency and steady state voltage, as well as transient frequency and transient voltage at 100 percent load decrease. For sudden load increase, transient frequency and transient voltage percentage ranges also are specified.

**Do your emergency power generating systems have to comply with any of the following requirements? R=824**

<table>
<thead>
<tr>
<th>Requirement</th>
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<tbody>
<tr>
<td>NFPA 110</td>
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<tr>
<td>NEC 700 Emergency Systems</td>
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<tr>
<td>Joint Commission requirements</td>
<td>17%</td>
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<tr>
<td>EPA Tier regulations</td>
<td>14%</td>
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<tr>
<td>NEC 701 Legally Required Standby Systems</td>
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<td>NEC 702 Optional Standby Systems</td>
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<td>NEC 708 Critical Operations Power Systems</td>
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<tr>
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<tr>
<td>Not sure</td>
<td>46%</td>
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<tr>
<td>Other</td>
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Allen believes load bank testing should be run annually "to determine how your equipment is working under different loads." According to Allen, the load bank test usually is conducted for four hours at different load percentages.

When portable load banks are being used, Wade recommends their loads be paralleled with the building load. "The proper way to connect the load bank is to a dedicated bus downstream from an overcurrent protection device inside a switchboard or to a bus located inside a NEMA 3R connection box mounted at a convenient place outside the generator building," explains Wade.

Further, these experts recommend four specific best practices and considerations to ensure load bank testing is maximally successful.

1. Recordkeeping

NFPA 110 requires a written schedule for routine generator maintenance and testing. A written record of generator inspections, tests, exercising, operation, and repairs must be maintained on the premises. These records must be available for review by the fire inspector or the authority having jurisdiction (AHJ) on request.

"Code compliance requires records be kept on site and available for inspection," observes Summers. "These can be paper records or electronic copies or reports."

"Good practice is to document what was tested, how it was tested, when it was tested, and the results of the test in summary form and with detail," explains Fluegeman. "Test reports should make it clear where and how much load was connected and for how long at each load level."

When testing a backup generator under live load conditions, load details along with time of day and other conditions (weather, building under normal use or unoccupied, etc.) should be documented. "Live load generator testing provides an indication of what the load on the generator might be during an actual power failure," says Fluegeman.
2. Analysis, Trending

Analysis and trending of load bank testing is invaluable for facility executives. “We look for variables in both engine and generator readings, including oil pressure, engine temperature, AC voltage and frequency as well as building load readings that may show changes,” explains Summers. “For example, during load bank testing we have been able to compare engine temperatures over several years and locate a blockage in a cooling system radiator,” enabling a repair to be made before failure during a power outage.

“Trending will allow analysis of load changes, performance changes (generator cooling, fuel consumption, etc.),” observes Fluegeman.

The benefit of good recordkeeping is “you can go back to your original baseline data to determine if your unit is wearing or not performing to its original levels,” says Allen. “You can also tell how your loads are within the buildings, if they are balanced or not.”

At Scottrade, Fowler has contracted to have all his generators load bank tested for four hours under full load conditions. Readings are taken every 15 minutes and recorded. The service company also does all the generator oil testing as well.

“Data logging tools are available from some load bank manufacturers,” says Summers. “These tools typically involve computer software that gives the end user the ability to customize reports.”

Sigma PC load bank software can perform a transient load test that monitors the deviation of the voltage and frequency of the gen-set when load is applied or rejected. The software can pass or fail a gen-set according to various classes of ISO 8528.

3. Preventive Maintenance

“When you purchase backup generation systems, the manufacturer provides an operations manual that specifies how often the systems should be tested and when to do that testing,” advises Gepner. He also notes that most corporations often have specific maintenance standards to be followed that may require more frequent load bank testing than recommended by the manufacturer.

“Load bank testing should be part of annual and triennial preventive maintenance,” recommends Fluegeman. “For standby generators that are often tested at no load or light building load, load bank testing as often as annually for a couple hours may be required to prevent exhaust wet stacking of unburnt diesel fuel. Standby generators should be operated under load for several hours annually to ensure proper performance in a long run, in particular as temperatures rise.”
Periodic load bank testing and weekly monitoring of the annunciator panels are critical in a preventive maintenance program, according to Allen, because they “will let you know what additional maintenance may be required beyond your normal scheduled work.”

At Scottrade, generators also are tested weekly under preventive maintenance contracts. “We don’t switch them to a building load,” says Fowler. “Doing so could cause our own power outage. We just use that test to make sure they turn on.”

After a load bank test and preventive maintenance are performed, Fowler warns of a single but common point of failure. “They forget to put the generator back on standby. That happens once every 20 times, so needs to be checked immediately.”

7. Is load testing part of your preventive/predictive maintenance program? R=767

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<td>Yes</td>
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<td>18%</td>
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4. Continuous Commissioning

Load bank testing ensures a high-performance building continues to operate optimally should the main electrical power supply be compromised.

“Commissioning new or existing facilities always includes load bank testing,” insists Summers. The need for reliable electrical power has made such testing an industry standard that is often engineered into the construction project, according to Summers.

“Load bank testing should be performed when crucial equipment is repaired or modified,” observes Fluegeman. “A good practice is to load test UPS batteries annually.”

Continuous periodic load bank testing “allows you to know that the system will perform when needed and for how long with or without fuel,” says Allen. “It allows you to know that you have a fully operational system that will support staff and operations.”

“Employing advanced load bank testing equipment and partnering with a respected equipment/services provider is essential to reducing overall data-center commissioning costs,” says Wade.