

Ask the Expert:

Why Resistive Reactive Load Bank Testing is the Smart Choice



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Introduction

In examining the key differences between resistive and resistive/reactive load testing, and why the latter is necessary, it is important to focus on addressing a facility's emergency power generation system as a whole by testing the entire system to identify system-wide weaknesses at the time of commissioning and at periodic test intervals to be in compliance with regulatory agencies.

Reactive load testing is most important at health care facilities, data centers, life safety and mission critical applications where the need to demonstrate the capability to provide electrical power as intended is prescribed by the regulatory standards and code specified by the designers. Examples of typical emergency power sources include gas and diesel fueled reciprocating engine-generators, liquid and gas fueled turbine-generators, rotary UPS and battery UPS systems.

Standards for Certification

While not of primary focus for understanding the key benefits of reactive load testing, it is important for consulting engineers and facility managers to understand the specific code requirements for installation, performance and testing of the emergency power systems.

The National Fire Protection Agency (NFPA) publishes and updates these standards on a regular basis with input provided by professionals, engineers and members of the industries providing related equipment and services. NFPA resources include:

- NFPA 101 (2012) Life Safety Code
- NFPA 99 (2012) HEALTH CARE Facilities Code
- NFPA 110 (2013) Standard for Emergency and Standby Power Systems
- NFPA 37 (2010) Standards for the Installation and Use of Stationary Combustion Engines and Turbines
- NFPA 70 (2011) National Electric Code
- NFPA 70B (2010), Recommended Practice for Electrical Equipment Maintenance
- Joint Commissions (formerly JCAHO).



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6.25MVA Resistive Reactive Loadbank

Specific regulations such as NFPA 101 Sec. 7.9.2.4 requires that emergency generators be installed, tested and maintained in accordance with NFPA 110. Provisions dealing with maintenance and testing of emergency generators can be found in NFPA99, Sec.4.4. and deals with such issues as:

- Test Criteria
- Test Conditions
- Test Personnel
- Maintaining and Testing Circuitry
- Battery Maintenance

Specifying engineers and facility managers should have a copy of these related NFPA standards. They are available online at www.nfpacatalog.org. Additionally, individual states and localities will also have additional standards, codes, and regulations pertaining to mission critical facilities.

Key Reason for Load Testing

Many generator sets seldom run under full load conditions after the manufacturer's factory testing. Though tested in compliance with the regulatory requirements that permit use of actual loads, over time, this practice can lead to conditions that affect performance and reliability. Modern diesel generator sets designed to meet the stringent EPA Tier Level emission standards are designed to be operated at loads higher than 50% for optimum life and performance. In addition, the use of after-treatment particulate matter filters (DPF) that depend on exhaust temperatures for regeneration to occur can be compromised by low load operation and restrict exhaust gas-flow due to build up, causing higher than recommended exhaust back-pressure and limiting the performance of the reciprocating engine-generator set and/or increased unscheduled maintenance activities.

When multiple units are installed they are often run individually for periodic and annual testing using a test load much less than the manufacturer's recommended levels. The use of a large capacity resistive reactive load bank can allow testing of multiple units simultaneously thus reducing the time it takes to perform and document the mandatory testing, and additionally, exercise the paralleling controls under the most realistic conditions possible.

Load bank testing is a critical component to meeting regulatory requirements. Today's diesel engine powered generator sets utilizing electronic engines and emission controls to meet the current and future EPA emission requirements depend on the



engines operating at the manufacturer's recommended load levels and temperatures.

Detailed review of the NFPA testing guidelines refer to minimum load levels of 30%, or as recommended by the manufacturer. Industry associations such as EGSA and the major engine-generator manufacturer's recommend load testing at higher levels to insure that the full benefits of load testing can be achieved.

Like regular maintenance, periodic testing is required by code in all healthcare applications to maintain compliance with the regulatory agency. It is common for healthcare facilities to perform regular generator set testing during off-peak times when loads are at their lowest. While this practice prevents the possibility of serious interruptions to large and/or critical loads, it does not adequately test the generator set under worst-case conditions.

Periodic weekly or monthly testing is often accomplished using loads much lower than recommended by the manufacturer's which can lead to equipment not meeting the performance or reliability required for a given facility.



Reactive Load Bank Testing

The ability to simulate more realistic reactive type loads is THE key benefit for a load bank that provides both varying kVA (resistive) and kVAR (reactive) loads. There are critical differences between testing with a resistive only load bank vs. a resistive reactive load bank including:

Resistive Load Bank Testing [KW = KVA @ unity power factor (COS F= 1.0)]

- Tests the prime mover (engine) at 100% load
- Tests the fuel delivery system operation at maximum rating and fuel consumption
- Demonstrates the cooling system operation at the generator set's full operating capacity
- Allows the exhaust and after treatment system to reach normal operating temperatures
- Eliminates exhaust wet-stacking by burning off built-up fuel and oil carbon deposits and reseating the rings when part load or low load conditions are encountered during periodic testing
- Evaporates moisture from the engine oil that reduces wear causing acid formation
- Identifies deficiencies than can be corrected with proper maintenance and repair before failure, avoiding downtime and additional expenses.

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Resistive and Reactive Load Bank Testing [Reactive Power Component (COS F = variable)]

- Tests the alternator and voltage regulator at its full rated (KVA/KVar) capacity
- Simulates the actual load (KW, KVA, KVAR) that the systems are specified and designed for
- Simulates transient loads to provide voltage and frequency response characteristics
- Tests are used to simulate and verify synchronizing, load sharing and voltage regulation on multiple unit paralleled systems under actual load conditions
- Allows thermographic/infrared inspection of the electrical systems and identification of potential hot spots and the condition of cables, terminations and buss work.

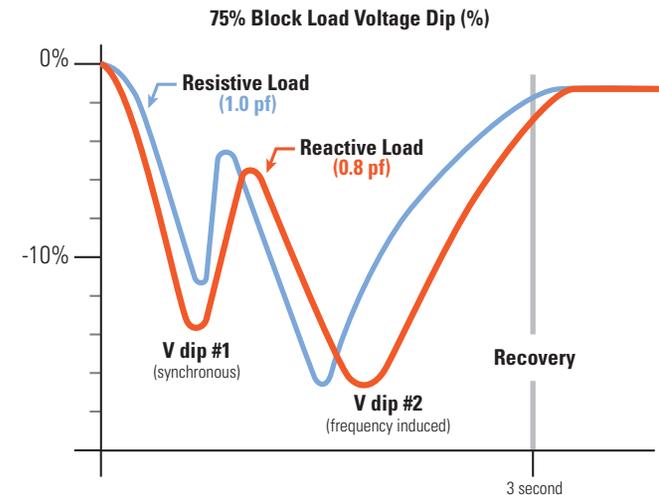
As shown in Table A at right, a resistive only load bank can provide adequate testing of the individual prime mover and load sharing (including load add/load shed) controls of a multiple unit facility. A reactive load bank allows testing of the alternator, load sharing and transient responses applying loads more in line with actual loads normally seen in operation.

All engine governors respond to loads with a reduction in engine speed. Figure A compares the transient response for a large diesel standby generator set when applying a block load using a resistive

Table A : Resistive vs. Resistive Reactive Load Bank

		RESISTIVE LOAD BANK	RESISTIVE / REACTIVE LOAD BANK
Prime Mover Capacity	(kW)	Yes	Yes
Alternator Capacity	(kVAR)	Limited	Full Load
Prime Mover Controls	-	Yes	Yes
Alternator Controls	-	Limited	Yes
Load Sharing Controls	-	KW Only	KW and KVar
Distribution Buss	-	Limited	Full Load
Transient Response	Hz	Yes	Yes
Transient Response	Volts	Limited	Yes

Figure A: Resistive vs. Resistive Reactive Test Results



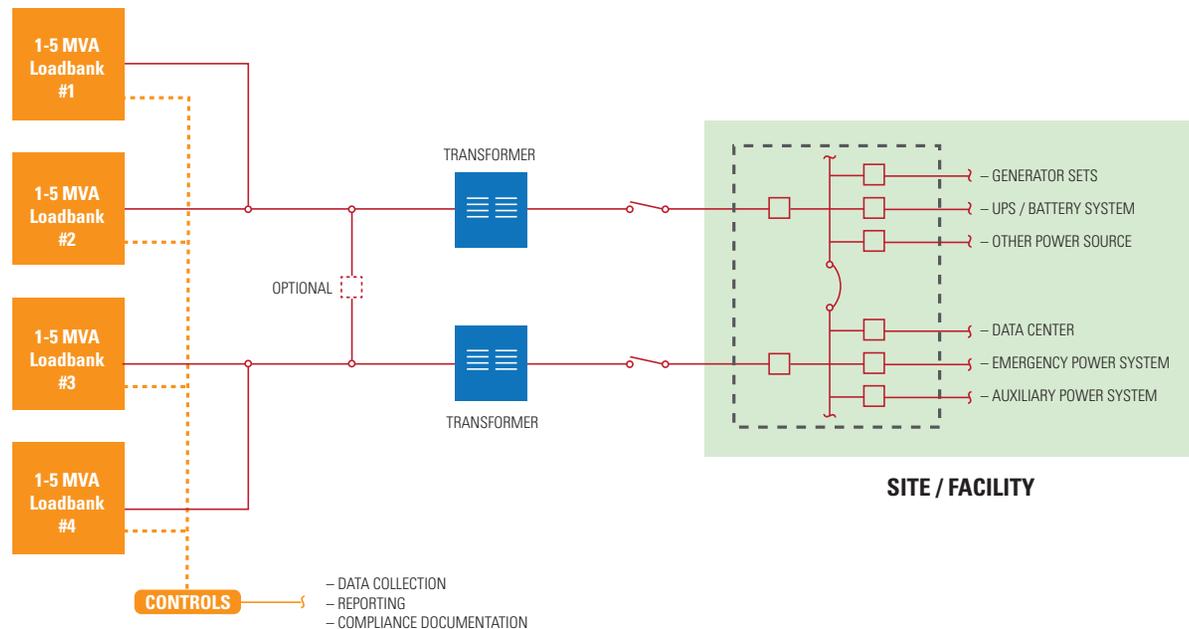


only and a resistive-reactive load bank. The resulting initial synchronous voltage dip (Vdip1) using the 75% load at 0.80 power factor results in a voltage dip approximately 25% greater when compared to the equivalent resistive only load applications. The engine speed related voltage dip (Vdip2) is similar, in both cases, due to the manufacturer's standard volts per hertz type voltage regulator (data courtesy of Caterpillar® Engine Sizer Program).

During testing with a resistive only load bank, a system that is sensitive to transient voltage dips would not necessarily provide an indication of a power supply or system condition that would lead to a potential problem during operation. Solid state controls and power supplies are particularly sensitive to transients and can unexpectedly shutdown during load changes unless specifically backed up with a dedicated power source capable of riding through the voltage and frequency transients associated with block loading of the generator sets.

When testing multiple unit generator systems the ability to share reactive loads (kVARs) equally is critical to achieving the maximum rated output of the power system. When load share controls are not properly setup and configured (i.e. droop settings, cross current compensation and polarity of the measurement and control devices) resistive only testing can fail to determine how the reactive load is accepted by the individual generator. In addition,

Figure B: Loadbank Test Setup



the paralleling switchgear and protective relays may perform adequately under resistive load applications, but the reactive load bank testing will provide load acceptance and rejection more closely simulating real world conditions. A single-line diagram showing the components used for a load test of a large facility is shown in Figure B.



Choosing the Right Load Bank

When selecting a resistive/reactive load bank it is important to consider key features including ease of operation, onboard diagnostics and metering, the ability for an operator to control multiple units from a single controller and data download capabilities. Load banks offering automatic step loading and duration, along with data collection and reporting capabilities, are beneficial in providing the necessary records for the demonstration of compliance with the facility and regulatory requirements

Table B: Types of Resistive and Resistive/Reactive Load Banks

< 100 kVA	Resistive Only	Portable, Small Generators and UPS System (120/208, 240 VAC, 60 Hz)
< 200 kVA	Resistive Only	Small Generators and UPS Systems (480VAC, 60Hz)
>200 kVA	Resistive/Reactive	Single Units (480VAC, 60 Hz)
1MVA – 6MVA	Resistive/Reactive	Single Units (480/5kV/15kV, 60 Hz)
>6 MVA	Resistive/Reactive	Multiple Units Combined (480/5kV/15kV, 60 Hz)

The connection of load banks to a facility normally involves temporary connection of the three-phase power conductors to the load bus. Electrical testing and load bank rental companies can provide the necessary load banks, transformers and cables to provide the correct service voltage(s) for the equipment being tested.

Yes to Reactive Load Bank Testing

Specifying engineers can and should promote reactive load bank testing because it is the best way to test the entire system to identify system-wide weaknesses at time of commissioning and at periodic test intervals to be in compliance with the regulatory agencies. Without proof of testing, the design remains hypothetical in nature. Testing systems with the correctly sized and type of resistive reactive load bank proves out the design of the power generation system.

For existing installations, proper reactive load bank testing provides real-time data and factual evidence of reliability, functionality and any reduction of capacity which is the result of aged equipment. Additionally, reactive load bank testing provides a 'best case' simulated real world condition where voltage drop, thermal heating, harmonics, efficiencies, etc. can be analyzed more efficiently than with just a resistive load.

Furthermore, full system integration testing of critical systems during commissioning establishes an accurate baseline for ongoing operational performance and is a valuable tool in providing a higher level of confidence in the emergency power system for the owner and tenants.



About HPS Loadbanks

HPS Loadbanks is the leading authorized distributor of Crestchic® Loadbanks in North America and a recognized premier dealer of Vantran® transformers. Crestchic loadbanks are used to test power supplies every day, all around the world from the coldest, snow-bound to the hottest, desert climates across all seven continents. HPS Loadbanks offers the best selection of new and used resistive load banks, resistive/reactive load banks, transformers, trailers and cables. Our load testing products and services include sales, rental training, parts and service. Our dedication to listening to our customers has given us insight into what the load bank industry and customers really want: flexibility, customer service, and only the highest quality products.

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