Resist or React:
The Case for Reactive Loadbank Testing for Stationary Engines

it works. every time.

Introduction

For years, responsible facilities managers have been aware that they need backup electric power generation equipment at their businesses as "insurance" against threats such as lost time and equipment damage due to utility power interruptions.

For critical and life safety institutions in the State of California, current Office of Statewide Health Planning and Development (OSHPD) regulations require backup power generation equipment be periodically tested in accordance with the manufacturer's recommendations and that proper condition and maintenance be adequately recorded.

Backup generators, and the testing and maintenance associated with their operation, represent a substantial portion of any facility manager's defense against these threats, but many managers (and some equipment and service providers) are not aware of their power generation equipment's real-world weaknesses due to incomplete testing procedures of their equipment. Consequently, when utility power fails at their facility, the lights go out.

This paper explains the importance of addressing a facility's emergency power generation system as a whole in order to identify system-wide weaknesses, and addresses and explains the difference between resistive and resistive/reactive loadbank testing, and why the latter is necessary.

This paper also addresses the importance of choosing a knowledgeable and experienced service provider as a partner in preparing a facility-specific emergency power generation maintenance and service plan.

> "Most people spend more time and energy going around problems than in trying to solve them."
>
> Henry Ford

Case Study: XYZ Hospital

XYZ Hospital in Southern California recently experienced a costly wake-up call in regard to their emergency power generation equipment. While XYZ's maintenance engineers believed that their backup power system was state-of-the-art and ready to complete its mission, they did not consider the system as a whole, and the results were nearly catastrophic.

As of September 2012, XYZ had three 1000kW generators operating in parallel at their facility, with a fourth unit scheduled for delivery. While XYZ had tested each of their three original generators separately with a resistive load for the previous 11 years, their service provider recommended a full-system resistive/reactive test before the fourth generator's arrival to check for problems with the existing units and isolate any possible problems encountered with the installation of the fourth generator. XYZ's service provider connected a resistive/reactive loadbank (see section three) at the main panel of XYZ's generator system and, starting with their switchgear, began testing the units.

The results were surprising and potentially very dangerous. The resistive/reactive load bank test revealed that in an actual emergency, XYZ's crucial systems would not function. At 50% generator capacity, XYZ's service provider noticed problems with XYZ's equipment: their switchgear was out of calibration, their alternators experienced heat problems and none of their voltage regulators worked properly. Their load-sharing and paralleling were asynchronous. If the hospital experienced a power outage, their system would fail completely. Almost identical circumstances happened at a California state prison with almost identical results.

Although the facilities managers at both locations followed the manufacturer's instructions on their equipment to the letter, they both narrowly avoided catastrophic systems failure only by considering their emergency power generation equipment as a whole system and testing it as a whole.

Stationary Engines: Greater than the Sum of their Parts

Most business owners and facility managers rightly conclude that an emergency power generation system of some kind is important to insure that the resources and services essential to their business, such as water or compressed air, are not interrupted during a supply failure from their power utility.

Other mission-critical operations such as hospitals depend on an uninterrupted supply of power because lives are at stake. Facilities managers at these businesses typically pride themselves on having chosen a knowledgeable and competent installer for their systems and carefully following their equipment manufacturer's recommendations for testing and service intervals.

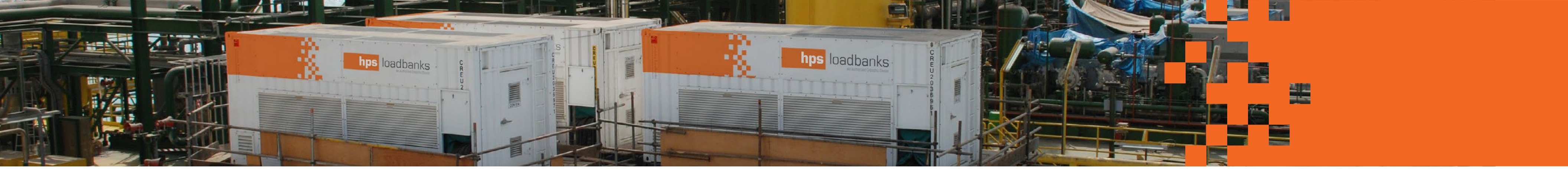
However, despite their careful planning and thoroughly maintaining their equipment, many facilities managers are caught unaware when their equipment does not operate correctly—or at all—during an actual emergency. What goes wrong?

Any given emergency power generation unit is actually a complex system, or series of systems, working together to perform several duties at once. At the system's heart is the "prime mover", which burns fuel to create movement, which in turn is converted into electricity. Various discrete systems and sub-systems in the unit make this possible: alternators, regulators, switchgear, and various other additions to generation systems, all of which contribute to the system's operation.

These additional components can be products from different manufacturers, usually designed to interface with a number of makes, models, and sizes of diesel generators. Like any other mechanical or electrical component, all are subject to failure and have varying maintenance needs: they all must be tested and serviced. But individually testing a series of components never answers the most important question of all: "How do you know that your system—and not merely its components—will work when it counts?"

In an emergency, a facility's entire emergency power generation system will be stressed. Unlike in a series of short, component-by-component tests, the system must operate at full power, with all components working together. The stresses introduced by this kind of operation cannot be simulated by discrete tests of a system's numerous individual components: automatic transfer switches, switchgear, load-sharing centers, voltage regulators, alternators, electrical cabling & connectors, ventilation, cooling systems, and fuel systems. Testing the system's engine alone is insufficient.

> A system-wide test is the only way to insure that the individual components of any emergency power generation system will work together effectively.



Test the System, Not Its Components

Facilities managers and business owners are occasionally hesitant to conduct a test of their facility's emergency power generation systems (as opposed to just testing their system's engine) because this sort of comprehensive testing is substantially more involved (and expensive) than a simple test of the engine. Power systems must be interrupted. A service provider must complete arduous and complex attachments to various points in the facility's power system to test it, both as a collection of several discrete units and as a whole.

However, a system-wide test is the only way to insure that the individual components of any emergency power generation system will work together. And unlike an actual power emergency, facilities managers can schedule a test of their complete backup power generation system at their convenience. Despite the inconveniences it represents, only a complete system-wide test will provide an accurate picture of how a facility's emergency power generation equipment will perform during an interruption in utility power, particularly in the actual conditions under which the system will operate.

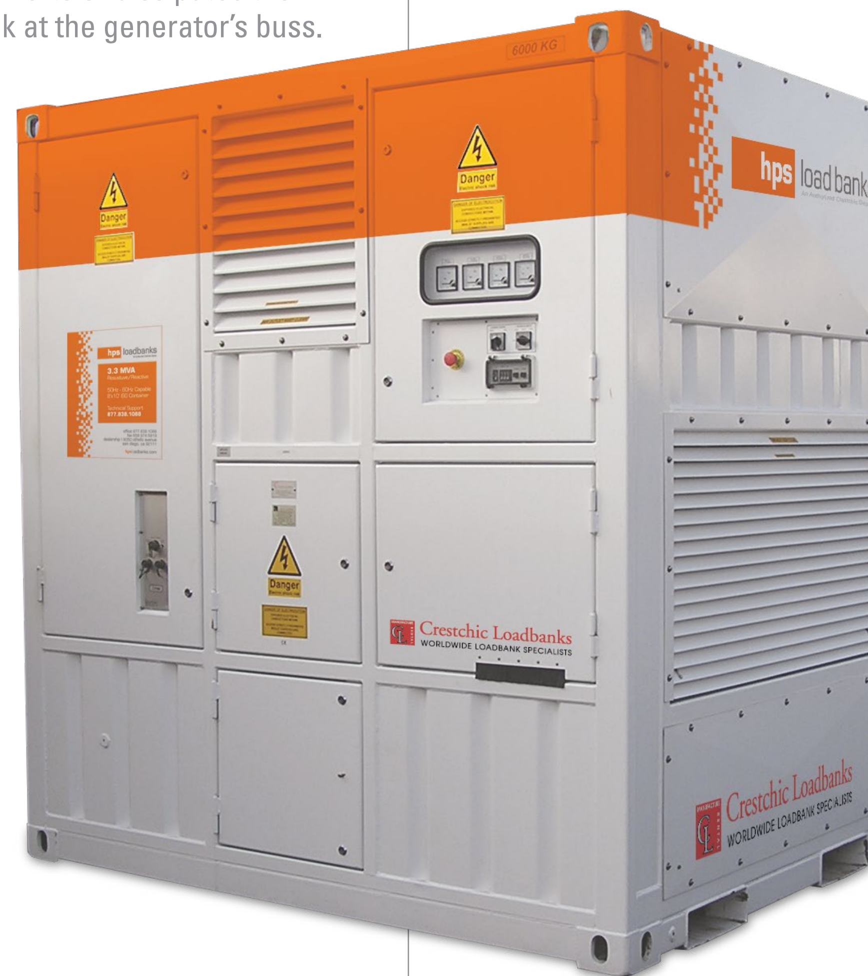
While the generator may have been tested at the factory, the installation variables of the interaction with other parallel-connected power generation units, consumer's load profile, altitude, ambient temperature, fuel, exhaust, and cooling systems can be significantly affected by the installation. The on-site acceptance test, typically done on a new installation, is a valuable tool for the engineer, building owner, and can be done periodically by maintenance personnel to determine the operating capabilities of the generator in its installed location and many years after installation, to verify that the systems continue to perform reliably as designed[1].

Resistive Testing: Only Part of the Story

Facilities managers typically only test their generator's engine(s). The most common form of testing is to use a resistive loadbank to run the engine, but this fails to account for the actual stresses produced during real-world emergency generator operation. Facilities managers seldom attempt to simulate real-world conditions by conducting periodic system-wide tests of their generation equipment primarily because they don't always know this service is available.

> Knowledge is power.
>
> Sir Francis Bacon

In a typical test of a facility's emergency power generation equipment using a resistive loadbank, the device develops an electrical load (at unity power factor) and applies it to a standby generator set, which converts or dissipates the resultant power output as heat. To perform the test, a service provider hooks up the loadbank at the generator's buss. The service provider who performs the test will diagnose engine problems (and identify potential problems) with the engine tested individually.



But this resistive testing does not provide a complete picture of a facility's preparedness in an emergency because resistive loads are usually only a small part of any facility's total power consumption. Quite often, the influence of a lagging power factor <0.8 due to reactive loads is underestimated.

Generally, in any facility, the only equipment operating on a resistive load are incandescent lights and electric heaters[2]. These units draw a steady supply of electricity from a generator but they don't produce the large block loads that truly test a generator's performance. A resistive load test will verify that a generator's prime mover is working, but it won't identify how well it will perform when stressed in an actual emergency.

Imagine a doctor attempting to ascertain a patient's health using a treadmill: verifying that the patient can walk provides little information to the doctor—to be considered healthy, the patient must be able to run at a steady pace (e.g. full load simulation) and climb (reactive load simulation) simultaneously.

> Brownouts, blackouts, hurricane storm surges, strong winds, ice storms, tornados, and grid interruptions can all disrupt utility power supply to a facility, and resistive-only testing cannot simulate the conditions in which the facility's equipment will operate.

The same can be said of emergency power generation equipment: in order to provide adequate “insurance” against lost power, it must be able to keep a facility fully operational during an interruption in utility service, which involves substantially more than supplying heat and light.

To continue our analogy, by only testing a generation system’s engine, one has only verified that the patient’s legs work, not that he can use them properly. In order to properly insure that an entire system will operate when it matters, the entire system must be tested as it would operate under normal circumstances: resistive load testing is insufficient and only part of the simulation of the real load situation.

Reactive Loadbank Testing: An Accurate Diagnosis

A reactive loadbank test of a facility’s power generation system can actually simulate the system’s response to a changing load pattern:

Resistive/reactive combination loadbanks are used to test the engine generator set at its rated power factor. In most cases this is 0.8 power factor. The reactive component of the load will have a current that “lags” the voltage. The resulting power is described in two terms: the KW - the real power and the KVA - the apparent power. Since the current lags the voltage in the reactive load the total power is not the direct sum of the two, but their vector sum. That vector is the phase angle difference between the voltage and the current. The combination of resistive and reactive current in the load will allow for the full nameplate KVA rating of the generator windings and voltage regulator excitation to be fully tested. Even though the generator set is producing more KVA it is actually not producing more KW. The “real” power, or horsepower, required from the engine is essentially the same[3].

Unlike resistive testing, a proper resistive/reactive test will create conditions in the equipment being tested that will more accurately simulate those it would experience during a real power failure: a facilities manager can manipulate the power factor to simulate a real power outage.

Like all modern electric systems, emergency power generation equipment must be tested and maintained at proper intervals, and its individual components must be tested as well.

Only reactive load testing can verify the true performance of a genset's voltage regulator: the voltage regulator is not fully challenged in a resistive only test[4] (the voltage regulator assists the system to recover quickly from large step loads).

The inductive loads developed during reactive testing illustrate how any given system will handle the voltage drop in its regulator, which is paramount when paralleling generators. This inductive load can verify that a system's voltage regulator is working properly, and only a reactive test can provide it—if the system's voltage regulator is not working properly, its magnetic field could collapse, rendering the generator useless and preventing other generators in the system to operate in parallel. Resistive/reactive testing can also reveal additional stresses (and predict pending failures) of a system's switch gear, alternators, and other systems that resistive-only testing cannot.

The Case for Continued Testing

A proper resistive/reactive test of a system's complete performance with help from a knowledgeable service provider is a facility manager's only means of truly verifying that his system will operate to an acceptable standard during an emergency.

Only after observing and rating a system's performance, and proving that its various components are able to operate in synch and produce power for a sustained period under the specific stresses produced by the facility, can a facility manager know with confidence that the business is safe from the various threats posed by a sustained interruption of utility power service.

But a proper service regimen doesn't end there. Like all modern electric systems, emergency power generation equipment must be tested and maintained at proper intervals, and its individual components must also be tested.

While a system-wide, reactive load test of a facility's emergency power generation equipment will determine its ability to function correctly under the stresses and load requirements of actual emergency operation, this testing is not a replacement for testing each component in the system's manufacturer-recommended service intervals.

Unfortunately, these components still require maintenance and monitoring but when combined with a reactive load, system-wide test, they can accurately forecast a system's performance and identify its service needs well into the future. But there is no substitute for routine maintenance and testing: it is the responsibility of all personnel charged with monitoring a backup power system to see that all its maintenance needs are consistently met.

Conclusion: A Word to Facilities Managers About Service Providers

Despite what would appear to be proper planning, many facilities managers are taken by surprise when their power generation equipment fails to properly operate during an actual emergency. Although these managers go out of their way to test and maintain their equipment, failure to initiate proper system-wide, resistive/reactive testing of their facility's equipment leaves them unaware of their system's weaknesses, and in some cases, these managers are taken by surprise when their equipment fails. Partnering with a responsible and knowledgeable service provider (who is up-to-date on the latest developments in electric power generation technology) is the best way for a facilities manager to prevent such surprises.

Talk to your service provider about your options for a long-term service contract that includes reactive loadbank testing of your entire generation system. Your provider should be able to recommend the proper intervals at which you should schedule this test, and may be able to work with you to plan a cost-effective service contract that includes comprehensive, full-system resistive/reactive testing in addition to the tests and maintenance required for the individual components in your system. You might be surprised at how inexpensive these services can be when combined, and how expensive they can be when ignored!

In addition to helping to ensure that your emergency power generation system meets your facility's current power needs during an emergency, your service provider should be able to help you plan equipment purchases as your business—and power consumption needs—grow.

Partnering with a knowledgeable and competent provider is an investment in your company's future that will surely pay off when the lights go out… Or when they don't.

Questions for Your Service Provider

Where will you place the loadbank?

Is there ample room in the switchgear to connect the load test cables?

How will the test cables be routed?

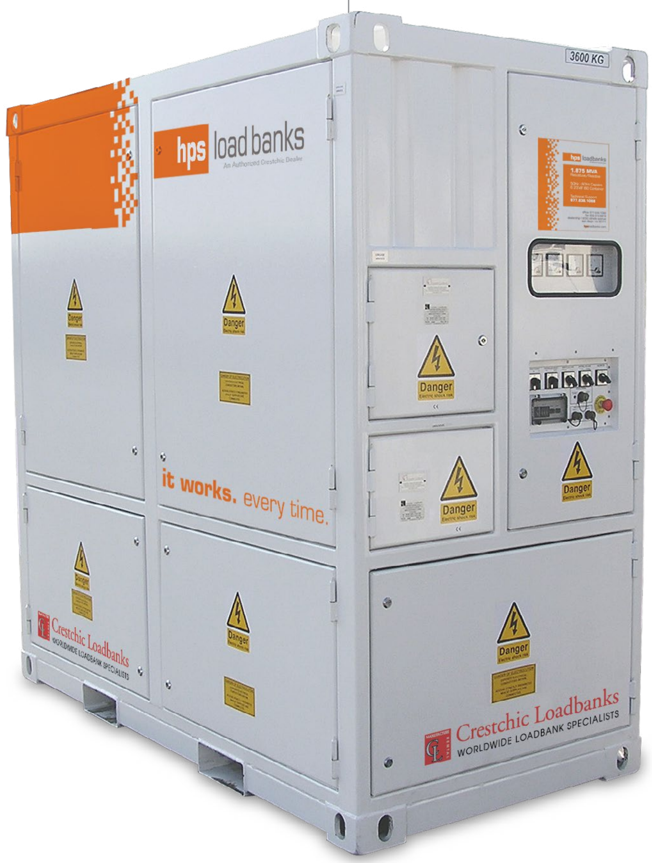
How long should the load test be?

When is the most convenient time for the test?

Is there a contingency plan for EPG during the test?

What are the parameters for the test?

Do I want a resistive-only or a resistive/reactive test?



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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.

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An Authorized Crestchic Dealer

HPS Loadbanks offers the best selection of new and used resistive loadbanks, resistive/reactive loadbanks, 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 loadbank industry and customers really want: flexibility, customer service, and only the highest quality products.

HPS Loadbanks is based in San Diego, CA. For more information, visit www.hpsloadbanks.com.

History of HPS Loadbanks

Crestchic UK has specialized in manufacturing the best in-class resistive-reactive loadbanks available since 1983. 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.

In 2001, Crestchic UK selected Crestchic USA to be their sole distributor in North America. Crestchic USA has grown the loadbank business into a national distribution channel servicing hundreds of loadbanks in industries ranging from data centers to manufacturers. In the past decade, we have sold more Crestchic loadbanks than any other distributor in the world.

In 2011, Crestchic USA became HPS Loadbanks and supports sales and rental in North America.

References

1 Scott, Dick. Application of Resistive/Reactive Load Banks for Diesel Generator Set Testing. Rep. July 29, 2008. Cleveland: Avtron, 2008. Print.

2 Smith, Kent. “Load Bank Testing of Engine/Generator Sets.” Plant Engineering 10 July 1995. Print.

3 Ibid. 1

4 Ibid. 2

Gould, Jim. “The History of Load Banks.” Worldwide Independent Power Sept. 2008: 20. Print.

Hollander, Albert. An Alternative Approach to Justify a Loadbank Investment. Rep. Burton-on-Trent: Crestchic Ltd., 2007. Print.

Scott, Dick. Application of Resistive/Reactive Load Banks for Diesel Generator Set Testing. Rep. July 29, 2008. Cleveland: Avtron, 2008. Print.

Simplex Inc. “What is a Load Bank?” What is a Load Bank? Simplex Inc., 2009. Web. 6 Nov. 2009.

Smith, Kent. “Load Bank Testing of Engine/Generator Sets.” Plant Engineering 10 July 1995. Print.