White Paper

Load Banks for Test Cell Applications

ASCO®

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A test cell is an integrated part of a manufacturing facility used for testing power generation equipment before real life operation. The majority of facilities will have a test cell that includes load banks. Load banks are an essential component of power system testing in test cells. Load banks effectively verify system components and provide proof of real life working conditions. Load testing ensures power quality in systems that are typically mission critical and ensures that it meets best practices for specific applications.

Why Use Load Banks in a Test Cell?

Meeting local and international standards

Due to the importance of the generation and reliability of power in the modern world, numerous local and international test standards apply.

ISO 8528 (BS7698) part 6 is the standard for testing engine-driven generating sets. It sets out general test requirements and defines a functional and an acceptance load bank test. Functional tests must always be performed and usually occur at the manufacturer's test cell. Acceptance tests are optional, they may be done on site and are often witnessed by the customer or a representative.

ISO 8528 (BS7698) part 6 defines three performance classes - G1, G2, and G3. A further class, G4, is reserved for performance criteria which are agreed upon between the supplier and the buyer. Each performance class has different criteria for a range of characteristics of the generating set.

- **G1** is the least stringent and generally applies to small, simple generating sets, intended to supply unsophisticated loads.
- **G2** is broadly equivalent to commercially available power.
- **G3** is intended for sets which are powering strategically critical loads or those which particularly require a stable and accurate power supply.

Engine governing is measured by frequency response and alternator voltage regulation is measured directly. Specified characteristics relating to frequency include steady-state variation, where frequency decreases when maximum power increase is applied and frequency rise, when 100% power is removed. Voltage characteristics again include the permissible voltage decrease, when maximum power increase is applied and the voltage rise, when 100% load is removed.

Some of these criteria are as follows listed in Chart 1 below:

Chart 1: Generator Set Performance Criteria.

Performance Class	G1	G2	G3
Steady-state frequency band	2.5%	1.5%	0.5%
Maximum frequency dip	-15%	-10%	-7%
Maximum frequency rise	+18%	+12%	+10%
Frequency recovery time	10 sec	5 sec	3 sec
Steady state voltage deviation	5%	2.5%	1%
Maximum voltage dip	-25%	-20%	-15%
Maximum voltage rise	+35%	+25%	+20%
Voltage recovery time	10 sec	6 sec	4 sec

The maximum power increase for these tests, expressed as a percentage of the rated load of the set is determined by the characteristics of the engine and the match between the engine and the alternator. Traditionally, naturally-aspirated engines were tested with 100% load acceptance, whereas turbo-charged engines were tested with a 60% power increase. However, the standard defines a more complex formula based on engine parameters and in practice the value is now usually determined by the manufacturer.

Market leading load bank PC based software provides the option to automatically test to ISO 8528 G1, G2, or G3 standards. The test can be performed automatically and after completion test result reports are provided to show a pass or fail with the corresponding results. Any power systems not meeting the requirements will need to be rectified and retested to ensure compliance.

Research and development

At the core, power systems all provide the same service, an electrical supply. However, the way in which power is supplied is how they are differentiated. Innovative and forward thinking research and development into noise, emissions, precision, reliability, and versatility are what separates the best power systems from others.

Load banks provide the means to apply specific and controllable load to any power system, which is vital in researching potential opportunities in operation. Market leading load banks are manufactured with a number of features including a range of capacities, types of load, selectable voltages, sophisticated control, data capture, and reporting.

Quality control and fault finding

The foundations of any great product or service is consistency. Power systems and the mission critical environments they tend to operate in need to work first time, every time. Load banks provide a means of testing a power system to ensure reliability with backed up test results. Finding faults at the test cell stage of production will ensure no costly product recalls or power system failures.

Load Bank Features Suited for Test Cell Applications

Variety of load types

Almost all but the smallest generating sets are designed and rated at a lagging power factor, usually 0.8 and virtually all set builders operate quality systems to ISO9001:2000. While this standard allows for organizations to set their own systems and procedures, it is difficult to argue against the concept that a product can be fitted with a rating plate, stating a load capacity at a power factor of 0.8 if it has not been tested at the name plate rating.

In a test cell environment, it is required that a generating set is tested to the correct standards and to the nameplate rating. This means non-unity or resistive/inductive load testing. ISO 8528 specifies that test reports should note if tests have been done at a power factor which is different than the rated one. Usually this means that tests done with a purely resistive load can be considered incomplete.

Non-unity power factor load testing with load banks is the best way to simulate real world load conditions that a power system may encounter. Load banks can be separate resistive, inductive, and capacitive that can be networked together or alternatively a single combined unit can be supplied. It is important that the test cell uses the correct types of load to ensure testing meets desired ratings.

Photo courtesy of ASCO Power Technologies

Integrated control

Many industrial test cell facilities have a single integrated control system for use on factory wide machinery such as compressors and generators. Load banks have the ability to integrate into industrial building management systems (BMS) and to be controlled by industry wide network protocol; Modbus. By integrating the load banks into the system, the controlling and monitoring works seamlessly and lessens training required for factory floor operation. All load steps, data capture and analysis are still enabled. Integrating load bank control ensures test cell efficiency.

Data capture and reporting

The ability to capture load test data is vital in proving the performance of a power system in a test cell environment. Load test data may be captured in the sophisticated software that market leading load bank suppliers provide (via a PC based software program or a hand-held control). The data can be analyzed and reports can be created stating a pass or fail. The test results for each power system moving through the test cell are compiled and used to refer back to. Power systems that do not meet the test criteria can be adjusted accordingly and retested. Test reports can be provided to the end user to prove power system reliability and performance.

Automatic testing

In a factory production line environment consistency is vital in the long term success of the product. Automatic load testing to the same parameters on any power system ensures consistency and reliability of the system. The manufacturer will have the knowledge that wherever the product is used it has been validated using the same load test profile.

Market leading load bank manufacturers provide in depth computer software that provides automatic testing solutions. Testing parameters such as amount of load steps, duration of each step, percentage of load and to which class in ISO 8528 standards as described earlier in this paper.

By using automatic load testing it presents numerous benefits to a test cell environment. There is no operator input except for test setup, so the power system is able to be tested the same every time without the external factor of missed step or incorrect load application.

Networking

Networked load banks in a test cell facility provide a cost effective and versatile method of load testing power systems. Networking provides the availability of higher capacities, varied voltages, frequencies, and load type by mixing and matching the types of load banks.

Engine manufacturers may use lower capacity resistive load banks for smaller engine testing and network a number of the same units together for higher capacity engines. Besides this obvious versatility, this method will also provide enhanced load resolution. Typically larger load banks are built to test high capacity power systems and due to nature current transformers, best practice states that the load bank capacity should only be a maximum of 20% larger than the power system capacity. By networking the units, fine resolutions found in smaller load banks are available.

Networking also provides the opportunity to create non-unity power factor loads – network a resistive and inductive load bank together to create a lagging power factor or a resistive and capacitive load bank for a leading power factor. The units can be used separately or together depending on the test providing flexibility within the test cell.

The use of smaller units and the option to move them around the test cell bay may provide more flexibility than a statically installed load bank. Market leading load bank manufactures provide the ability to link up to 42 load banks in a network. Units can be stored and moved between

test bays and used depending on the type of test required. Furthermore smaller units will take up less footprint within the test bay area ensuring testing is fast and reliable.

Multi voltage

Different regions and applications utilize a variety of voltages and frequencies. For example, typical U.S. ratings are 480V, 60Hz whereas typical European are 400V, 50Hz. The ability for a load bank to test a variety of voltages and frequencies is highly useful in a manufacturing test cell that provides power systems for many global regions.

Manufacturers will often specify load banks to the largest voltage and frequency of all of the power systems they produce. By doing this they are able to use same the load bank to test a range of lower voltage and capacity products in the range. However, lower voltage power systems may not be able to achieve the same capacity as the higher voltage versions. It is important to disclose all information on the test cell and the products that will be tested to ensure the correct load bank is specified.

High voltage testing

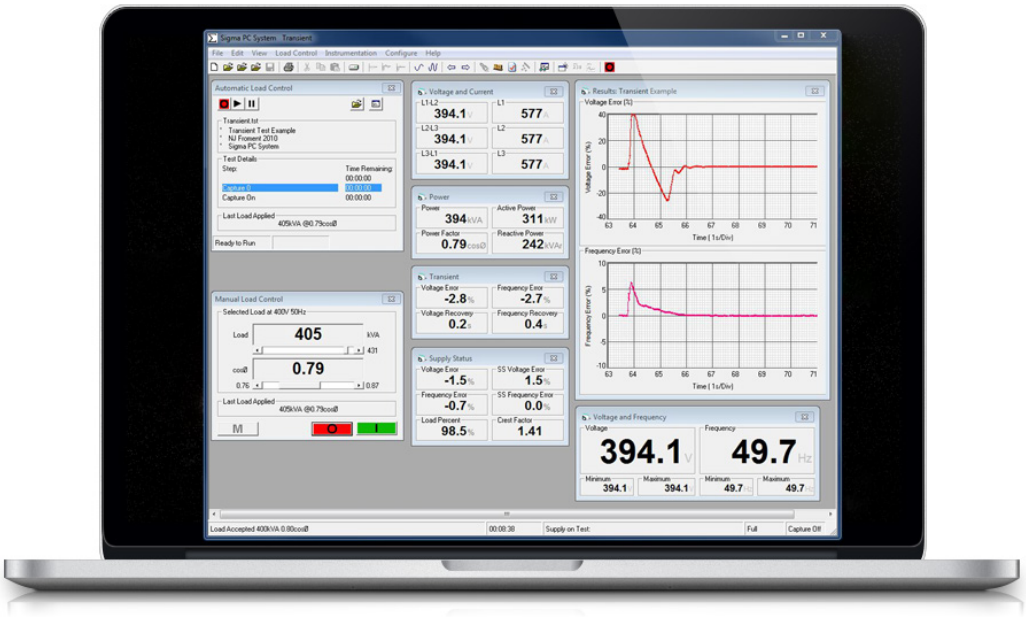
Many power systems produce over 1000 Volts and can be considered High Voltage (HV). There are numerous options to consider when installing a high voltage load bank into a test cell environment. There are two main types of HV load bank. The first is a directly connected HV load bank and the second is a Low Voltage (LV) load bank that utilizes a step down transformer connected to the supply. Both methods have their own benefits and draw backs and understanding the nature of each, is imperative when the load bank is specified.

Direct connect HV load banks in general require less servicing as there is no step down transformer in operation. Also by not having a transformer the directly connected load bank tends to be lighter, which may be a requirement in certain test cell environments. Without a transformer, the losses from the supply-on-test are minimal, where as a load bank with a transformer may have losses of up to 6%. However, there are also a few drawbacks of directly connected load banks. Load steps tend to be much larger due the high cost of HV contactors and without more contactors, load step resolution is reduced.

LV load banks used with a step down transformer either have the transformer integrated in the enclosure and are connected constantly or they have an external transformer that is connected on site. The benefits of using a transformer may be a reduced cost as the test cell or manufacturer may already have an existing transformer to utilize. By stepping down the voltage, fine load steps are still available as the load test is using the contactors found in the LV load bank.

Transient testing

Transient load testing measures the time taken by the power system for the voltage and frequency to return to a steady state after changes in load. The faster it takes a power system to recover to a steady state, the better. Advanced computer based load bank software is programed to measure and capture transient responses of a power system. Graphical reports are created to show the transient response of the test and are included in a full report. In a test cell these reports can be filed by serial number and passed through to the end user if required.



This is a screen shot of software showing transient response. (Photo courtesy of ASCO Power Technologies.)

Typical Test Cell Environments and when Load Banks are Utilized

Engine and gen-set manufacturers

Consistency and reliability in power generation is vital. Consumers expect the same power output and working parameters for the same models no matter where they are in the world. Load banks testing engines and generators as they come off a production line ensures nameplate

Photo courtesy of ASCO Power Technologies

ratings are met and proves power and reliability. The automatic testing feature in a sophisticated load bank software ensures the same test is performed every time ensuring consistency.

Load banks will ensure gen-set components are providing correct operation including voltage regulator response time, verification of governor operation, verification of control systems, prove alternator capability, ensure stability of voltage, and validate the general performance. All these parameters must be met to provide a generating set for any back up power system.

Uninterruptible Power Supply (UPS) Systems

UPS systems provide a momentary power supply while back up power such as generating sets initialize. This gap may be a matter of seconds or up to a few minutes, but no matter the time period UPS systems are vital in keeping power on.

There are two typical types of UPS system; battery/static or rotary.

Battery/Static UPS Systems use a large array of batteries to momentarily meet the power demands when the grid fails and the back-up power systems initialize. Battery UPS systems need to ensure power demands are met and the batteries can handle the power required. Load banks can effectively discharge the batteries to monitor and prove performance in the test cell. By using a load bank in the UPS test cell any faulty batteries are identified and performance of the system is verified.

Rotary UPS Systems incorporate a flywheel spinning in a vacuum that has enough inertia to provide power for a few seconds while the backup generators start. The flywheel is powered by the grid and spins at a constant rate when powered. Load banks are an effective method of testing this system. The load banks can test the system's ability to cope with the loss of the grid. The flywheel power output can be monitored and verified in the test cells as well as the system's ability to switch over to a backup power supply.

Marine gen-set manufacturer

Marine generators must meet all of the standard generating set specifications as well as more stringent parameters and regulations. Marine regulatory bodies have a variety of regulations depending on the locations such as the Lloyds register, DNV, NMMA and ABYC. Load banks provide the means of testing the supply to meet these regulations.

An interesting function of leading load bank software is M load. M load simulates a motor start on an already highly loaded marine generator typical in marine applications. The load bank M load function can be configured with the motor size, gen-set size and start time, and integrated as part of a test cell regime.

Summary

The installation and use of load banks in test cells for power systems is essential. Numerous test features and control integration from market leading suppliers make thorough and reliable testing easily achievable. Load testing insures that the power source is fit for purpose and provides an important benefit for either standard or mission critical power systems.

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