White Paper

Load Banks for Power System Testing

ASCO®

A load bank provides a consistent and repeatable electrical load that can be accurately controlled, measured and recorded. Load banks convert or dissipate the resultant electrical energy (kilowatts, kW) into thermal or heat energy (British thermal units, BTU). A basic load bank utilizes precise resistive elements cooled by an integral fan.

Load banks provide a stable and controllable load for determining performance characteristics of a power system. They can be as simple as a single resistor or as complicated as a resistive/reactive load system with computer control. Their main category of use is with generator sets, however there are a number of other applications where they may be used.

Load Bank Types

A **resistive load bank** can be used to fully test the generator set at 100% nameplate kW rating. It will also fully load the generator cooling, fuel, and exhaust systems. Only 80% of the generator set nameplate kVA rating can be achieved when utilizing a resistive unit. The resistive load bank will provide a unity or 1 power factor (PF) load to the system under test. Resistive units are predominantly used for AC voltages, however specifically designed DC load banks are also available.

An **inductive load bank** is normally used in conjunction with a resistive unit to provide a lagging power factor load test. This provides the capability to test the generator set fully at 100% nameplate kVA rating. Inductive load banks add inductance to the load and therefore reduce the PF to less than unity (lagging). Inductive load banks are rated in kilovolt-amperes reactive (kVAR). See Figure 1.

Power Triangle

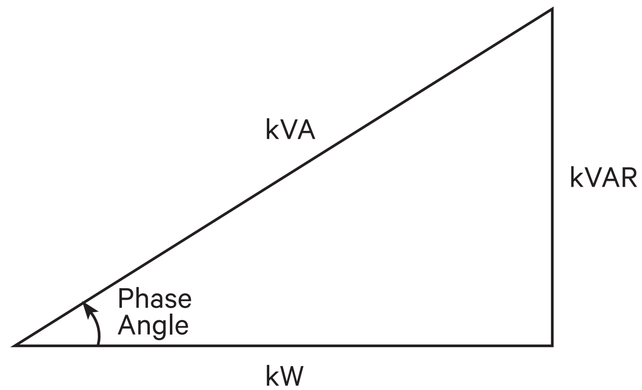

Figure 1

kW: Real or true power measured in kilowatt.
kVA: Apparent power measured in kilovolt-amperes.
kVAR: Reactive power measured in kilovolt-amperes reactive.


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A **capacitive load bank** is normally used in conjunction with a resistive unit to provide a leading power factor load test. Capacitive load banks incorporate industrial capacitors and increase the PF to above unity (leading). Capacitive load banks are rated in kilovolt-amperes reactive (kVAR).

A **combined load bank** usually consists of both resistive elements and inductors that can be used to provide load testing at non-unity PF (lagging) including the capability to test the generator set fully at 100% nameplate kVA rating. Combined load banks incorporate resistors and inductors all in one construction which can be independently switched to allow resistive only, inductive only, or varying lagging power factor testing. Combined load banks are rated in kilovolt-amperes (kVA). It's worth noting that combined load banks can consist of resistive, inductive, and capacitive (RLC).

Main Reasons for using a Load Bank

The main reason for using a load bank is to proof test power sources. Load Banks are also effectively used for verification of heating, ventilation, and air conditioning systems.

Maintenance and Repair Verification. A load bank is an essential service and maintenance tool. The major reason why a generator or uninterruptible power supply system fails to perform is inadequate or improper maintenance. The correct operation of the standby power system can only be guaranteed with regular scheduled maintenance routines. Upon completion of the maintenance schedule or repairs, a load bank is used to verify the design and the functional capabilities of the entire power system.

Installation Acceptance / Commissioning / Witness Testing. When a new power system is completed or installed, it is important to verify that the entire system will perform as designed. In the case of a generator set being installed into a building this will include the design of the engine's cooling, fuel and exhaust system. With uninterruptible power supplies their ability to perform at differing power outputs and for how long is key. If any of these systems are not designed and installed properly, a load bank will help ensure that the power system can provide its full capabilities.

OEM Product Sign Off and Engineering Design Development. ISO8528 is best practice testing and verification for AC generator sets driven by reciprocating internal combustion (RIC) engines for land and marine use and specifies the test methods for characterizing an entire generator set. New product designs in engine, alternators, or batteries

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require verification of load carrying capabilities, the ability to replicate running over long periods of time to assess fuel or energy consumption, develop cooling, and exhaust system, and Automatic Voltage Regulator (AVR) characteristics.

Mission Critical Facilities. Hospitals and data centers are typically required to comply with NFPA 110 so that the facility can comply with the NEC Section 7.13 of **National Fire Protection Agency** (NFPA). Standard 110 details the type and length of load testing for generator sets in these critical applications.

Common Load Bank Classifications

The load bank classification will depend on the sector or application in which it will be used. Typically load banks can be categorized into the following classifications below:

Load Bank Classification	Load Bank Type	Description
Radiator Mount	Resistive	Radiator/Duct-Mounted load banks are custom built for each application, matching the generator set's radiator core height and width. They are mounted directly to the generator set radiator and utilize the engine fan for cooling. They can be provided for indoor, duct-mounted, or outdoor locations. These load banks are commonly installed inside the engine generator's outdoor enclosure.
Portable	Resistive	Portable load banks are used in a wide variety of service and rental applications for the temporary testing of power systems. Portable load banks can be as small as 5-10 kW or as large as 700 kW. A properly designed portable load bank should have overall dimensions small enough to fit through a man door or freight elevator.
Mobile/Static	Resistive Capacitive Inductive Combined	Mobile/Static load banks are multi-purpose in their use and application. Characterized by heavy duty bases with fork pockets and lift frames these load banks can either be used in highly mobile environment via fork lifts, cranes, road trailer, or can be permanently installed on a concrete base for applicable static applications.
Static Only	Resistive	Static only load banks are permanently installed in a fixed outdoor location and are continuously connected to the power system. This setup allows the load bank to be readily available for testing by properly trained building personnel. This encourages regular, scheduled load bank testing, which should be included in established maintenance procedures.

Photo courtesy of ASCO Power Technologies

Load Bank Classification	Load Bank Type	Description
Container	Resistive Combined	Container load banks have components housed in an ISO container forming the structure of the load bank. They are fitted with CSC certification for top-loading shipping and can be used as a mobile or static product where required. While these load banks are fundamentally designed for high capacity testing (6 MVA) they are also ideal for very heavy duty applications and environments.
Medium Voltage	Resistive Combined	Typically load banks are low voltage from 220V to 690V however medium voltage solutions are available. A medium voltage load bank usually consists of a standard load bank (resistive or combined) and incorporates a step down power transformer. These can either be individual components mounted on a skid or specifically designed and incorporated as a containerised product. Advances now allow for direct connect medium voltage load banks that eliminates the requirement for a step down transformer. The construction has additional insulation and phase-to-phase spacing to accommodate the higher voltages. Direct connect utilizes vacuum contactors for load step control and tend to be rated for capacities higher than 4000 kW.

Types of Load Control and Monitoring

Load bank control can vary from very simplistic pilot relays, toggles, or decade switches to a multi-functional embedded system giving differing types of load application, full instrumentation and data capture. Market leading controls have the ability to network multiple load banks of varying capacity by a single remote controller or PC.

Advances in control design now mean a digital toggle local to the load bank allows for synchronous load steps and local instrumentation. Adding a remote controller with a color touch screen allows even further enhanced control and user capabilities.

PC based software provides increased sophistication for control along with transient speed instrumentation, full data acquisition reporting with graphical displays. Real time data such as crest recovery times and percentage error necessary for testing to ISO8528 should always be used for witness testing and product verification.

The embedded control module can communicate via MODBUS allowing the load bank to be integrated into building management systems for control and monitoring through PLC, HMI, or SCADA systems.

Site load correction or automatic load control is also possible and maintains the required levels of loading especially on generator sets to prevent the problems associated with light load, such as wet-stacking.

The ability to network load banks brings many potential benefits not only from the ease of use where one remote controller or PC can control multiple linked units to allow higher capacity testing. Furthermore this also allows flexibility of load bank utilization and use in restrictive areas where the ability to use a single unit to carry out the test is not achievable.

Load Bank Standards

Load banks are designed to control and absorb a specified amount of power (kW and kVA) and should be designed to insure safety of the operator and equipment. The load bank must be designed to the latest applicable **International Electrotechnical** (IEC), **National Electrical Manufacturers Association** (NEMA), **National Electrical Code** (NEC), and **American National Standards Institute** (ANSI) standards. Stationary and portable load banks should carry a third party listing such as **Underwriter Laboratory** (UL) standard 508A, **Canadian Standards Association** (CSA) or the **European Union's CE** marking.

Summary

In today's world, we have become extremely dependent on electrical power to maintain our safety, communications, and lifestyle. This dependency has increased our awareness for the need of reliable power systems.

Emergency and primary back-up power systems are very sophisticated and have provisions to interface with the facility's supervisory control and data acquisition systems.

Technological improvements are important for the continued reliability of power systems. However, even with all these technological advances the system is only as good as your last load test. A load bank still provides the best practical means of proving and verifying the power system without interruption to the critical loads and assures performance at full load capability.

ASCO Power Technologies | Avtron
6255 Halle Drive
Cleveland, OH 44125
Tel: 216.573.7600
LBsales@vertivco.com

ASCO Power Technologies | NJ Froment & Co. Ltd
Easton-on-the-Hill
Stamford, PE9 3NP
United Kingdom
Tel: +44 1780 480033
froment.sales@vertivco.com

www.ascopower.com

customercare@ascopower.com

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