

CRESSALL



Load bank testing white paper

Helping to keep the light on

Why load banks are a necessity in industry

Handling electrical failure

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Avoid costly retrofits by adding a fixed load bank

Helping to keep the lights on

Building and plant managers need to be sure that people will be safe if the electrical supply to their buildings is cut off in an emergency. Almost all the equipment and systems that we depend on when things go wrong need an electrical supply in order to work, including emergency lights, lifts, pumps, computer systems and fire alarms. For this reason, most public buildings, banks, hotels and process industries will have at least one alternative power source that can be called on when primary power from the Grid is cut off for any reason.

These alternatives will invariably be one or more diesel generators, sometimes supported by battery-backed uninterruptible power supplies (UPS) to ensure continuity of supply to computer systems and emergency lighting.

The challenge for the managers of these systems is how to ensure that they will not fail on the relatively infrequent occasions when they are called on to work. As in any system that spends most of its time unused, relays stick, filters clog up, batteries go flat, pipes burst, fuses and timers fail.

Regular ‘real’ testing of emergency systems is a must

For these reasons, regular ‘real’ testing of emergency systems is a must. However, it is common sense that the testing needs to be done in such a way that does not regularly inconvenience the people that the system is designed to protect. If it did, sooner or later someone would decide that it wasn’t necessary.

In the case of both batteries and diesel engines, the worst way of testing them is to switch them on or start them up without applying any load. This is for exactly the same reason that you wouldn’t leave your car’s engine idling for any length of time. The only way to ensure that systems are functioning properly is to put them to work and if this can be done offline, then the disruption to normal operations is minimised and routine tests won’t be discontinued.

For these reasons a dummy load is an essential component of any well-designed emergency power system.



Most public buildings have at least one alternative power source that can be called on when primary power is cut off.

Load bank models can range from small portable loads used for testing petrol generators to high voltage load banks for large diesel generators and gas turbines. Regular load testing, along with correct battery maintenance, is the best way to ensure the reliability of standby power systems.

Battery-backed uninterruptible power supply (UPS) with an autonomy of 5 to 30 minutes are usually part of a standby power installation. They ensure continuity of supply, while standby diesel generating sets are started. In most applications, UPS are considered critical to business continuity. Put simply, they allow loads to operate without a break during a power outage. To maintain UPS reliability, load bank testing is implemented to ensure UPS can meet the requirements when most needed.

Load bank testing analyses the UPS and generator under load conditions and is most often carried out during preventative maintenance.

A UPS battery set is only as strong as its weakest battery cell. This means load bank testing can also be used to ascertain the condition of UPS batteries to indicate if any individual cells are losing capacity as they approach the end of their working life.

Load banks are now easier than ever to operate thanks to features such as touch screen controllers and Ethernet connectivity. Cressall Resistors recently launched its own range of high-tech load banks, after working closely with BAE Systems and Ruselprom. The versatile new range is the perfect example of how Cressall is able to design, manufacture and test bespoke load banks for almost any application.

Feedback from customers in the rail, automotive, defence and financial industries has been invaluable to Cressall in the creation of a wide range of versatile products. In this white paper, Cressall Resistors explains the importance of load bank testing for any company that relies on an electrical supply network.

Handling electrical failure

The failure of an electrical supply network can have disastrous consequences and the practical way to plan for these risks is by having standby or fully-redundant power supplies in place. These normally come in the form of batteries, generating-sets or a combination of the two.

For example, in a bank or financial institution of any kind, you would typically find a battery-powered uninterruptible power supply, which would instantaneously take over if the electricity supply from the grid failed. There would also normally be a diesel generator that would run for as long as it had a fuel source. Its purpose is to take over as medium-term supply once the battery has done the job of managing the immediate problem.

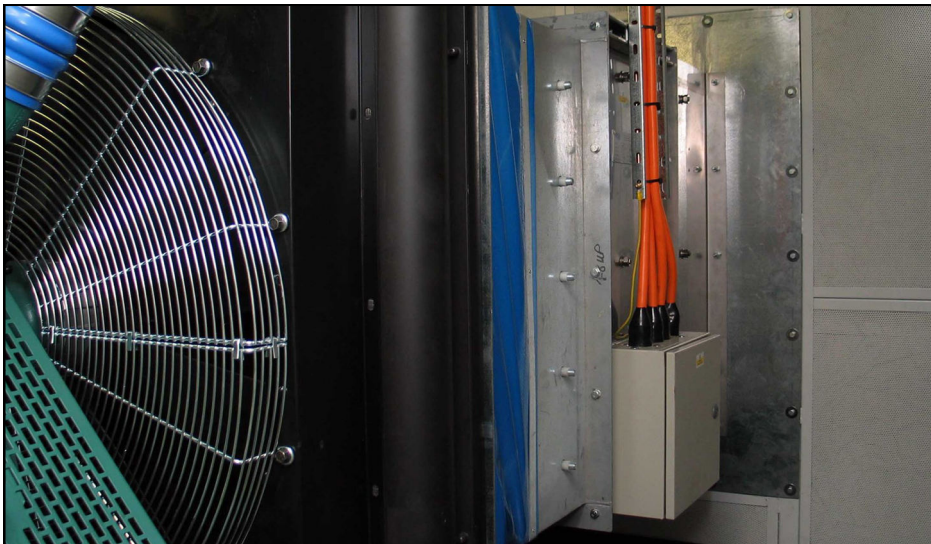
Regular testing and maintenance
It is not sufficient to simply turn the motor on once a month to see if it works. Equally, it is not desirable or acceptable to interrupt the power supply to a hospital, financial centre or other critical application once a month by connecting the generator to run a test.

The principal reasons for this relate to the significant problems it could create for a diesel generator.

This is how to ensure that the set will perform as expected in a real power outage.

Many large users of generating sets, particularly the water, power and telecommunications utilities, recognise that the relatively low cost of including a fixed load bank at the time of installation is justified by the saving in maintenance costs over the life of the set, including the costs of regular load bank hire or purchase after installation.

It is not sufficient to simply turn on a motor once a month to see if it works



There are still countless standby generators going untested in industry.

Supplying sufficient fuel to run the equipment for an extended period is the first and most basic requirement. In addition to this, you should also ensure the generator is tested regularly. The price of doing so is trivial compared with the cost of the generator failing when it is needed.

The price of regular testing is trivial compared with the cost of the generator failing

Diesel engines that are regularly run on very low loads - or no load at all - become increasingly unreliable and costly to maintain. The effects include smoky exhausts, carbon build-up, fuel system problems and lubricating oil deterioration, all of which decrease reliability and add to running costs. These consequences can be largely avoided if the set is regularly operated on a load of at least 25% of its rated power for 10-20 minutes. Running on load uses up expensive fuel, so the appropriate load for routine testing is the lowest one for the shortest time that will ensure that the diesel and its ancillaries are brought up to their full working temperature.

However, there are still countless standby generators going untested that may or may not work in the event of a power outage. If power outages were more common, the value of a standby generator and associated load bank would be more clearly understood in industry.

For many years it has been routine for all newly-installed generating sets to have a load test during the commissioning process in order to prove the performance of the set and all its ancillaries - the cooling system, exhaust system, switchgear and protection scheme. When using mobile equipment these tests have traditionally been performed by contractors who visit the site, bringing with them a [portable load bank](#).

Many financial and telecoms firms now invest in their own portable load banks and in many cases still using the same contractors to carry out the tests.

Why add a fixed load bank?

Adding a fixed load bank to a generator at the time of installation is much less expensive than retrofitting one. The reason is that a fixed load can be fitted in the air outlet between the radiator and the acoustic splitters, saving the space and cost of separate fans and ventilation systems.

A further benefit is that a load bank in front of the radiator doesn't create any additional noise.

More importantly, in most retrofit projects there is not sufficient space in front of the radiator to do this. As a result, the most convenient location is often the plant room, but in applications where space is at a premium - such as skyscrapers in a crowded city centre - the roof of the building can also be used.

Another way of reducing capital expenditure is to use a single load bank to test multiple generators, or multiple generators and a UPS, in sequence. Again, by considering testing at the planning stage it's easy to build this into the system.

In some cases there is a further benefit in that the same load bank can be used as a ballast load during normal operation of the generating set. In those applications where the connected load may vary over a wide range, either as a result of seasonal variations or the nature of the load itself, when the 'real' demand is small it can be beneficial to add some additional load to keep the engine operating at least at 20% to 40% of its capacity.

If a load bank is incorporated into the set when it is built, the only addition needed to the control scheme is a load-sensing relay in the generator control panel. Cressall Resistors' load banks for fixed installations are designed as a stage bolt-on addition to the generator set, requiring a space of only 400 - 800 mm between the radiator and the acoustic splitters.

The grids are assembled in banks with ceramic insulation rated for 1kV operation. Because the load bank makes use of the radiator airflow for cooling, the basic design is simple, low-cost and adaptable to almost any engine.

Most standard generating sets in the 50-1000kW range have radiators with a free pressure loss of at least 125Pa, so a load bank can be added without the need for modifications to the basic design or an increase in the rating or cost of the acoustic splitters.

Test, test and test again

Where power ratings of more than 50% of a set's capacity are required, or where a single load bank is installed to serve multiple generating sets, other cooling arrangements can be used. Cressall has even arranged for cooling systems to use the existing plant room fans. Cressall Resistors has supplied many such loads for these applications, with power ratings ranging from 5kW up to 2MW. Customers include generating set builders, contractors and end users themselves.

To buy a generating set and not test it is as short-sighted as buying insurance and not checking that the certificate is valid.

You have recognised the likelihood of failure in the electrical supply network - increasing as our distribution and generation infrastructure ages - but undermined your own preparations for it.

Load bank testing for Rolls Royce
Rolls Royce's 86MW load bank is the largest ever produced by Cressall and is used in one of the power systems giant's development facilities for testing gas turbine generator sets. It was installed in 2000 at Rolls-Royce Canada's Test Cell no. 7, beside the Lachine Canal in Atwater, a suburb of Montreal. At 60-metres long, the load bank is around five and half times the length of a Double Decker bus and is cooled entirely by convection. Despite its gargantuan proportions it is almost completely silent in use - an important consideration in a suburban location in the sixth largest conurbation in North America.



In some cases, the same load bank can be used as a ballast load during normal operation of the generating set.



The load bank is used for the development and final production tests of industrial gas turbine generator packages. It is suitable for 13.8kV/60 Hz and 11kV/50 Hz testing, allowing turbines for markets outside North America to be developed and tested alongside products for local use. Fine control of the exact load is achieved by varying the output voltage. The load bank is necessary because, although it is beneficial to return power generated during a test back to the grid, this isn't possible with 50Hz generator packages because the local grid in Montreal operates at 60Hz.

Before installing Cressall's load bank, Rolls Royce used fan-cooled models on a number of test sites in the area. As a result, the company experienced severe problems with insulator breakages in the winter, caused by rainwater freezing inside the insulators and leading to cracking. However, as well as protecting the nearby residential area from intrusive noise, the use of convection cooling instead of fans means there are no motors to freeze up during the harsh Canadian winter.

Another bonus is that there are none of the running costs associated with fans and no need to mitigate for the possibility of fan failure.

The use of convection cooling means there are no motors to freeze up during winter

Despite this, the Montreal site always has problems with the accumulation of snow and ice *outside* the load bank structure during the winter months. But clearing the load bank for use involves nothing more complex than the application of a reduced voltage and power, typically 50-100kW per module, to the load itself for a short period to melt the snow and ice. This means no separate heaters are needed and there are no doors to be opened or closed, simplifying health and safety procedures.

The modular load bank has 21 separate enclosures each rated 4.11MW at 13.8kV continuous power dissipation.

The 21 modules are arranged in groups of three, providing seven independently switchable sections and a total installed capacity of 86MW. The load banks are installed on a purpose-built steel platform, five metres high, to ensure adequate flow of cooling air up to and through the gratings on the platform and into the base of the load banks. There is provision on the platform for the future installation of three more modules to raise the total capacity to 98MW.

Each module is a double-decker construction 5m long by 3m deep and 8m high, weighing 8.5 tonnes. The platform layout is designed to ensure equal cooling for upper and lower modules while making the whole structure as compact as possible.

There are twelve stacks of low inductance expanded mesh resistors in each module, made from a high-grade (25% nickel, 20% chrome) stainless steel, optimised for high-temperature resistor use. These are graded to minimise temperature variations throughout the stacks and the use of non-magnetic stainless steel helps ensure silent operation.

The load banks are contained within enclosures that use a mixture of hot-dip galvanized steel frames with stainless steel panels and stainless steel mesh covers. The switchgear and control systems are installed in separate rooms under and alongside the load bank.

To compound the challenges presented by size and environment, the load bank had to be delivered to site in flat pack form. Assembly and installation was handled by a local contractor under the supervision of Cressall's engineers. When this process was completed, Canada's second largest city was left with one of the world's largest load banks, so silent in running that inhabitants will never know it's there.

Testing under extreme conditions

Finite Element Analysis (FEA) based simulation has become an integral part of engineering practice. Sophisticated FEA software is used in industry for the design and analysis of complex engineering systems. The process aids numerical modelling of physical systems in engineering disciplines across the board, including electromagnetism and fluid dynamics. It can reduce the need for physical prototypes and predict conditions, such as material fatigue, for durability testing.

FEA design tools were used when Cressall received an order from a multinational petrochemical giant, through Fortress Systems (Pty), a Cressall partner company based in Melbourne, Australia. Environmental conditions, including cyclonic weather and potential earthquake problems dictated a requirement for the equipment to be assessed for structural integrity. Working from first principles, it required a clean sheet of paper and an open mind for the design, as nothing like this had been produced before.

Cressall and Fortress combined their resources for this project. Cressall manufactured the 650kV resistors and Fortress designed and assembled the enclosures.

To ensure both the internal components and the enclosure itself could withstand the extreme conditions associated with site, Fortress used FEA specialist [Leap Australia](#).

The company specialises in end-to-end software support for a product. It gets involved in design, testing, manufacturing and managing the lifecycle of the equipment it works on.

Leap performed stress analysis on both the resistor and the associated enclosure to ensure that they would be structurally sound when they were all put together.

When designing equipment for use at extremely high voltages, it is essential that the levels of insulation be correct. As part of the design verification, Cressall tested the resistor assemblies to ensure the voltage distribution was even and predictable, allowing the insulators and air gaps to be optimised.

Following successful supply, subsequent orders were received for a design that went one stage further, reducing the enclosure size by changing from an earthed enclosure to a live enclosure design.

With an earthed enclosure, none of the live parts touch the box; so all the insulation has to be suitable for the full voltage. In a live enclosure, the equipment is electrically connected to the enclosure, reducing the air gaps and making it physically smaller than an equivalent earthed design.

However the enclosure has to be completely insulated from earth and access must be restricted to qualified persons. The concept of exposed live enclosures is accepted practice for higher voltage installations.

For these orders, Cressall supplied the complete assemblies. Because the enclosure then needed to be supported on insulators, Cressall used its own FEA software supplied by Ansys to determine the strength, position and orientation of the mountings, ultimately selecting pairs of insulators mounted at 45 degree angles to withstand the stresses that may be encountered during an earthquake.



When designing equipment for use at extremely high voltages, it is essential that the levels of insulation be correct.

The enhanced enclosure design took up half the space of the original earthed version offering savings to the customer and making both delivery and installation much easier.

Conclusion

Rolls Royce and Fortress Systems had extremely different requirements and the key was to evaluate this before manufacturing. Whether it's lack of space, high voltage use or large development facilities, overcoming obstacles through planning is the key to efficient load bank testing.

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