

**White Paper**

**Adverse Effects of Low Load  
Operation on Diesel Generating Sets**

# Adverse Effects of Low Load Operation on Diesel Generating Sets

Load Banks provide the best practical means for allowing the engine of diesel powered generator to operate at its designed load and temperature ratings. Using a correctly sized load bank will prevent fuel system and emission issues that can affect diesel engine reliability and performance.

## LOAD BANK

A load bank develops an electrical load and applies it to an electrical power source. The load bank then converts or dissipates the resultant electrical energy into heat energy. The amount of power is rated in kilowatts (kW) and the amount of heat energy is quantified in British Thermal Units (BTU).

Load banks provide a stable and controllable load for evaluating the performance characteristics of a power system. A load bank can be as simple as a single resistor, or as complex as an integrated resistive and reactive unit that is controlled by an advanced software package. Figure 1 shows the configuration of components in a typical resistive load bank.

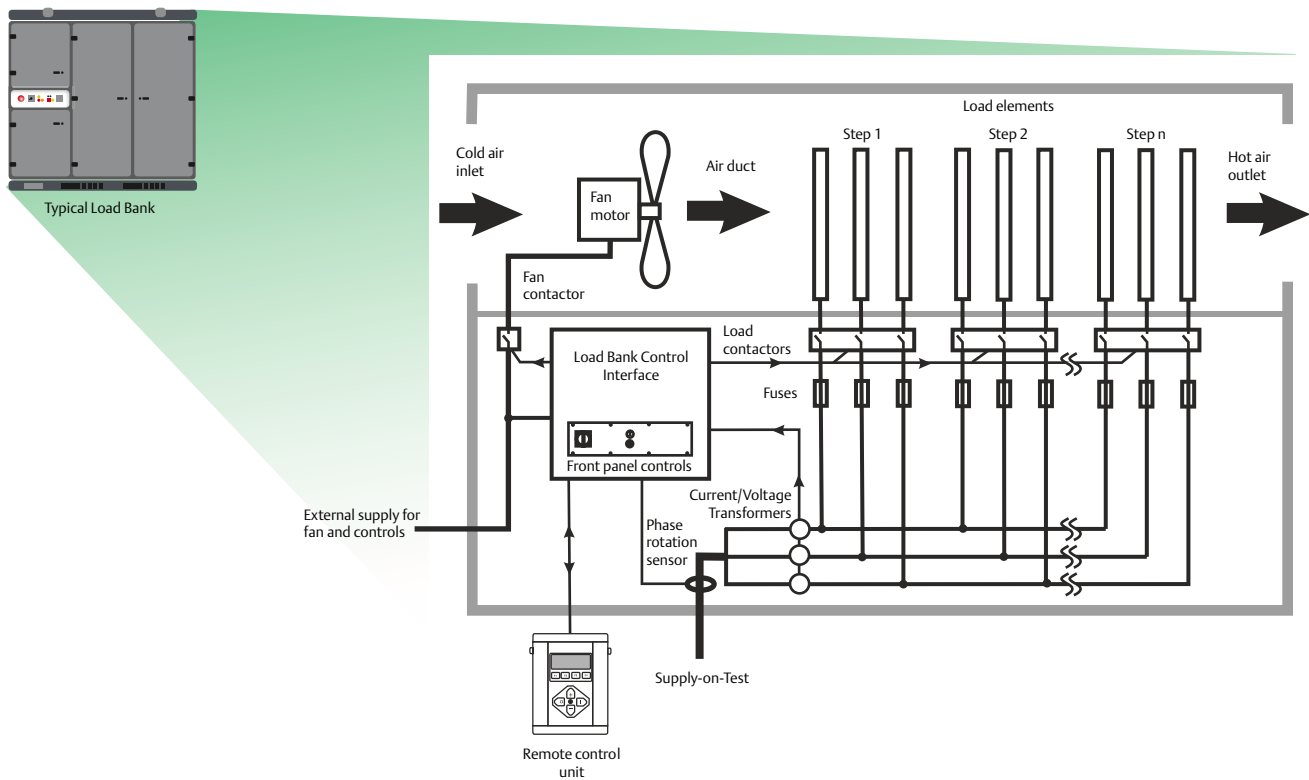


Figure 1. Configuration of a resistive load bank.

## WET STACKING

Wet stacking is an industry term for the accumulation of unburned fuel in the exhaust system of a diesel engine. While multiple conditions can result in this effect, wet stacking commonly occurs when engines are under loaded and do not reach operating temperature. If uncorrected, wet stacking can reduce engine output and efficiency and result in premature failure.

Diesel engines also depend on cylinder pressures generated by higher loads to correctly seal the combustion chamber. If load is too low during combustion the chemical reaction taking place will not be as strong, causing hydrocarbons to be left completely intact and then expelled in the form of particulate matter. Partial burning of diesel fuel results in large carbon dioxide particles as well as greenhouse gasses all of which contribute to air pollution.

In general, operating a diesel generator between 30-50% of the nameplate rating allows the engine to reach its recommended operating temperature and burn off any fuel deposits. Slowly increasing load until the excess fuel is burned off and system capacity is attained typically reduces wet stacking. Depending on how excessive the fuel build up is, this process can require up to several hours under continuous load. Frequent wet stacking can shorten the life of a generator, increase maintenance costs, and increase the level of emissions produced.

Load banks provide the precise incremental load values for properly reducing the effects of wet stacking. Load banks can also be sized as supplemental loads in a backup emergency power system to maintain diesel generator set load levels.

## DIESEL PARTICULATE FILTERS

Particulate matter is responsible for the black smoke traditionally associated with diesel exhaust. Diesel Particulate Filters (DPF) are designed to remove particulates from the exhaust gasses of diesel engines.

Rather than mechanically cleaning the filter, “DPF Regeneration” burns off particulates to return the filter to a serviceable condition. This usually occurs whenever an engine reaches a certain operating temperature, a process known as “Passive DPF Regeneration”. However, engines running at low load levels do not attain the exhaust temperatures needed for passive regeneration to occur. Failure to reach and maintain normal exhaust temperature can result in the DPF becoming blocked by unburned deposits. (See figure 2).

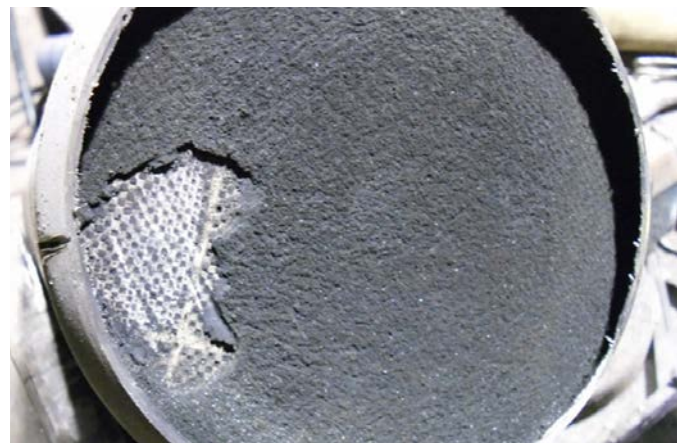


Figure 2. Blocked DPF filter.

Some diesel engine manufacturers have turned to “active” regeneration to avoid clogged particulate filters. This process is initiated after engine control software detects that a DPF is becoming blocked. When this occurs additional fuel is injected into an engine’s combustion chambers to increase the temperature and trigger regeneration.

It is important to note that active regeneration typically requires approximately 10 minutes to complete. If the cleaning cycle is interrupted, the filter may be only partially cleaned and may continue to restrict exhaust flow through the filter. For this reason, active filters require elevated temperatures to be maintained throughout the entire cleaning cycle.

Load banks provide an effective means to attain and maintain exhaust temperatures for proper DPF operation. Many load bank manufacturers have specially designed units with sophisticated temperature and load leveling controls to help achieve DPF regeneration.

## CORRECT LOAD LEVELS

Properly specified generators should have an available load of at least 30 to 50% of their rated output. Exercising your generator or running it during off hours with very little load will increase the risk of fuel and emission problems due to wet stacking.

Ideally, diesel generators should be run at a minimum of 30% of nameplate ratings. Short periods of low load operation are permissible provided the equipment is run at or near full load on a regular basis.

Extended run times and excessive idling at low loads can cause several problems, such as poor combustion, wet-stacking, the formation of deposits on cylinders/turbocharger components and internal glazing. Notably, newer engines increasingly rely on increased turbocharger output to optimize the balance between performance and emissions. This increase in turbocharger output narrows the operating range to avoid wet stacking. In these instances, long term low load operation below 45% of nameplate rating can reduce engine service life<sup>1</sup>.

These conditions may also occur due to excessive idling (such as standby) operation, or by under loading that occurs when the generator capacity is purposely oversized for future growth. These conditions can result in failures when the generator is not operated according to application requirements and operating guidelines.

The best practice is to consult an engine generator manufacturer regarding their specific operation requirements. All major generator set manufacturers typically suggest a minimum load of at least 30% of nameplate capacity to insure proper fuel and emission operation.

## SUPPLEMENTAL LOADING

Load banks offer an optimal means for applying supplemental load to diesel powered generator systems. Supplemental loads are defined as loads that make up a percentage of the generator sets nameplate rating. Supplemental loads are typically sized 30-50% of power source capacity (never 100%).

Portable load banks can be used in applications where they must be moved to various locations. Permanent load banks are designed for continuous outdoor operation and can be installed on a concrete pad or rooftop. Radiator mounted load banks are primarily designed to provide supplemental loading and are installed directly on the engine radiators. Each type is shown in figure 3.

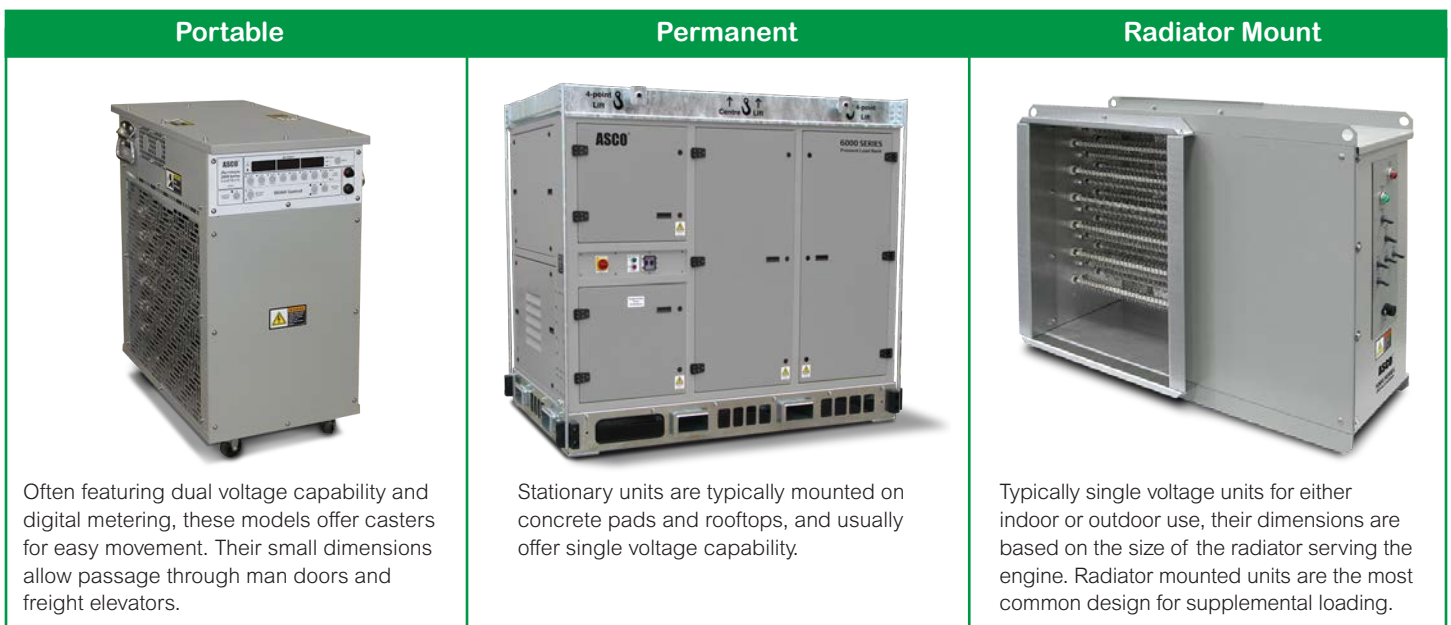


Figure 3. Load Banks



Photo courtesy of ASCO Power Technologies

Any of the above load bank designs will allow regular system testing and emission verification without interrupting power to building loads. This can be especially important where the generator systems serve critical life, safety, communication, or financial systems.

## **BUILDING LOAD**

To test backup power systems, live building loads can be applied to the generator, however this may cause power interruptions when loads are being transferred from utility to generator. In addition, transferring live load does not allow load to be applied in the discrete steps needed to accurately monitor performance and data logging. Other disadvantages include:

- Unavailability of sufficient building load (depending on the time of day, load may rarely exceed 50% of the required amount)
- Building load fluctuations (this can make it difficult to achieve and maintain the required test load level)
- It does not allow the load to be applied in steps, where performance can be monitored and recorded.

Providing adequate building load may not be practical when critical life, computer, safety, or communication systems are present. Any interruption of power to these loads may cause a loss of data, interrupt operation, or jeopardize personal safety. It is generally agreed that a load bank is the preferred method to test and load a diesel generating system.

## **LOAD BANK CONTROLS**

Because load banks provide precise repeatable loads, they are ideal for maintaining minimum loads on the generator sets (gen-sets). Most modern load banks can automatically add or subtract loads in steps to maintain a set value. This enables diesel gen-sets to operate at exhaust temperatures that promote more efficient fuel combustion, reduce emissions, and avoid wet stacking.

Load bank controls like Site Load Correction (SLC) will automatically maintain a required level of loading on the generating set. SLC control includes current transformer(s) which continually monitor the site load. When the site load decreases the load provided by the load bank will increase. Conversely, when the site load increases then the load bank load will decrease, thereby automatically maintaining an acceptable level of loading on the gen-set.

The level of load (set points) which is applied to the generator can be adjusted manually or through software. Load steps will only be applied when the site load is continuously below the set point threshold for a predetermined time, each step going consecutively. Load steps will be removed immediately when the generator set load increases above the set point selected. On receiving the initial signal that the generator is running, the load bank load will be delayed from operating to allow the generator to stabilize.

For proper SLC and automatic load control, the kW capacity of a gen-set must be known to provide the necessary amount of load, correctly size current transformer and specify load control steps. If inappropriate load steps and current sensor settings are specified, a generator could be overloaded. Figure 4 shows how load bank controls modulate the interaction of building and load bank loads during a generator test.

For more information review ASCO Power Technologies [Advances in Load Bank Controls White Paper](#).

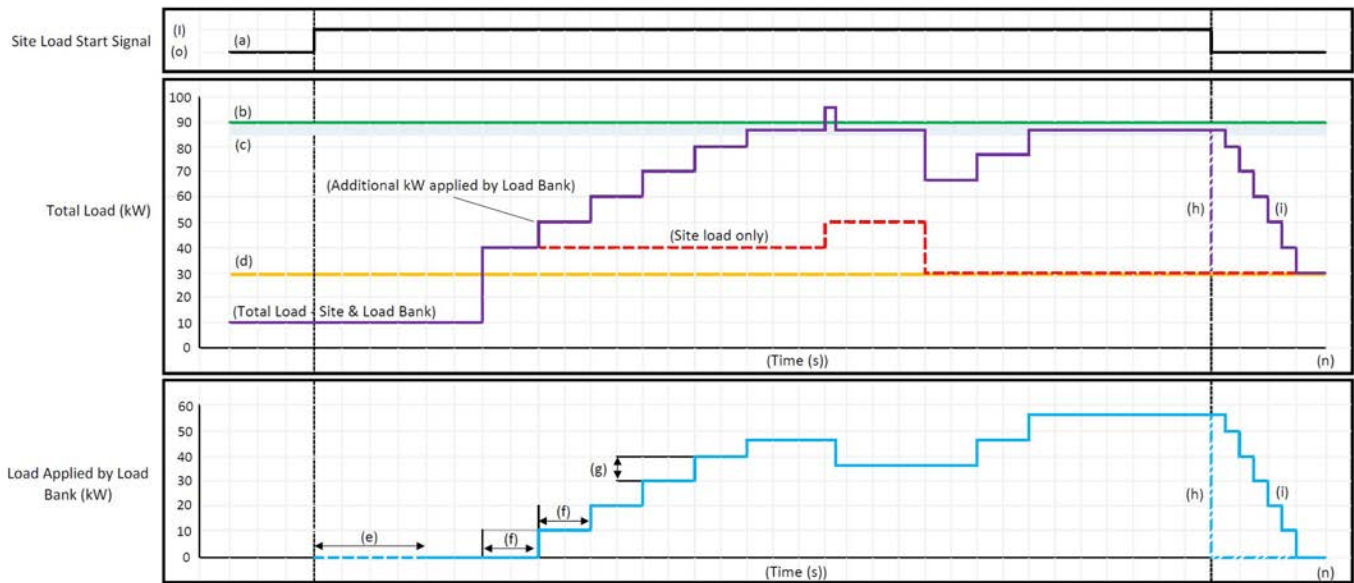
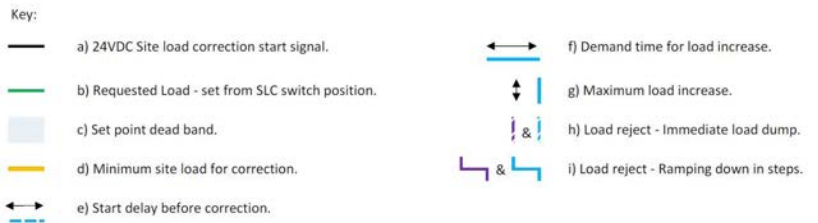


Figure 4. Site Load Correction Timing Diagram example.



## GEN-SET TESTING and EMISSION STANDARDS

National Fire Protection Association (NFPA) 100 standard for Emergency and Standby Power Systems sets forth testing and maintenance recommendations for backup generation systems. Section 8.4.2. recommends conducting load tests at least monthly. These tests must run for a minimum of 30 minutes at not less than 30% of the generator's nameplate rating. Additional information can be found in this standard <https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=110>.

ISO-8528-1:2005 (<https://www.iso.org/standard/30567/html>) is an industry standard for performance parameters in on-site power applications. The ratings outlined in this standard, define basic generator set rating categories based on four segments; emergency standby, prime power, limited time running time, and continuous power. In each category, a generator set's rating is determined by its maximum allowable power output in relation to running time and load profile. Misapplication of these ratings can jeopardize the longevity of the generator set, void manufacturer's warranties, and put the gen-set at risk for failure.





Photo courtesy of ASCO Power Technologies

The European Union (EU) also has standards regarding Diesel Emission Levels. The most up to date and comprehensive summary information can be found at<sup>2</sup>: <http://www.amps.org.uk/eu-emissions-update>.

## SUMMARY

For a diesel engine to operate at peak efficiency, it must operate at temperatures sufficient to completely burn all the fuel. The use of a load bank will allow the diesel engine to maintain proper operating temperature. Maintaining this temperature will help prevent wet stacking which can result in the loss of capacity and increase of emission. Modern load banks offer designs and control operation that can ensure diesel engines run at load level required to ensure reliability and prolong the operational life of a gen-set.

## REFERENCES

- 1 <https://forums.cat.com/t5/Power-Generation-Site-Design/Generator-Capacity/td-p/11870>
- 2 <http://www.amps.org.uk/eu-emissions-update>

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

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

[loadbanks.ascopower.com](http://loadbanks.ascopower.com)

[whitepapers.ascopower.com](http://whitepapers.ascopower.com)  
[customercare@ascopower.com](mailto:customercare@ascopower.com)

©2018 ASCO Power Technologies. All Rights Reserved.

**ASCO. Innovative Solutions.**