



# Minimizing Generator Set Exercising

## Purpose

Diesel generator sets have long been the primary choice for backup power in mission-critical applications due to their power density, quick response time, and cost-effectiveness. However, despite being an effective choice for backup power, their reliance on fossil fuels presents significant challenges for air permitting. Besides emitting greenhouse gases like CO<sub>2</sub>, diesel generators are also sources of criteria emissions such as particulate matter (PM, or soot) and nitrogen oxides (NO<sub>x</sub>).

Data centers typically deploy large numbers of diesel generators for backup duty to protect the entire facility against utility power outages, or other calamities, that could disrupt the regular power supply. Although backup generators rarely need to run in such circumstances, they must be maintained and ready to operate in case of an emergency.

To ensure readiness, data center operators typically run their backup generators bi-weekly to monthly, with additional extended tests on a yearly basis. Although maintenance run hours are relatively low, the sheer number of units needing testing contributes to a substantial total amount of emissions. In many data centers, permitting authorities limit run hours to keep total annual site emissions below a mandated threshold, creating a strong incentive to reduce testing hours. As there

are currently no realistic alternatives for on-site backup power, it is extremely important to reduce maintenance runs to improve the overall sustainability of these backup generators. This paper advocates test regimens that minimize costs, operating hours, and emissions while maintaining reliability. With modern engine controls and a planned maintenance program that includes the right procedures, standby generators can perform their function with only an annual exercise run.

## Introduction

Historically, standby generator sets have been exercised monthly or bi-weekly to confirm that the system will work properly when called upon during an outage.

In the United States, NFPA 110 requires diesel backup generators used for critical and life-safety infrastructure to be exercised at least once per month for a minimum of 30 minutes. These generators must be loaded either to a minimum of 30% of the genset standby rating or to a level that maintains a minimum exhaust gas temperature as recommended by the manufacturer. Data centers, although not required to follow all NFPA 110 requirements, have generally adopted testing regimes in line with critical infrastructure practices. In Europe, similar monthly or quarterly testing regimes are either advised or imposed by local authorities.

Over time, testing practices have evolved, leading to a proliferation of diverse methods across the market. Environmental incentives are prompting data center operators to reduce their testing regimes. Consequently, it's essential to review the effectiveness of these regimes in ensuring that diesel generators will start and run when needed.

In essence, the testing or exercise regimes that data centers adopt can be divided into two sub-categories:

- **No-load or loaded short exercise runs:** These are typically performed weekly, bi-weekly, or monthly and usually last no longer than 10 to 15 minutes.
- **Yearly full-load exercise runs:** These typically last 1 to 2 hours at 70% to 100% of the rated output and are performed against a load bank.

This document will predominantly focus on the effectiveness and alternatives for the no-load/low-load exercise runs, including maintenance items that allow eliminating monthly test runs. This paper will also cover the yearly exercise runs, as reducing or removing low-load testing can also decrease the time needed to test at full load.

### No-load or loaded short exercise runs

Standby generator sets are typically "exercised" by starting and operating at rated frequency with no load. With a properly maintained modern engine, there is no requirement to run monthly. Where a monthly run is required, it is not necessary to operate with load above a certain threshold.

Historically, the purpose of requiring a loaded operation is to eliminate the possibility of wet stacking, a condition in which the exhaust stack temperature does not reach a level for complete fuel combustion. This results in poor operation and emissions performance and eventually damages the engine if the condition persists particularly when operating repeatedly or extended at no load, or loads below 30%, combustion-related problems can accumulate. In addition to wet stacking, risks of extended low load application include water contamination of lube oil, fuel dilution of lube oil,

carbon buildup on top piston rings and injectors, and piston detonation. The wet stacking and carbon buildup of these low load runs will require the yearly full load run to be extended to burn off the effects, whilst the oil dilution will require a more frequent engine oil change.

Newer engine controls maintain control over combustion temperatures and minimize the risk of wet stacking, so loaded exercise runs are unnecessary. It is important to work with the engine manufacturer to assess the risk of wet stacking with that engine model.

### Exercise runs and Emissions Aftertreatment

Emissions Aftertreatment systems do not require exercise runs and are typically not effective at limiting emissions during unloaded or lightly loaded runs.

### Selective Catalytic Reduction (SCR)

SCR aftertreatment systems are installed to reduce NOx emissions and are becoming more common. As these systems are flow-through catalysts, they are not negatively impacted by testing regimes. However, they require the catalyst temperature to exceed a threshold to start operation. Therefore, when tested at low load, or for a short timeframe (i.e., 10-15 minutes), the urea injection system will not be actuated. This means that during short exercise runs, the engines will emit unregulated NOx, and the SCR injection system operation will not be tested in most cases due to the exhaust temperature being below the operational threshold. For SCR systems, a frequent short-term exercising regime does not add any value in testing their operational readiness and is, in fact, counterproductive to their purpose of reducing NOx emissions.

### Diesel Particulate Filters (DPF)

DPF are installed to prevent particulate matter or soot emitted in the diesel engine exhaust gas from entering the atmosphere. These filters trap the soot in a ceramic filter until enough exhaust heat is produced to allow it to burn off during operation. This process is called DPF regeneration.

It's important to understand that, particularly during engine start, an excess of soot is accumulated onto the filters. If the engine is only started but not run long enough or with enough load to properly regenerate, the filter will eventually clog after a number of start cycles. In the event of a utility outage with a clogged filter, the rapid load ramp will result in excessive backpressure, potentially causing a shutdown.

As DPFs are passive devices, frequently starting the engine to run short on low loads is not effective for ensuring its operational readiness. On the contrary,

this sort of regime is detrimental and could require a premature need for a prolonged loaded run of the engine to regenerate the filter.

### Preventative maintenance

To eliminate periodic testing, preventative maintenance actions are recommended for several subsystems, as outlined below (Figure 1). Work with the engine manufacturer to develop a maintenance plan appropriate for the engine deployed.

## Preventive maintenance minimizes exercise requirements

### Why minimize generator exercising?



**Lower emissions** to ease air permitting requirements.



**Reduce fuel costs** (diesel or HVO) and improve operational expenses.



**Reduce Scope 1 carbon**, supporting sustainability goals.



**Enhance community relations** by minimizing noise and air impact.

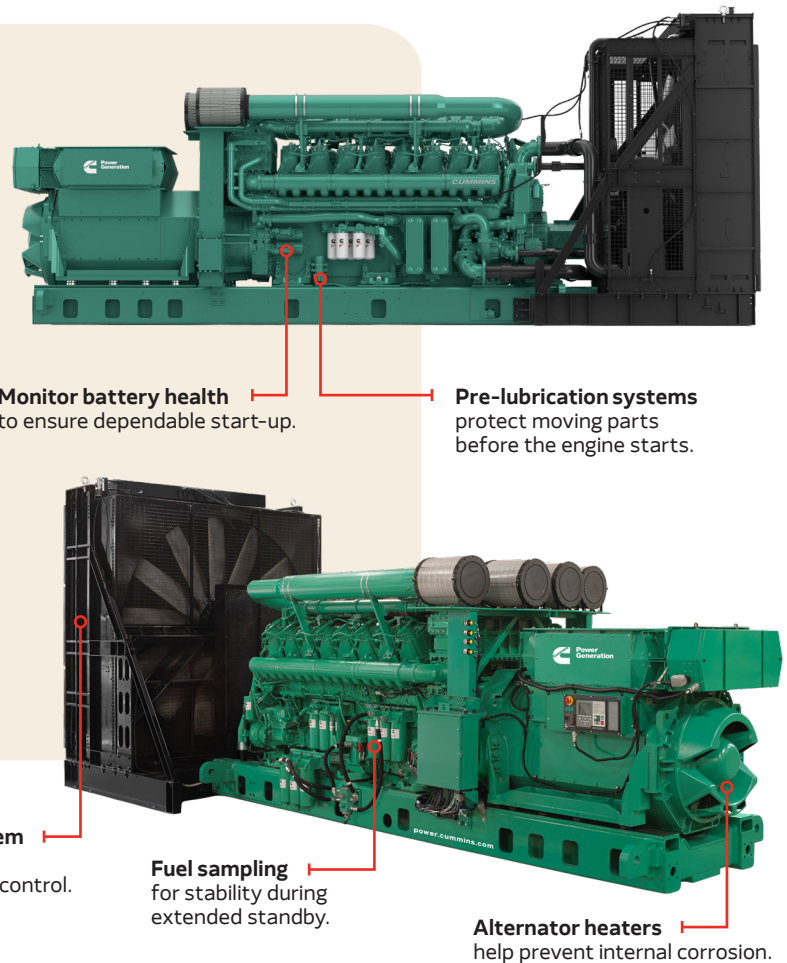


Figure 1: Preventive maintenance minimizes exercise requirements

## Starting system

Standby generators for data center applications are typically equipped with redundant batteries and starters in an N+1 or N+N configuration. The redundant starting system is deemed highly reliable, with the most common potential failure point requiring frequent checks being a weak or faulty battery in the string. It's important to follow the manufacturer's planned maintenance procedures, which typically include visual inspections, topping off battery fluids, and measuring open circuit voltages. Additionally, a battery management system can be installed to monitor battery health.

## Fuel system

Biological content in fuel can lead to filter plugging and other fuel system component issues, like sticking actuators, especially if allowed to sit idle for prolonged periods. Biofuels are generally not recommended for standby applications; however, in some regions, all diesel fuels have some biological content. Where that is the case, fuel sampling and testing are required.

It's important to recognize that Hydrotreated Vegetable Oil fuels (HVO) are not to be regarded as biofuels. On the contrary, they are superior with regard to stability and shelf life, making them an ideal application for standby generators with extended exercise intervals. For more information on operating with biofuels, reference the Cummins whitepaper<sup>1</sup>. For more information on HVO, reference the following Cummins whitepapers<sup>2</sup>.

Another important factor in potential failure to start is the fuel feed to the engine. If the fuel system is not designed with a system to ensure a constant positive head, there's a risk the fuel feed line will lose its vacuum, and fuel will drop back to the fuel tank. In such a case, when the engine is started, it might struggle to prime the fuel line and therefore start with more difficulty or fail to start altogether. Assuming the fuel system setup is not prone to this effect, it's still important to regularly check for leaks, as they can cause similar issues.

Overall, if the fuel is of the right quality and stable, there's no benefit to exercising the engine monthly. With regards to the external fuel system, it's important to assess each specific setup for the risk of fuel drop-off in the feed line. However, even if the system is prone to this, there's no reason to start and run the engine for longer than 30 seconds.

## Oil lubrication system

In general, engines need pressurization of their lubrication system to ensure an oil film is present on all moving metal parts. When the engine is not in operation, the oil film will degrade over time.

To minimize engine wear, particularly the main bearings, an oil pre-lube system is often installed. This system pressurizes the oil at predetermined intervals, typically multiple times a day. It ensures the engine oil film is in optimal condition for starting, with minimal time to reach rated speed and minimal wear.

In case no pre-lube system is installed, the monthly exercise runs will function to re-establish the oil film and reset its degradation, although less effective due to the long interval. It is important to note that aside from reestablishing the oil film, there is no additional benefit to the lubrication system, and thus prolonged running of the machine up to 10 or 15 minutes does not provide added value.

## Cooling system

The engine cooling system is a closed-loop system with a mechanically driven engine pump. Generally, very little can go wrong, except for coolant leaks. Running the engine has some benefits, primarily because some leaks only become active when the system is at operating temperature or due to the heat cycling of the engine. However, this requires a loaded run for an extended period to ensure the thermostats are opening and the engine is at operating temperature. Low-load or short runs cannot ensure that the system is at full operating temperature and therefore has very little additional value in checking the cooling system for leaks not present when the engine is cold.

<sup>1</sup>[QSK95 HVO Fuel White Paper](#)

<sup>2</sup>[HVO Fuel FAQs](#)

Additionally, any leaks present when the engine is cold can be detected without running the engine through the following methods:

- Low-level alarm on the radiator top tank
- Leak detection devices in the genset enclosure or room-bounded area
- Frequent oil samples or oil level checks to detect minor or large leaks within the engine
- Regular visual inspections

If the radiator fans are driven by electric motors, operators typically check their function when accessible. In many cases, however, the fans are not easily accessible and if one is broken, running the engine at low load would not trigger any overheating alarm. Alternatively, when the fans are powered by site power, they can be tested manually with motor contactors. If powered by the generator set, a brief start-up to rated speed will be sufficient to confirm that fans are operational.

## Alternator

Overall, alternators are very reliable devices if maintained properly. It's important to have alternator heaters switched on when the alternator is not operated to ensure the windings stay dry and to avoid corrosion. During regular inspections, operators can additionally check for loose, broken, or corroded connections, as well as the good operation of the heater system.

To ensure the health of the Permanent Magnet Generator (PMG), stator, varistor, windings, Automatic Voltage Regulator (AVR), and other electrical components, resistance can be measured every 6 months according to the manufacturer's manual.

Re-greaseable bearings should be greased every 6-12 months, and to avoid flattening of those bearings, they must be rotated at least once a year.

## Yearly full-load exercise runs

Currently, most data center operators run their engines annually at 70 to 100% of their rated power for 1 to 2 hours on a load bank to test the backup system. This test duration and engine load are not

necessarily needed to prove good operation of the engine. A common requirement is to run the engine at a load that raises the exhaust stack temperature to the manufacturer's recommended level for 30 minutes. Typically, it suffices to run the engine above 30% long enough to bring it up to operating temperature.

Depending on the engine and ambient temperatures, it can be more effective to run the engine at a higher load point to reach this operating point more quickly.

The load point and duration may need to be increased if there's a need to regenerate the DPF or remove potential wet stacking. Both will be heavily dependent on the engine type and the exercise regime exposure throughout the year.

Also, when SCR systems are installed, there's often a need to prove the aftertreatment to the authorities annually. Such tests need to be conducted when the engine is at full operating temperature and at design load, and as such, are best paired with the yearly exercise run. This will easily extend the testing duration over 1 hour.

## External system requirements and customer considerations

Customers may have a requirement to test or do maintenance on other parts of the standby power systems which require running the genset. Service level agreements may also require periodic demonstration of system reliability. These scenarios should be considered in planning exercise strategies.

## Summary

Table 1 provides an overview of the relative impact of the discussed exercise methods on generator reliability. It also indicates the potential reliability implications when exercise intervals are extended.

Table 1 indicates that frequent generator tests conducted under minimal load conditions for durations of 10-15 minutes offer no reliability advantage over equivalent tests limited to 60 seconds. Consequently, for test protocols involving low-load scenarios, it is advisable to optimize the procedure by reducing the runtime to 60 seconds.

|                                                                 | Wet stacking | SCR system | DPF system | Oil lubrication system | Cooling system | Starting system | Fuel system | Alternator |
|-----------------------------------------------------------------|--------------|------------|------------|------------------------|----------------|-----------------|-------------|------------|
| 10-15min no load/<br>low load run                               | --           | 0          | --         | +                      | 0              | ++              | ++          | ++         |
| 30-60s no load/<br>low load run                                 | -            | 0          | --         | +                      | 0              | ++              | ++          | ++         |
| Prolonged testing intervals (against the above testing methods) | 0            | 0          | 0          | -                      | 0              | --              | -           | 0          |
| 1h high loaded run                                              | ++           | ++         | ++         | +                      | ++             | ++              | ++          | ++         |
| Loaded run up to operating temp                                 | +            | ++         | +          | +                      | ++             | ++              | ++          | ++         |

Table 1: Effects of engine exercise methods to system reliability

Extending generator test intervals necessitates focused attention on three key subsystems: fuel delivery, lubrication, and starting mechanisms.

### Lubrication system:

The integration of a pre-lubrication pump is considered the most robust solution to mitigate startup wear. Alternatively, operators should engage with engine manufacturers to evaluate the trade-off between oil film degradation and bearing wear. In certain configurations, reduced start frequency may be advantageous, though potential impacts on startup performance must be assessed.

### Fuel system:

It is essential to verify that the fuel system maintains adequate fuel head pressure over extended idle periods. As testing intervals shift to quarterly or semi-annual schedules, fuel stability becomes a critical factor. The adoption of HVO is recommended due to its superior storage characteristics and reduced degradation risk.

### Starting system:

The starting subsystem, particularly battery integrity, becomes increasingly critical with prolonged intervals. Implementing battery health monitoring and redundancy strategies can enhance reliability.

With appropriate coordination and alignment with the generator OEM, test intervals may be extended

to 6–12 months, contingent on the implementation of suitable maintenance protocols and system safeguards.

For annual loaded runs, it is essential to test the system and ensure the generator reaches full operating temperature. These tests can be optimized for time and fuel consumption, depending on several factors: whether the engine is prone to wet stacking during the year, whether electrical systems need to be tested at specific loads, and whether emissions aftertreatment systems require regeneration or validation. Additionally, the engine configuration and ambient conditions will influence the optimal load point for the test.

### Conclusion

In the data center industry, diesel generator exercise protocols and their associated frequencies are shaped by a combination of OEM guidelines, genset configuration, operator-specific operational strategies, and comprehensive risk assessments. While current practices reflect industry norms, there remains significant potential for optimization.

By reassessing exercise methods and intervals, operators can reduce generator run hours, minimize fuel consumption, and lower overall pollutant emissions—without compromising reliability. These improvements support both operational efficiency and environmental performance, aligning with broader industry goals for cost reduction and sustainability.

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Blair Lauer is a Data Center Engineering Technical Advisor at Cummins Inc., with nearly 20 years of experience in customer engineering and service roles across mining, agriculture, and power generation markets. Blair holds a Master's in Agricultural Engineering from the University of Kentucky and an MBA from the Kelley School of Business.



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