ULTIMATE SERVICE ASSOCIATES
A NORTH AMERICAN SITE SERVICES CO.

The ultimate solution for maintaining your nationwide generator network

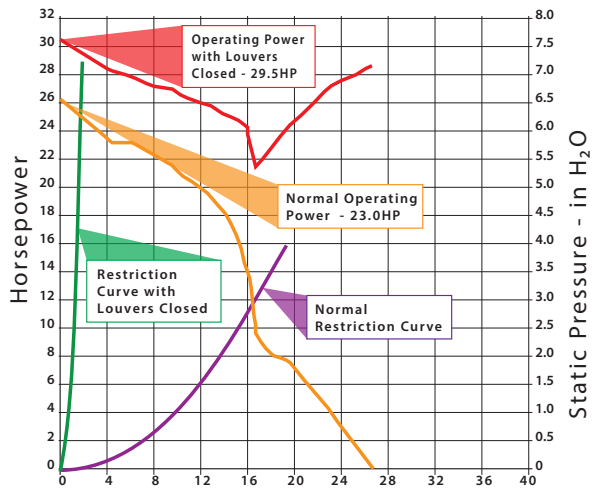
Avoiding Over-Cooling of Diesel Generators in Low Ambient Temperatures

1.0 Introduction

Diesel engines are designed to operate at a nominal temperature for maximum efficiency and to ensure combustion is maintained within a rated emission standard. If ambient conditions prevent the engine from attaining its designed operation temperature through over-cooling, a loss of performance may result. The majority of the US and Canada can reach temperatures at or below 20°F (-6.6°C). Potential over-cooling is especially an issue in the rental market where generators are frequently relocated between hot and cold climates or run at less than full load.

This information sheet discusses the issues that can occur from over-cooling on Tier 4 engines diesel engines using diesel particulate filters (DPF) and selective catalytic reduction (SCR) to meet the latest EPA emission standards, and recommended solution to over-cooling. *(Continued over)*

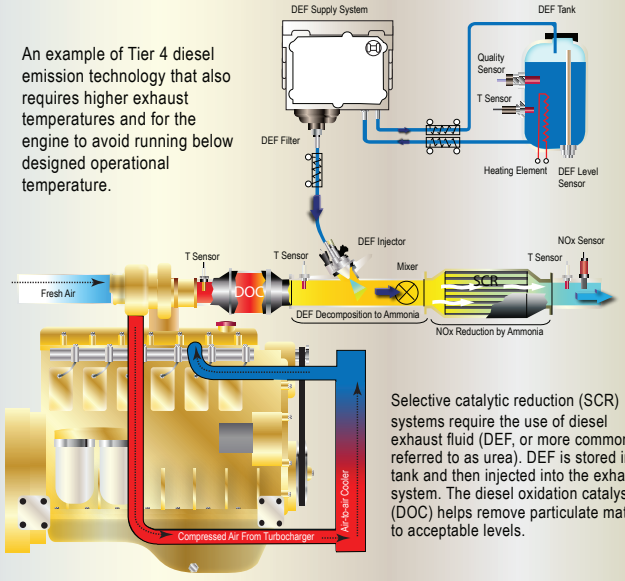
Effect of Closed Louvers on Fan Power



This graph shows the increased power draw of approximately 6.5 to 7.5 HP for a 156kVA Prime generator set containing a direct drive that turns the fan at 1900 rpm.

Selective Catalytic Reduction (SCR) and a Diesel Oxidation Catalyst

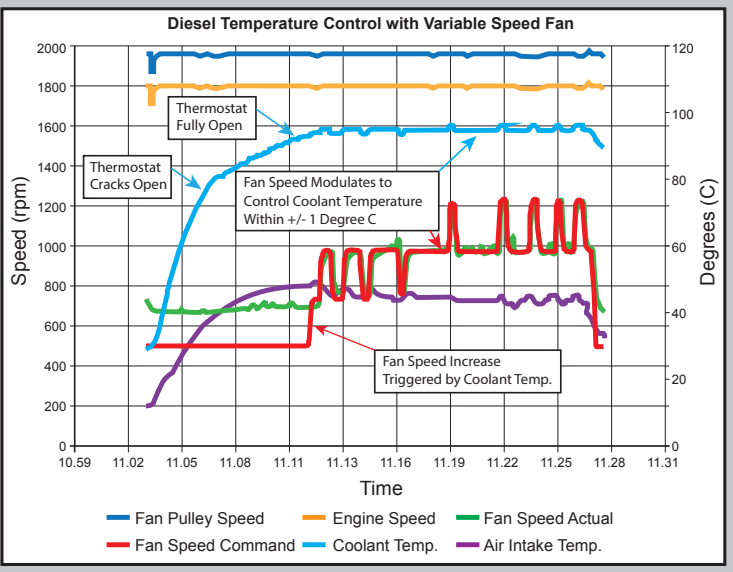
An example of Tier 4 diesel emission technology that also requires higher exhaust temperatures and for the engine to avoid running below designed operational temperature.



Selective catalytic reduction (SCR) systems require the use of diesel exhaust fluid (DEF, or more commonly referred to as urea). DEF is stored in a tank and then injected into the exhaust system. The diesel oxidation catalyst (DOC) helps remove particulate matter to acceptable levels.

Motorized Louvers

Diesel Temperature Control with Variable Speed Fan



To fulfill our commitment to be the leading network service provider in the Power Generation Industry, the USA, Inc. team maintains up-to-date technology and information standards on Power Industry changes, regulations and trends. As a service, our **Information Sheets** are circulated on a regular basis, to existing and potential Power Customers to maintain awareness of changes and developments in engineering standards, electrical codes, and technology impacting the Power Generation Industry.

2.0 When is Over-Cooling Likely to Occur:

Several conditions can result in over-cooling of a generator set. The most frequent are:

- **Light electrical load -** This is probably the most common cause for over-cooling generator sets. Not only can this lead to a 'wet stacking' condition, but it can also cause excessive carbon buildup of exhaust valves and in the exhaust piping runs if diesel engine fails to reach proper operating temperatures in its cylinders. In addition latest Tier 3 and 4 engines are designed to run with higher exhaust temperatures.
- **Low ambient temperatures -** The engine will be over-cooled when the normal cooling system is not matched for operation in cold ambient conditions, particularly below 20°F (-6.6°C).

3.0 Why Tier 3 & 4 Diesels Have to Avoid Over-Cooling:

Prior to the introduction of Tier 3 emissions requirements, over-cooling of engines typically was not a critical issue for engine performance. However, when emissions standards require diesel engines to be fitted with diesel particulate filters (DPFs) and cooled exhaust gas recirculation (EGR) systems, maintaining minimum exhaust system temperatures becomes important for engine performance and efficiency. While the engine can operate below its optimum temperature, it can experience decreased efficiency.

The move to Tier 4 interim and Tier 4 final-emissions solutions has accentuated over-cooling issues in cooler climates. Each engine manufacturer has optimized its emissions solution for specific engines. Many have multiple solutions based on engine size and power. In addition to DPFs and cooled EGR systems, the latest emissions technologies include catalysts and selective catalytic reduction (SCR) systems (See Image 1). As with Tier 3 engines, these Tier 4 systems require a minimum exhaust temperature in order to operate properly. However, Tier 4 solutions also require closed-loop control. Tier 4 engines, with closed-loop control, will de-rate and can shut down if the emissions solutions are not operating correctly. As a result, over-cooling has become a mission-critical issue, leading to unexpected downtime and lost performance.

4.0 The Right Amount of Cooling:

The engine manufacturer should be consulted regarding the nominal operational engine temperature required for optimum performance and to maintain emission levels. If the potential for over-cooling is mainly due to location and seasonable temperatures, the generator manufacturer through its authorized distributor is able to offer several solutions to ensure required engine operating temperatures.

5.0 Solutions to Over-Cooling:

Even before the adoption of Tier 3 and 4 engine technology to meet emissions standards, engine over-cooling could be an issue. Several solutions to over-cooling have emerged such as:

- **Auxiliary Load -** When a generator systems load can be light, such as below 30% of rated load, for long periods, an additional 'dummy" load bank can be switched on to increase the minimum load. This is an effective method to ensure correct engine loading, but requires added equipment and expense.
- **Motorized Louvers -** (See Image 2). When operating in low ambient temperatures, thermostatically- controlled louvers can control air-flow into the generator enclosure or building to restrict the intake of cold ambient air. A thermostat monitors the temperature around the generating set and opens and closes the louver slats to maintain an optimum temperature. This is an effective method but when louvers are partially or fully closed, restricted airflow results in the fan pulling against progressively higher static pressures. This leads to greater power consumption and increased noise from the fan. The other factor to be considered is the increased cost of installing motorized louvers to restrict air-flow (See Chart 1).
- **Winter and Summer Cooling Fans -** Different fans can be fitted during planned maintenance programs when seasonal temperatures are due to change. Different fans will ensure the correct air flow is maintained in hotter or cooler ambient temperature. The drawback of this method is the cost to change the fan and to ensure the fan is changed at the right time.
- **Variable Speed or On/Off Fans -** Generator sets with the latest Tier 3 and 4 engines have started to adopt the fan technology of on-highway vehicles. Most common is the electric fan controlled from the engines Electronic Control Unit, or ECU. There also are fans with speeds that can be varied by the ECU.

6.0 The Advantages of Variable Fan Technology for Latest Tier Diesels:

Today's reduced-emissions generators require optimized, precision-controlled cooling to meet the vast array of application variables and environmental conditions. The best solution to over-cooling issues is to disengage or slow the fan speed when cooling is not needed. Power generators equipped with a variable speed or on/off fan drive deliver additional cooling only when it is essential. In extremely cold ambients likely to produce over-cooling, the following fan types can be considered as the solution for maintaining optimum engine temperature:

- **On/Off Fans -** On/off fan drives disengage completely, keeping the fan from turning when cooling isn't necessary. When cooling is required, the fan drive engages and turns the fan at full input speed. On/off fan drives are suitable for generators primarily used in very cold conditions. This tends to be the best-cost option on generators below 500kW.
- **Variable Speed Fans -** For larger generators, a fully-variable fan drive is another way to avoid over-cooling. On generator sets with fully variable fan drives, the fan speed is controlled to match the unit's specific cooling needs. In cooler weather, or when the generator set is lightly loaded, the fan speed is slowed and optimum exhaust temperatures are maintained. (See Chart 2). As ambient temperatures or loads rise, the ECM or Di controller monitors the various temperatures within the generator set, engaging the fan when temperatures hit pre-set limits. The fan speed is precisely controlled to keep all temperatures within an acceptable range. The typical operation of a fully variable fan drive is shown in the accompanying graph.

7.0 Who to Consult Regarding Over-cooling:

Generator manufacturers work closely with the engine manufacturers to determine the optimum use of the engine to meet performance, reliability, and emission standards. When using or specifying a generator set that will be likely running in low ambient temperatures, your nearest authorized generator distributor should be consulted. They will advise if the application will be subject to over-cooling and determine the correct specification required to ensure trouble free operation.

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