Service Bulletin

Diesel Engine Wet Stacking And Prevention

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Bulletin Type	Models/Series Affected:
____ Mandatory __X__ Information Only ____ Recommended Change	DCA SERIES GENERATORS STUDIO SERIES GENERATORS CONTAINER GENERATORS ALL DIESEL POWERED ENGINES S/N ALL

Details

Problem:

When a diesel engine operates without sufficient load (less than 40% of the rated output), it will not operate at its optimum temperature. This will allow unburned diesel fuel to accumulate in the exhaust system, which can foul the fuel injectors, engine valves, glazed cylinders and exhaust system, including turbochargers, and reduce the engine operating performance. In the industry this is referred to as "wet stacking".

Solution:

Periodically use a suitable load bank to exercise the engine and clean the accumulated deposits.

DIESEL ENGINE WET STACKING AND PREVENTION

This documentation is intended to educate and give a better understanding of the cause of diesel engine wet-stacking, its prevention by use of load banks and maintenance. The information is general and does not reflect any specific generator application or engine manufacturer.

What Is Wet-Stacking?

Wet stacking is a condition in diesel engines in which not all the fuel is burned and passes on into the exhaust side of the turbocharger and on into the exhaust system. The word "stacking" comes from the term "stack" for exhaust pipe or chimney stack. The oily exhaust pipe is therefore a "wet stack".

Diesel Engine Fundamentals

To understand how wet stacking happens, one must have at least a cursory knowledge of the operation of a diesel engine. Here’s a simplified description—looking at a single cylinder—of how a four-stroke, turbocharged diesel engine works:

Diesel Engine Fundamentals

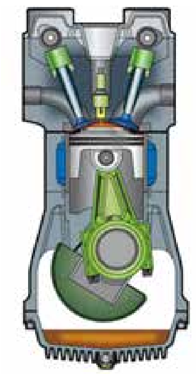
Fig. 1

- The intake stroke Fig 1: As the piston travels downward, the intake valve opens, and the turbocharger delivers compressed air to the cylinder.
- The compression stroke Fig 2: When the piston reaches the limit of its downward travel, it reverses direction, the intake valve closes, and the piston compresses the air in the cylinder. The temperature and pressure of the air in the cylinder rise dramatically.
- Fuel injection: With the piston at the top of the compression stroke, the fuel injector sprays a fine mist of fuel into the cylinder. The air in the cylinder is hot enough to vaporize and ignite the fuel. The burning fuel adds heat to the air in the cylinder, and its pressure and temperature rise further.
- The power stroke: The hot compressed gas in the cylinder pushes the piston downward. The force on the piston is transmitted to the crankshaft through the tie rod, turning the crankshaft.

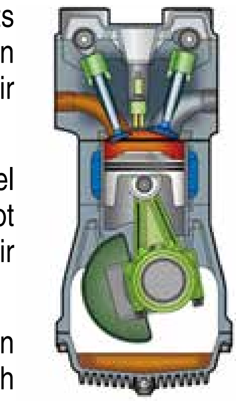
Fig. 2

- The exhaust stroke: The exhaust valve opens, and the piston pushes the hot gas out of the cylinder, through the exhaust valve, into the exhaust system. A portion of the exhaust gas is diverted through the turbocharger to drive compression of the intake air, and the cycle begins again.

Wet Stacking - How Does It Happen?

When a diesel engine runs without load, it develops only enough power to drive its accessories and overcome internal friction. It uses very little fuel and consequently develops little heat inside the cylinder. The cylinder's internal surfaces stay considerably cooler than when running at higher load.

A diesel engine doesn't use spark plugs. It relies on the hot compressed air in the cylinder to vaporize and ignite the fuel. With the air cooler than the design temperature, conditions for combustion are less than ideal. The fuel ignites and burns, but it doesn't burn completely. What remains are vaporized fuel and soot—small, hard particles of unburned carbon. Fuel condenses in the exhaust system, and soot deposits on surfaces inside both the exhaust system and the engine.

In the exhaust system, fuel vapors condense and mix with soot to form a dark, thick liquid that looks like engine oil. It may ooze from the turbocharger or drip from the exhaust outlets. The appearance of liquid on the exhaust stacks leads to the term "wet stacking."

Inside the cylinder, soot can form hard carbon deposits on the fuel injector nozzle. The nozzle is designed to atomize the fuel, delivering a fine mist that vaporizes readily. When the injector nozzle is fouled with carbon, its ability to atomize the fuel is compromised, and it delivers larger droplets to the cylinder. The fuel consequently vaporizes less efficiently, more fuel remains unburned, and more fuel passes into the exhaust system. Wet stacking is a progressive condition; it tends to lead to more wet stacking.

It's generally believed that prolonged operation at low loads can lead to permanent engine damage, requiring a major engine overhaul. Costs of an overhaul can run so high that replacing the unit is the most economical option.

Evidence Of Wet Stacking Condition

The following pictures are result of wet stacking conditions taken from generator engines experiencing the problem. As you can see "extreme clogging" of one pipe suggesting that the unit has been operating for a prolonged time in low load conditions.

In the following picture comparison is made between a new EGR valve and one with clear signs of wet stacking.

PREVENTION

The general cure for wet stacking is a few hours of operation at a load of about 75% of the generator's nameplate rating or more, raising the exhaust temperature high enough to vaporize the unburned fuel in the exhaust system and blow out the soot.

Load banking is an essential part of generator maintenance and engine break in. New generators should be load banked to break in an engine. If a new engine is immediately placed into a no/light load application, the engine components may never break-in properly and wet-stacking can occur.

Load banks can be used as a supplemental load applied to the generator to prevent wet-stacking. These can vary from small portable load banks or large trailer mounted load banks. Portable load banks can be rented and brought to the generators location for testing. Pad mounted load banks are used as supplemental load that allows the operators to perform regular and periodic testing under load.

Applying an increasing load over a period of time until the engine has reached optimum operating temperature allowing it to burn off the excess fuel will usually repair the condition. This can take several hours to burn off the accumulated unburned fuel / carbon. In cases on known extreme wet stacking conditions, load banking should be done with gradual load increases, and not to generate too much heat and back pressure in the exhaust system to quickly.

SAFTEY NOTE: When performing load banking to engines suspected of having been wet stacked an operator must monitor the procedure at all times. A fire extinguisher must be readily available due to the potential of a fire hazard from residual fuel and soot igniting in the exhaust system

During a load bank procedure exhaust temperature at that load is well above the auto-ignition temperature for diesel fuel and can reach 1000 degrees F° or more. On rare occasions fuel and soot can ignite within the exhaust system or surrounding material due to the unburned fuel in and around the exhaust system

If a unit has a history of extended operation at low load, or if there's no documentation that it's been exercised recently at adequate load, it's important to have a generator maintenance expert manage the load testing procedure.

It is also recommended that the exhaust system is inspected (remove muffler, EGR valve, exhaust pipe) and severe deposits are cleaned as good as possible to prevent sparking from these deposits as they are being incinerated during these extreme temperatures generated as mentioned above. Load banking should never be done unattended to units with a history of wet stacking.

Other helpful hints and information:

OIL CONSUMPTION

During engine operation, some lube oil will be consumed. Lube oil provides a seal between the piston rings and the cylinder wall and during the combustion process, some of the "sealing oil" will burn and travel out the exhaust valve. The amount of oil burnt during this process is influenced by several factors, but will generally fall in a range of from 0.3% to 0.5% of overall fuel consumption.

(In cases of continuous low power demand, as high as 0.7% may be normal)

BREAK-IN

Due primarily to more exacting machining tolerances and more stringent quality control measures, modern diesel engines require less “break-in” than their predecessors did. Most engines however, will experience higher than normal lube oil consumption during the initial period of operation, which depending on the load factor applied, should stabilize within the first 150 to 200 hours of operation. During this time, the pistons rings are “seating”, or forming a perfect seal with the cylinder wall. It’s important to understand that this process is greatly influenced by the load applied to the engine during its early life and as long as the engine is demonstrating a decrease in oil consumption, this means that the “break-in” period is still occurring and more time (hours of operation) may be necessary.

Select the correct oil by consulting the operator’s manual. When the engine is new, try to limit the idle time of the engine by shutting the engine down when the machine is not in use. It’s best to apply a heavy load to the engine during the “break-in period” in order to seat the rings as quickly as possible. Sufficient load will assure a rapid “break-in” period and good piston ring sealing.

Lube oil consumption is expressed as a percentage of the fuel consumption during a test period of about one day. To calculate consumption, top off both the lube oil in the engine and fuel in the tank. Then operate the engine for a full work day and measure the exact amount of lube oil and fuel necessary to bring both back to the “full” level.

$$\text{Oil consumption \%} = \frac{\text{Quarts of lube oil added}}{\text{Gallons of fuel used} \times 4}$$

LUBRICATION PROBLEMS

Bad things can happen to lubricating oil when an engine is operating and when an engine sits at idle for long periods. A full service, including lubricating oil filter and fuel filter change should be performed annually for generator sets in emergency standby service. Lubricating oil is the “life blood” of an engine and it has a limited life inside of the engine. As the engine runs, the lubricating oil accumulates and binds contaminates, which could be harmful to the engine if not properly contained.

Since standby systems rarely run for very many hours, they are especially vulnerable to the moisture and acids that form in the engine. These contaminates must be neutralized to prevent them from attacking bearings and engine wear surfaces. Operating an engine with contaminated lubricating oil can be very detrimental to engine components. Buildups of carbon and corrosive damage can occur, which can cause excessive bearing wear, crankshaft damage, wear surface seizure and other severe engine failure. Periodic lubricating oil and oil filter changes are very effective at preventing these problems and extending engine life.

PREVENTIVE MAINTENANCE PROGRAMS

Most challenging to a Rental Organization is the fact that customer's power assumptions may not meet the minimum load requirements of the power equipment selected. When in doubt, it is always recommended to apply a load bank application to the equipment following a longer rental period.

Equipment on extended, long term contracts needs periodic onsite inspection. If possible interview the operator and survey the equipment hooked up to the generator to estimate load conditions.

Preventive maintenance and a few extra steps prevent downtime and protect your investment and business. A well planned preventive maintenance program will reward you with years of service.

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PLEASE HAVE THE MODEL AND SERIAL NUMBER ON-HAND WHEN CALLING

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Service Department

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