



Diesel Engine Liner Pitting

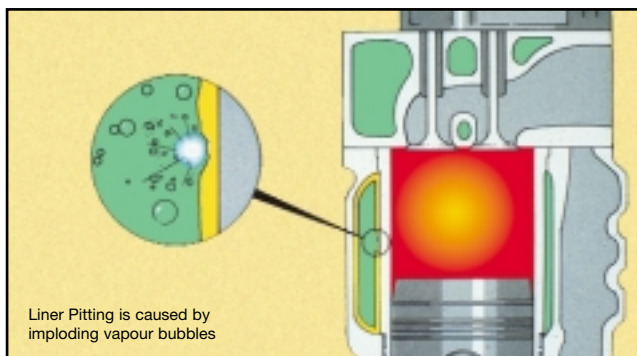
Cavitation Corrosion/Erosion

Modern high speed diesel engines contain cast iron replaceable cylinder liners that are subject to accelerated corrosion due to a process commonly known as liner pitting. When plain water is used as a coolant, liners can be penetrated in a matter of 500 hours of operation when conditions are severe. It is important to understand the causes of this liner pitting and how to prevent it.

Cylinder liners are installed in a press fit with the engine block. Gaskets, called crevice seals, are used to seal the lube oil system from the cooling system across the liner.

The pistons strike the liners as they travel up and down due to the side thrust imparted by the connecting rods as the power is translated from the linear up and down motion of the piston to the rotary motion of the crankshaft.

The clearance between the piston and the liner and the liner and the block allows this piston slap to be translated into a high frequency vibration, much like the vibration of a bell when it is struck.



The side of the liner in contact with the coolant moves first toward the coolant and then away from it. This rapid movement can cause small vapour bubbles to form as the liner moves away, and to collapse or implode as the liner moves back. Very large forces are generated in very small areas as this happens. This is known as cavitation corrosion/erosion.

The violent shock waves caused by bubble collapse hammer the liner surface. The resulting bare liner surface has been highly stressed and is very active. The resulting corrosion/erosion is localised and effectively drills small holes in the liner wall. If allowed to progress, these holes will penetrate the wall and oil will flow into the coolant when the engine is running and coolant into the oil when the engine is shut down.

Liner pitting can occur anywhere on the cylinder liner. Most frequently it is found on the side of the liner where the piston strikes just after the cylinder fires, and to a lesser degree on the opposite side where the cylinder strikes on the up stroke. However, it can occur anywhere on the liner where the highest level of vibration occurs. Because of variations from cylinder to cylinder and engine to engine, no two liners will appear the same.

Engine Conditions Effect Liners

The formation of bubbles in coolant during cavitation corrosion/erosion is very similar to the way bubbles are formed when boiling water. Remember how water in a pressure cooker boils at a higher temperature because of the higher pressure? In the same way, anything that affects the local pressure or the local temperature around the liners will impact on the ease with which bubbles are formed and will effect the potential for liner pitting.

Incorrect plumbing of the cooling system can cause local hot spots or local low pressure areas near the liners making them more susceptible to liner pitting.

Air leaks in the cooling system can cause local hot spots because of the insulating properties of air. In addition, when air is present in the coolant, more oxygen is available to accelerate corrosion in general.

Prevention

Since the early days of high speed diesels, Supplemental Coolant Additives (SCAs) have been used to prevent liner pitting. In the early days, sodium chromate was used. Around 1969, borate/nitrite was introduced. In 1984, Fleetguard introduced a state-of-the-art SCA containing phosphate/molybdate under the trade name of DCA4. In the late 90's Fleetguard introduced a hybrid of this formula with more emphasis on the utilisation of organic acids. This new product, ES Coolant™ provided more stability over the long term to confirm to ESI requirements.

All of these SCAs are effective in preventing liner pitting when used in the cooling system in the recommended concentrations. Basically, they all work by the same mechanism. They form a protective microscopic film on the coolant side of the liner by transforming the ferric oxide (rust), which is very soft, into FE_3O_5 , which is very hard.

This very hard film resists damage from the implosion of air bubbles. As long as the concentration of SCA is high enough, any damage to the protective coating will be healed.

Borate/nitrite SCAs are still commonly used, however, they rely on nitrite for their protection against liner pitting. High concentrations of nitrite are aggressive against the solder in the radiator. These inhibitors also rely on large amounts of silicate to protect against aluminium corrosion. Silicate is already present in large amounts in many commercial antifreezes. The combined silicate can cause silica gel to form, a "green goo" that plugs coolant passages.

DCA4 contains 30-40% less nitrite as the borate/nitrite SCAs. Fleetguard discovered that a mixture of nitrite and molybdate provides better liner pitting protection than nitrite alone. This lower level of nitrite also allows DCA4 to provide better protection against solder corrosion than borate/nitrite SCAs.

Preventative Maintenance

SCA is added to the coolant to provide necessary protection against liner pitting, general corrosion and scale. Most often, the SCA is contained in a coolant filter which serves the dual purpose of keeping the cooling system clean of debris and providing a convenient way to add the necessary make-up SCA at the same time other filters are changed. Sounds simple, but lots can go wrong.

There is frequent confusion regarding the initial SCA charge of a cooling system versus the service dose used to maintain the concentration. The required recharge dose is three to four times the amount added at the service interval. If maintenance personnel do not understand the need to precharge, the SCA concentration is never sufficient to protect the cooling system.

The issue of precharging is further complicated because to do it right, cooling system capacity must be known — information that is not always readily available. In a large over-the-road fleet with many different vehicles, the cooling system capacity can range from 30-80 litres. The same amount of SCA can adequately precharge the 30 litre system, but leave the 80 litre system marginally treated at best. The problem only gets worse in construction/mining fleets where cooling system capacities can vary from 20 to over 400 litres.

Always top up the system with the same correct mixture as provided at initial fill. Coolant leakage can lead to major problems, in particular incorrect topping up practices. e.g. using plain water only. This practice will lead to dilution of the coolants SCA package. As well as lowering of the antifreeze or glycol level. Today's modern diesel engines require 40% to 60% glycol as well as a heavy duty SCA.

It is common to see a 10% loss of coolant every 12,000 to 15,000 kilometres. One drop a minute from a highway truck is approximately 4 litres each month of lost coolant. Make sure more than ever before and particularly when antifreeze (glycol) is used, that all joints and flanges are tight. Now that engine coolant is moving towards the classification of an engineering fluid, continual loss from the system will prove not only damaging but costly as well.

More attention needs to be made as to how far the radiator is filled. Coolant will expand 2% of its volume when heated to normal running temperature. If allowance is not made for this expansion, i.e. topping up above fill neck, it would equate to say a 50 litre system losing one litre each time the engine is fired up.

There are two ways to maintain proper SCA concentration in a vehicle with a leaky cooling system. You can resort to frequent coolant testing, or use a properly mixed concentrate or premixed solution which already contains the precharge level of DCA4 additive and glycol antifreeze/anti-boil such as found in Fleetguard's Compleat-50™ or DCA4 PLUS found in ES Coolant™ and PGPlus™ for extended service intervals. This not only simplifies what to use at initial fill-up but also assures that at top up, the same balanced coolant is replacing that which is lost.

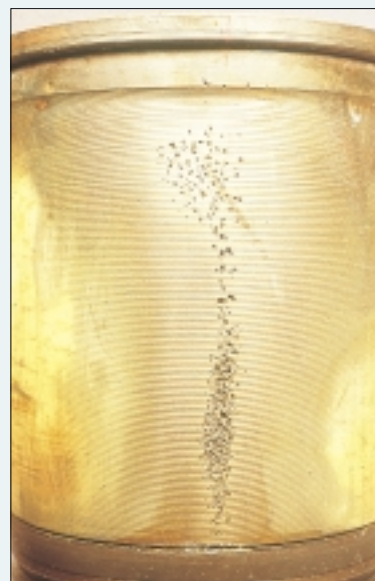
Guarding against liner pitting in today's modern high torque and computer managed engines relies more than ever on a correctly balanced glycol as well as heavy duty SCA coolant, meeting or exceeding TMC RP 329 or 330 recommendation.

Using a premixed coolant to this heavy duty standard will help eliminate most of the complexity in coolant maintenance.

Trouble Shooting

Review maintenance records to see if the proper amount of chemical has been maintained in the system. The addition of large amounts of make-up water should be a signal that more than likely SCA was not added every time water was.

Review maintenance practices. Are radiators topped off above the fill neck when they shouldn't be? If so, there is no expansion area remaining in the top tank, and when the engine warms up, coolant will be forced out of the system. This leads to dilution of the SCA unless more SCA is added every time the radiator is filled.



Look at the liners. If there is a coating of any kind, most likely the level of SCA was not adequate. The SCA in the proper amount will protect against the formation of scale or oil coatings. The microscopic protective coating of ferrous oxide is invisible and will not be seen by the naked eye.

Review oil analysis records, if available, for traces of potassium which indicate leakage of coolant into the oil and oil into the coolant.

**FOR FURTHER ADVICE CONTACT YOUR
FLEETGUARD STOCKIST OR
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Coolant Testing Kit CC2602M or CC2607C

Traditional Service Intervals

Fleetguard's Supplemental Coolant Additive (SCA) is measured in units. For Compleat-50™, this is provided in the premixed product by DCA4 at 0.4 units per litre (UPL). The acceptable range is 0.3 to 0.8 UPL. This level is maintained by installing a service filter containing DCA4 at each oil change interval. The correct sized service filter selected should contain DCA4 units totalling approximately 0.1 to 0.2 UPL. If the system does not have a coolant filter, maintain system in the same way using liquid DCA4 or add 1% or 2% by systems total volume.

Extended Service Intervals

ES Coolant™ premixed SCA level is at approximately 0.7 UPL and provided by DCA4 PLUS. Also available a safer alternative Non-Hazchem Propylene Glycol formulated PGPlus™ (Bulletin 3.301.000A).

The SCA level in these coolants is best maintained up front with the installation of a slow release filter such as WF2121. Replace every 250,000 kms or 4,000 hours. If no coolant filter fitted use ES Coolant Liquid™ CC2840 for up to each 80 litres of system capacity at the same intervals.

For more information see Bulletin 3.300.962A

For more information, contact your nearest stockist or phone Fleetguard Customer Assistance

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