Engine Malfunction and Failure.

Cause and Prevention.
Technical Paper.

By Professional Coolant Services. www.pcscoolant.com

With reference to Caterpillar and Cummins Inc., (world leading engine manufacturers), forty to fifty percent of engine malfunction and failure starts in the cooling system.
This leads to major unplanned equipment down-time and high operating costs.

The primary cause of malfunction and failure is undetected and undetectable contamination in the cooling system restricting the dissipation of combustion heat from entering the coolant to be cooled via the radiator. Contamination creates hot-spots deep within the engine causing extreme localised overheating leading to serious damage.
These conditions do not show on the temperature gauge leaving operators and plant service managers uninformed of the damage taking place.

Coolant/antifreeze has three functions, anti-boil, anti-freeze and anti-corrosion.
Anti-boil and anti-freeze functions are tested with a hydrometer or refractometer.
The anti-corrosion function is tested by pH level, this is critical. A digital pH meter is best practise for testing coolant as other methods are not precise.
In general the anti-boil, anti-freeze functions of coolant are tested more often and will last longer than the anti-corrosion function.
Once the pH begins to drop as it naturally does, coolant starts to sour. As the process continues, coolant looses its protective function and the opposite takes place, it becomes corrosive, and in time becomes very corrosive. This occurs while still maintaining its colour along with both anti-boil and anti-freeze functions.

As anti-corrosion properties decrease, metal particles flack from internal surfaces and become suspended in the coolant, finally settling in depressions around the engine. The accumulation of these particles severely restricts engine cooling at that location, creating extreme localised overheating known as hot-spots.
Also, once the anti-corrosion function starts to fall, ethylene glycol the primary chemical in coolant begins to separate from the carrier fluid and form a substance know as glycol-gel or coolant film. Along with other contaminants this film sticks to and coats parts of the interior surfaces of the engine greatly restricting heat from passing through to be cooled.

Coolants are conditioned with Supplementary Coolant Additives (SCA's) that become depleted over time, adding to contamination.
Contamination is also found in the form of core sand from manufacturing and casting engine components such as the block along with metal fragments of swafe, milling debris and solder.

Cooling system contamination is common and in any form can lead to premature engine wear, altered critical clearances, damaged engine components, metal fatigue, metal cracks, damaged oil viscosity, gasket failure and catastrophic engine failure.
These failures are preventable by keeping the cooling system in pristine condition.
This is achieved by a regularly power-flush and purge of the entire internal cooling system including the cylinder head, block, radiator and heater cores and reinstating with new coolant every two years, or annually in extreme conditions.
Flushing the cooling system is a requirement of engine manufactures as part of the maintenance plan.

Engine malfunction and failure caused by cooling system contamination:

(1) Sticking and burnt valves. Metallic and non metallic particles and contaminants carried in coolant accumulate in depressions in the cylinder head around and near valve guides, restricting the cooling process, damaging oil viscosity lubricating the value stems. As oil looses viscosity and its lubricating function, valves stick in the guides leading poor performance and burnt valves.

(2) Blown head gaskets and cracked cylinder heads. Metallic and non metallic particles settle in depressions in the cylinder head, even the smallest accumulation will severely restrict heat from dissipating into the coolant to be cooled causing the head gasket to blow, and or cause the cylinder head to crack in that location.

(3) Worn piston rings, scouring of the cylinder bore/liners.
Intense combustion heat is generated in the cylinder chamber and passes through into the coolant to be cooled. Glycol-gel, scale and other coolant film sticks to the coolant side of the liners, usually in one location, greatly restricting heat transfer and in turn seriously damaging oil viscosity causing the loss of lubrication. Having lost lubrication, the piston rings and bore/liners are reduced to metal on metal friction, severely damaging both. Resulting damage varies from loss of compression, scouring of the bore/liners, burning of oil, broken rings to cracked pistons and con-rods. Bearings and the crank-shaft will also receive damage.
As heat does not transfer evenly and consistently through the bore/liner due to the contamination forming in one location, the bore/liner becomes oval leading to major failure.

(4) Engine Detuning.
Computer sensors located in the cooling system become contaminated and coated with gel/film sending wrong information to the computer causing a de-tuning of the engine, leading to poor performance, higher fuel consumption and excessive and toxic exhaust emissions.

(5) Water-pump wear.
Metal particles and abrasive contaminants circulating in the coolant wear the leading edge off water-pump impellers. The smallest amount greatly reduces water-pump efficiency leading to general engine overheating.

(6) Leaking seals.
Coolant contamination leads to leaking engine seals including water-pump and cylinder liner seals.

(7) Cavitation and pitting of cylinder liners.
Contaminated coolant and depleted SCA's (Supplemental Coolant Additives) allow tiny volatile air bubbles to form on the cylinder liner walls, leading to cavitation and pitting, allowing coolant to seep into the combustion chamber causing pistons to hydraulic, ending in serious damage and engine failure.

Prevention of these conditions and failures is only achieved by keeping the cooling system in pristine condition.

For today's engines, the current methods of cooling system service are not sufficient, such as:

(a) Drain and refill.
This method does not remove contamination particles and gel/film. It also leaves several pints/litres of spent coolant in the block contaminating the new coolant being added. (This is similar to adding fresh milk to a small amount of sour milk in a container, in a short time it all turns sour).
Residual coolant of a different type can start a chemical reaction with the new coolant being added, leading to engine damage.

(b) Drain, fill with water, run engine, drain and refill with new coolant.
While this method, when repeated several times may remove all spent coolant and the contaminants suspended within it, this method will not remove other contaminants such as accumulated and settled particles or coolant gel/film that create the engine hot-spots.

(c) Hose flush.
This brings the same results as method (b).

(d) Chemical flush.
The use of chemical flushing agents can cause leaks in the cooling system. The modern engine is manufactured from a wide variety of metals, alloys and materials that react differently to chemicals, a sealant then has to be used to remedy leaks caused by the chemicals. Any residual chemicals will react with the new coolant compromising its effectiveness.
If used, it is imperative that all chemical flushing agents but thoroughly power- flush out.

To achieve a reduction in emissions and greater fuel efficiency, today's engines are required to operate at much higher temperatures than in the past. There is little tolerance for the operating temperature to rise as they are now near maximum. Coolant contamination causes a rise in operating temperatures and must be prevented at all cost.

Cooling systems must be power-flushed and purged and reinstated with new coolant to reduce and eliminate the unscheduled down-time, malfunction and catastrophic failure covered in this article. Engine manufactures require cooling systems to be flushed. Power flushing is best practise.

The FL100 PulseFlush Machine incorporating Advanced Pulsating Hydro-pneumatics is leading technology in cooling system power flush servicing, bringing a high level of reliability, performance and longevity to engines of all types.

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