TECHNICAL BULLETIN

Aluminium Components in Diesel Engine Cooling Systems

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The most common metal used in engine cooling systems is aluminium. Heavy duty diesel engine manufacturers use aluminium components in cooling systems to reduce weight. Aluminium as a metal in this application shows characteristics that concern system health and maintenance.

A drawback to using aluminium components is that the metal is sensitive to chemical reactions, causing corrosion. Another characteristic of aluminium is that it is a softer metal and extremely conductive. Because of this, aluminium components are also prone to failure due to erosion and electrolysis. Since today's engine cooling systems are made up of dissimilar metals, this can be a challenge in maintaining cooling systems. Couplings made of copper and aluminium can be difficult areas in preventing system component failures.

Under some circumstances, corrosion can start to attack aluminium cooling system components within 250,000 miles (400,000 kilometers) or 2,000 hours of engine life. Metallic corrosion particles subsequently circulate in the cooling system, causing erosion damage to other parts and plugged passage ways.

Aluminium cooling system components can be corroded by some types of antifreeze, therefore antifreeze engineered for aluminum components should be used when this metal is present.

Aluminium corrosion accelerates when the coolant pH reaches levels higher than 9.0. Though it is best to keep pH levels below 9.0, aluminium also reacts with acidic environments as well as high alkaline or basic fluids. Therefore the pH of the circulating coolant should be maintained in the alkaline range, but below 9.0 when aluminum is present.

Coolant inhibitor additives (dependent on the type) protect against corrosion by either creating a protective layer on metal parts (conventional), or by targeting corrosion and eliminating it (ELC.) Coolant formulations that contain nitrite corrosion inhibitors (SCA's) are not recommended in systems that have aluminum brazed heat exchangers and other aluminum parts. Nitrite and aluminium cause a chemical reaction that creates ammonia and hydrated aluminum oxide (bayerite.) Excessive nitrites in the system over extended periods will cause excessive corrosion of aluminum components. The ammonia in turn will cause the pH to rise.

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When corrosion occurs on aluminum components, metal oxide particle are generated and enter into the coolant. This in turns causes erosion of components. Water pump housings made of aluminium can be particularly susceptible to this.

Metal oxide particles in a cooling system are effectively removed by proper flushing procedures. Reverse flushing is the most effective technique, removing most of the particulate debris that causes erosion and reducing coolant passageways when the concentrations build up. With aluminium components, it is particularly important to avoid using coolant flush chemicals that are acidic.

Electrolysis causes metal corrosion due to stray electrical currents. Since aluminium is conductive it is susceptible to electrolysis. Coolant will conduct electricity and stray voltage will travel through the coolant to find a ground. As aluminium is a soft metal it is also more susceptible to the damage caused by electrolysis corrosion. Dissimilar metals used in engine cooling systems can contribute to the occurrence of electrolysis. Electrolysis in an engine cooling system can also reach other aluminum engine parts that have contact with the coolant.

Another type of electrolysis is chemical electrolysis. Cooling systems that possess dissimilar metals (which is most) in an acidic environment due to chemical imbalances can create their own electrical current within a cooling system, resulting in the occurrence of electrolysis.

A magnesium sacrificial anode is often used to combat electrolysis. The anode is designed to attract and absorb the electrical energy that causes electrolysis. Proper grounding of cooling system components will help reduce the occurrence of electrolysis. Improper grounding provides a pathway for stray voltage to enter back into a cooling system. Also, not using distilled or purified water increases the potential for corrosion and electrolysis of aluminium cooling system components.

To ensure optimal engine cooling system reliability and performance regular testing of your fluid is recommended, just as you would do for your in-service lubricants.

ALS can provide analysis services to monitor coolant service life, additives, contaminants, and corrosion and erosion of metal components.

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