

Cooling Systems

More than half of head gaskets we receive for evaluation that have failed in service, clearly show signs that can be directly attributed to poorly maintained cooling systems leading to engine overheating. The reasons for overheating are many and varied. Quite often however the condition and proper functioning of an engines cooling system is ignored.

It is the job of the cooling system to absorb, transport and dissipate the heat generated by the engines combustion process. In today's modern vehicles the cooling systems are smaller and are designed to operate at near maximum capacity. It is therefore essential that the cooling system is properly maintained to the manufacturers' specifications. Following a major engine repair or rebuild it is essential that the vehicles cooling system is thoroughly checked. Radiator tanks and cores, thermostats and thermo switches, fan belts and water pumps should all be inspected and if necessary replaced. The cooling system should be drained, thoroughly flushed and refilled with fresh coolant.

One of the basic principles of heat is that it will always flow from an area of higher temperature to an area of lower temperature. Corrosion and or contamination of the engines water jackets can adversely affect the transfer of heat from the engine to the coolant, severely reducing the cooling systems ability to operate efficiently and effectively. In basic terms corrosion is the deterioration of a solid by a chemical or an electrochemical process. Corrosion is assisted by moisture and oxidation. When we apply this to an automotive environment the solids are the engines metal components which are immersed in a chemical, the engines coolant. These metals are subjected to a number of different forms of corrosion; cavitation, chemical, crevice, galvanic, general and pitting corrosion are all common in automotive cooling systems. In the case of the more modern engines we must add to stray current corrosion.

Cavitation Corrosion

Cavitation corrosion is due to the sudden collapse of air bubbles against the walls of the casting. This exploding action of the air bubbles erodes the protective film formed by the coolant and eventually the oxide layer of the metal exposing the casting to corrosive action. Preventative maintenance can greatly reduce the occurrence of cavitation corrosion by maintaining the layer of protective film over the casting as well as suppressing the occurrence of foaming and the formation of air bubbles.

Chemical Corrosion

Chemical corrosion can be caused by mixing different types of coolant or having an incorrect amount of ethylene glycol in the cooling system. Chemical corrosion can also occur when the coolant has exceeded its service life and the protective properties of the corrosion inhibitors have been severely depleted. Again the best cure is prevention through proper maintenance of the cooling system.

Crevice Corrosion

Crevice corrosion can occur in areas where coolant flow is poor and small amounts of coolant can stagnate. Typically this type of corrosion can occur where radiator and heater hoses join clamping areas such as thermostat housings and water outlets. Hose clamps should be positioned as close as possible to the lip of the outlet or housing to prevent coolant from penetrating between the ID of the hose and the OD of the outlet.

Galvanic Corrosion

Galvanic corrosion or electrolysis occurs when two or more dissimilar metals are in contact with each other or immersed in a fluid capable of conducting a charge. For example if copper particles from the radiator, carried by the coolant, coat an aluminum housing a galvanic cell is formed as the two metals react chemically producing an electric charge. The aluminum becomes the sacrificial metal and the housing begins to corrode. Eventually the corrosion will completely perforate the aluminum housing.

General Corrosion

General corrosion will occur where cast iron is contact with both water and oxygen. A common result of general corrosion is rust and scale which can block radiator tanks and cores. Even a relatively thin layer of rust / scale can greatly reduce the transfer of heat from the components and into the coolant. A layer of rust only 1.5mm thick provides a thermal barrier equivalent to that of 100mm of cast iron.

Pitting Corrosion

Pitting corrosion is a very localized form of general corrosion which penetrates deeply into the metal component, eventually establishing a stress point in the component. Pitting corrosion is usually found on components such as cylinder sleeves.

Stray Current Corrosion

Stray current corrosion generally occurs in modern vehicles where, for vibration and noise control reasons, the radiator is insulated from the vehicle on rubber mountings. Introduce a bad electrical connection in a component such as a cooling fan or headlight and a condition exists for very aggressive electrolysis as the electrical current endeavors to find an earth path through the engine coolant. Older vehicles may also suffer from stray current corrosion, however the radiator in these vehicles is usually fixed directly to the bodywork providing an earth path for stray current that may get into the cooling system. Corrosion damage to components in and around the radiator of a vehicle operating a clean cooling system is usually a good indication of stray current.

Coolant

The function of an engines coolant is to absorb, transport and dissipate the heat generated by the combustion process from the engine to the radiator. For many years ethylene glycol has been the main ingredient in almost all automotive coolants. Mixed with water, ethylene glycol will lower the freezing point and raise the boiling point of the coolant. Too high a concentration of ethylene glycol however, reduces the coolants primary function of absorbing and transporting heat away from and out of the engines components and can also promote corrosion in the cooling system. Ethylene glycol also has a tracking property which can cause leak problems with hose connections, gaskets and welsh plugs on rebuilt engines. As a caution you should also be aware that ethylene glycol is a toxic substance which if ingested can be lethal.

As the coolant is in constant contact with metal, antifreeze also contains inhibitors that form a protective coating on the surfaces of the engines cooling system against rust and corrosion. These inhibitors create an alkaline coolant mixture that needs to neutralize the acids that are formed over time from degradation of the glycol. As the chemicals in coolant deteriorate, their protection against corrosion becomes greatly reduced. Once depleted the level of acidity within the coolant increases and corrosion within the cooling system accelerates.

More recently we have seen the emergence of Long Life Coolants using corrosion inhibitors called Organic Acid Technology (OAT). The main advantage of OAT coolants over more traditional coolants is an extended service life; up to five years or 240,000km. To distinguish OAT coolants from other coolants an orange dye is added. OAT coolants should not be mixed with any other type of coolant.

When adding antifreeze to a cooling system, a key point to consider is what is the coldest temperature that the vehicle is going to be exposed to when parked overnight or when in operation? Based on this information how much antifreeze is actually required for the protection of the vehicle?

Water Pump Performance

An engines water pump is the heart of its cooling system. Its primary function is to circulate coolant through the engine in sufficient volumes to maintain the correct operating temperature. In order for the cooling system to function correctly it is essential that the water pump is performing at optimum levels. Corrosion of a water pumps impellor, or incorrect impellor clearance will greatly reduce the water pumps performance. Water pumps should be tested for efficiency, pressure and cavitation.

Preventative Maintenance

As we can see from above, prevention is the best cure for a number of the problems that can occur within the cooling system. Following are some preventative maintenance measures that can be taken to extend the life of an engine:

- Use a good quality coolant. For newer vehicles use the coolant specified by the vehicles manufacturer. On older vehicles use a coolant that meets or exceeds the manufacturer's specifications.
- The entire cooling system should be flushed and the coolant replaced at the specified intervals even if the coolant looks to have maintained its color and is clean. The chemicals in coolant deteriorate over time and their protection against corrosion becomes greatly reduced.
- Never mix different makes or brands of coolant additives. The chemicals in one brand may not be compatible with those of another brand resulting in a chemical reaction which could damage your cooling system. If the coolant in the system is unknown drain, flush thoroughly and refill with fresh coolant.
- When adding new coolant to a system, or topping up the existing coolant always use a solution that is premixed to the correct concentration as specified by the coolant manufacturer. Do not exceed the recommended concentration as this may change the coolants properties. Premixing the coolant will eliminate the guess work in estimating the cooling systems capacity and ensures that the correct concentration level is maintained.
- When premixing coolant, rain water, dematerialized or distilled water is best. Ordinary tap water contains trace elements that can accelerate corrosion. Do not top up coolant level with plain water as this will dilute the coolant and reduce its protection level.
- When refilling a cooling system ensure that all air is purged from the system and that there are no air pockets are trapped within the vehicles cooling system.