

Module 6: Liquid-Cooling Systems

- TERMS AND DEFINITIONS
- INTRODUCTION TO LIQUID-COOLING
- LIQUID-COOLED ENGINE COMPONENTS
- COOLING SYSTEM COMPONENTS
- SYSTEM OPERATION
- EFFECTS OF INCORRECT TEMPERATURE REGULATION

Terms and Definitions

READY FOR REVIEW

- Antifreeze is material added to coolant to prevent freezing.
- Bypass is the design that routes coolant around the closest thermostat and directly back to the water pump inlet.
- Cavitation erosion is pitting caused by vapor bubbles.
- Coolant is an antifreeze/water mixture circulating in the engine cooling system.
- The de-aeration circuit (vent line) connects the thermostat housing or water manifold to the surge tank and prevents cavitation by allowing bubbles and small amounts of trapped air to escape.
- Dropout is the sludge or deposits that form in or on the cooling system components and is caused by excessive amounts of chemicals in the engine coolant.
- Ethylene glycol is a chemical compound that is commonly used as antifreeze.
- The fill line connects the water pump to the upper radiator tank and prevents cavitation by maintaining positive pressure inside the pump.
- The inhibitor is a chemical additive in antifreeze that prevents rust and pitting.
- Manual bleeds can be opened during a system fill to allow trapped air to escape.
- Permanent antifreeze is the liquid solution that contains properties that will not readily boil away.
- Note: Permanent does not mean the solution never has to be tested or replaced.
- The water jacket is the part of the casting that surrounds the cylinder head and engine block and contains the coolant as it passes over the cylinder liners and combustion chamber.
- The water manifold is the tube connecting different parts of the water jacket.

Introduction to Liquid-Cooling

READY FOR REVIEW

- Basic cooling process (thermo-siphon)
 - Coolant is stored in the radiator and in the engine.
 - The engine heats up and natural circulation starts.
 - Coolant rises through the engine block by convection.
 - Coolant passes through the top hose into the radiator.
 - Inside the radiator, heat is removed from the coolant that falls from top to bottom.
 - Reaching the bottom, the coolant returns to the engine through the lower radiator hose.
 - This process is called thermo-siphon.
- More powerful engines and a change in radiator design
 - The thermo-siphon process is common in older cars with low-powered engines and high, narrow radiators.
 - Modern vehicles have more powerful engines, and low and wide radiators.
- The thermo-siphon process could not move coolant quickly enough.
- Modern cooling process
 - The water pump forces the coolant through passages (water jackets) in the engine block.
 - Collects heat by conduction and becomes hot itself
 - Heated coolant returns to the radiator for cooling.
- Cycle repeated
 - Heat is removed from the engine and dispersed to prevent overheating.
 - Most engine wear and pollution occurs during the warm-up period.
- Functions of the cooling system
 - Prevents the engine from overheating
 - Helps the engine reach the best operating temperature as soon as possible
 - Every engine has the best operating temperature.
 - Below this temperature, ignition and combustion are difficult.

- Functions of the thermostat
 - Shortens the warming-up period
 - Operates according to the closed coolant thermostat.
- Cooling process
 - When the cold engine starts, coolant circulates within the engine block and cylinder head.
 - Passes through the coolant bypass to the water pump inlet
 - Cannot get to the radiator
 - As the engine warms up, coolant trapped in the engine gets hotter and hotter.
 - Starts to open the thermostat
 - Allows hot coolant to flow to the radiator

Liquid-Cooled Engine Components

READY FOR REVIEW

- De-aeration tank
- Thermostat
- Bypass passage
- Cylinder sleeves
- Distribution passage
- Oil cooler
- Water pump

Cooling System Components

READY FOR REVIEW

- The radiator is the heat exchanger that absorbs heat from the engine coolant and transfers it to the atmosphere.
- The expansion tank is a separate tank that collects and holds the expanding coolant, and as the engine cools, the coolant is drawn back into the radiator.
- The radiator pressure cap allows the cooling system to operate under pressure and raises the effective boiling point of the coolant and prevents coolant loss from boil over.
- Coolant is a mixture of antifreeze and water that absorbs engine heat.
- The fan forces the air through the radiator core to speed heat transfer.
- Fan belts transmit engine motion to drive the fan and water pump.
- The water pump circulates the coolant through the radiator and water jacket.
- The thermostat is a device that maintains a stable engine operating temperature by controlling coolant flow through the engine.
- Hoses are flexible connections between the engine and other parts of the cooling system.
- The coolant filter (optional) traps and collects impurities, sand, and scale, and sometimes contains a water conditioner cartridge to soften the water in the cooling system.

System Operation

READY FOR REVIEW

- The water pump circulates the coolant.
 - The water pump circulates the coolant from the radiator to the water jacket.
 - The water jacket surrounds the engine block and heads.
- Engine heat passes into the water jacket.
 - Engine heat passes through the cylinder walls into the water jacket.
 - Heat is absorbed by the moving coolant.
- Coolant is routed through the oil cooler.
 - Coolant is also routed through the oil cooler.
 - On some engines, the coolant is routed through the air charge after the cooler.
- Heated coolant flows into the radiator.
 - Heated coolant flows past the thermostat and into the radiator.
- The radiator routes the coolant.
 - In the radiator, the coolant is routed through wide, thin tubes.
 - Heat from the coolant is absorbed by metal tubes.
- The radiator fan removes the heat.
 - Forced air from the radiator fan removes heat from the tubes.
 - Directs the heat to the atmosphere
- The thermostat routes the coolant.
 - During engine warm-up:
 - The thermostat routes the coolant through the bypass loop and back to the engine.
 - The coolant “bypasses” the radiator.
 - The engine operating temperature is quickly achieved.

Effects of Incorrect Temperature Regulation

READY FOR REVIEW

- The temperature is too hot.
 - If the temperature is too hot, the lubricating film on moving parts becomes too thin to coat and protect.
- Effects
 - Insufficient clearance between moving parts
 - Accelerated wear on the bearing surface
 - Scoring and seizure of pistons, rings, and valve stems
 - Power loss
- The temperature is too cold.
 - If the temperature is too cold, there is poor oil flow and poor fuel atomization.
- Effects
 - Accelerated wear on the bearing surfaces and cylinder walls
 - Oil contamination
 - Sludge build-up in the crankcase
 - Poor fuel economy
 - Power loss