Module 4: Cooling Systems

Terms and Definitions

Antifreeze is a material added to coolant to prevent freezing.

Bypass is a 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 the antifreeze/water mixture circulating in the engine cooling system.

Deaeration 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 sludge or deposits that form in or on 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 an antifreeze.

Fill line connects the water pump to the upper radiator tank and prevents cavitation by maintaining positive pressure inside the pump.

Inhibitor is a chemical additive in antifreeze that prevents rust and pitting.

Manual bleeds can be opened during system fill to allow trapped air to escape.

Permanent antifreeze is 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.

Water jacket is 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.

Water manifold is a tube connecting different parts of the water jacket.

Common Types of Cooling Systems

Air

• A fan provides a steady supply of ambient temperature air for engine cooling.
• A shroud is a sheet metal cover that contains and guides the cooling air around the engine cylinders and cylinder head(s).
• Cooling fins absorb combustion and friction heat from the engine cylinders and cylinder head(s) and dissipate it into the airstream.
• A thermostat controls the amount of air flowing from the fan and speeds engine warm-up and maintains a safe operating temperature.

Liquid

• A radiator is a heat exchanger that absorbs heat from the engine coolant and transfers it to the atmosphere.
• An 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.
• A 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.
• A fan forces air through the radiator core to speed heat transfer.
• Fan belts transmit engine motion to drive the fan and water pump.
• A water pump circulates coolant through the radiator and water jacket.
• A thermostat is a device that maintains 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.

A 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.

Operation of Air-Cooled Engines
READY FOR REVIEW

- Ambient temperature air is drawn in by the cooling fan and forced through the sheet metal shrouding.
- The shrouds direct the air over the finned surfaces of the cylinders and cylinder heads, collecting heat.
- The heated air is expelled into the atmosphere.
- During engine warm-up, cooling air is either restricted or rerouted until engine operating temperature is reached.

Operation of Liquid-Cooled Engines
READY FOR REVIEW

- The water pump circulates coolant from the radiator to the water jacket surrounding the engine block and heads.
- Engine heat passes through the cylinder walls into the water jacket, where it is absorbed by the moving coolant.
- Coolant is also routed through the oil cooler (and on some engines the air charge after cooler).
- The heated coolant then flows past the thermostat and into the radiator.
- In the radiator, the coolant is routed through wide, thin tubes, and the heat from the coolant is absorbed by the metal tubes.
- Forced air from the radiator fan removes the heat from the tubes and directs it to the atmosphere.
- During engine warm-up, the thermostat routes the coolant through a bypass loop and back to the engine, and because the coolant “bypasses” the radiator, engine operating temperature is quickly achieved.

Effects of Incorrect Temperature Regulation
READY FOR REVIEW

- Too hot
  - A lubricating film on the moving parts becomes too thin to coat and protect the engine properly.
  - Insufficient clearance between moving parts
  - Accelerated wear on the bearing surface
  - Scoring and seizure of pistons, rings, and valve stems
  - Power loss

- Too cold
  - Poor oil flow and poor fuel atomization
  - Accelerated wear on bearing surfaces and cylinder walls
  - Oil contamination
  - Sludge build-up in the crankcase
  - Poor fuel economy
  - Power loss

Common Types of Radiators
READY FOR REVIEW

- Down-flow
- Cross-flow
- Low-flow coolant (double bypass)

Types of Drives for Water Pumps
READY FOR REVIEW

- A belt is usually mounted at the front of the engine.
- A gear is driven off the gear train and may face the front or rear of the engine.
Types of Drive Belts

**READY FOR REVIEW**

- **V-belt**
  - V-shaped belt with a load applied to both angled smooth surfaces
  - Commonly used in combination, matched sets, or pairs
  - Commonly available ⅜ inch to ½ inch wide

- **Poly V (serpentine)**
  - Flat belt with a serpentine ridged surface on one side that receives the load, and a smooth surface on the other side that receives no load
  - One belt is commonly used to drive most or all accessories.
  - Commonly available 1 inch to 1 ½ inches wide

Functions of Coolant Filters, Conditioners, and Additives

**READY FOR REVIEW**

- **Coolant filters**
  - Traps and holds sand, scale, and rust particles
  - Maintains system purity by eliminating contaminants from added coolant.

- **Coolant conditioners**
  - Softens the water to minimize scale build-up
  - Contains rust inhibitors that provide a protective film around metal surfaces in the cooling system
  - Contains seal conditioners and pump lubricants
  - Prevents cavitation and erosion

- **Coolant additives**
  - Prevents corrosion and the formation of deposits
  - Minimizes cavitation
  - Provides protection for cooling system components

Types of Antifreeze

**READY FOR REVIEW**

- **Inhibited ethylene glycol (IEG)**
  - Typically combined with distilled/deionized water in a 50/50 mix
  - The boiling point is raised to 263°F.
  - The freezing point is lowered to –34°F.
  - Highly toxic to plants, animals, and people

- **Inhibited propylene glycol (IPG)**
  - Typically combined with distilled/deionized water in a 50/50 mix
  - The boiling point is raised to 257°F.
  - The freezing point is lowered to –27°F.
  - Thermal efficiency is similar to IEG (slightly less).
  - Considered “environmentally friendly” because it is less toxic to plants, animals, and people; sour smell and taste discourage accidental ingestion

Characteristics of a Suitable Antifreeze

**READY FOR REVIEW**

- Prevents the coolant mixture from freezing
- Raises the boiling point
- Absorbs and conducts heat readily
- Is chemically stable
- Inhibits rust and corrosion
- Resists foaming

Purposes of a Radiator Cap

**READY FOR REVIEW**

- **Seals the radiator**
  - Prevents entry of air, which causes corrosion
  - Prolongs the useful life of antifreeze and cooling system additives

- **Positive pressure**
  - It raises the effective boiling point of the coolant.
  - It minimizes coolant loss.
  - It minimizes cavitation erosion.

- **Maintains pressure**
  - Prevents damage to the radiator core and hoses
  - Maintains a consistent boiling point for coolant

- **Overflow**
  - Maintenance of the correct coolant level in the radiator
  - Elimination of air pockets
Typical Radiator Cap Operation

READY FOR REVIEW

- Cooling system at atmospheric pressure
  - The vacuum valve is closed.
  - The pressure relief valve is closed.

- Cooling system operating at high load/high heat
  - The vacuum valve is closed.
  - The pressure relief valve opens when the system pressure exceeds the cap rating, and coolant is released into the expansion tank.

- System cool down
  - The vacuum valve opens allowing coolant to return from the expansion tank.
  - The pressure relief valve is closed.