Module 4: Cooling Systems

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Terms and Definitions

READY FOR REVIEW

- 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

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- 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

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- 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

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- 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

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- 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

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

Types of Drives for Water Pumps

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- 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

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- 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

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- 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

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- 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

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- 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

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- 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

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- 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.