Module 7: Cooling System Components

Basic Cooling System Components

- **Radiator location**
  - Convenient position under the hood of the vehicle
  - Actual location under the hood depends on:
    - Engine configuration
    - Available space
    - Shape or line of the hood

- **Radiator components**
  - Top and bottom tanks
  - Core

- **Radiator core**
  - Allows coolant to pass through it
  - Either vertical down or horizontal cross flow direction
  - Serves as a good conductor of heat away from the engine

- **Header tank (reservoir)**
  - Can be mounted separately from the radiator
  - Has a supply of coolant
  - Located higher than the top of the radiator
  - Usually made of hardened plastic
  - Allows a visual check of fluid level through the plastic

- **Radiator cap**
  - Fitted on some tanks
  - Used to increase the coolant’s boiling point
  - Can be located directly on top of the radiator or on the header (surge) tank

- **Thermostat**
  - Located under the thermostat housing
  - The engine running at an operating temperature allows the circulation of coolant to flow from the engine to the radiator.
  - A cold engine is closed to allow the engine to warm up more rapidly.

- **Thermostat housing**
  - Normally located on the outlet side of the coolant flow from the engine
  - The majority used today are made from aluminum alloy.
  - Will corrode away instead of the engine or cylinder head

- **Known as the sacrificial component**

- **Water pump**
  - Normally bolted to the front of the engine block
  - The bottom radiator hose comes from the radiator.
  - Connected to the water pump inlet
  - Driven by the engine via a fan or drive belt

- **Water pump and coolant**
  - Coolant leaves the outlet of the radiator where much of the heat is removed.
  - Water pump impellers force the coolant through water jackets.

- **Cooling fan location**
  - Either on the water pump shaft or attached directly to the engine crankshaft
  - In most cases, there requires some engine power to drive the fan.

- **Cooling fan blades**
  - Made of steel or plastic
  - Draw cooling air through the radiator core
  - Lowers the temperature of the coolant

- **Radiator hoses**
  - Most vehicles have two radiator hoses:
    - The top hose is attached to the thermostat housing and allows heated coolant to enter the top or inlet side of the radiator.
    - The bottom (lower) hose is connected between the outlet of the radiator and the inlet of the water pump.

- **Radiator hose and by-pass hose clamps**
  - Radiator hoses and by-pass hoses are held in position by clamps.
  - Attached to the engine block or radiator assembly
  - Types are:
    - Spring clamps
    - Wire wound clamps
    - Worm drive clamps

- **Heater hoses**
  - Normally preshaped for a particular make and model of vehicle
- The construction is same as a radiator hose with reinforcing material embedded.

**Coolant flow**
- Hot coolant comes in through the hose attached to the thermostat circuit.
- Sheds some heat into the vehicle
- Cools down
- Returns to the engine via the water pump inlet

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## Radiators

### Why many radiators are mounted at the front of the vehicle:
- In the path of the greatest airflow
- Air carries the heat away.
- Liquid cools before returning to absorb more heat from the engine.

### Space considerations and header tank
- Where the radiator is mounted depends on space and how the engine is mounted.
  - Header tank
    - Can be mounted away from the radiator
    - Provides a coolant supply stored above the engine
    - Made of sheet metal or hardened plastic

### Materials used for the tank and core
- The radiator has two tanks and a core.
- Materials used:
  - Must be good heat conductors like brass or copper
  - Brass and copper are often used for tanks.
  - Combined with copper core
- Modern vehicles
  - Often use plastic tanks
  - Combined with aluminum core
  - Saves weight
  - Still provides good heat transfer

### Radiator core tubing
- A number of tubes in the core carry coolant between the two tanks.
- Tube patterns
  - Vertical down-flow
  - Horizontal cross-flow
  - The cross-flow radiator is easier to fit under the steeply-sloped hood.

### Core fins
- Small, thin, cooling fins are in the core.
- In contact with tubes
- The shape of the fins increases the surface area exposed to the air.

### Removal of coolant heat
- Where heat removal from coolant takes place
  - Coolant touches the tube walls.
  - The tubes touch the fins.
- How heat is removed
  - First, by conduction
  - Then, by radiation and convection at the surface of the fins
  - Air rushing by carries heat away.

### Coolant flow to the engine
- Liquid emerges cooler at the bottom of the radiator.
- Travels through the lower radiator hose to the water pump inlet
- Flows through the engine again

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### Common Types of Radiators

- Down-flow radiator
- Cross-flow radiator
- Low-flow coolant (double bypass) radiator
Coolant Hoses

- **Function of coolant hoses**
  - Coolant hoses transfer coolant throughout the cooling system.
  - Heater coolant hoses carry coolant to the heating system usually located inside the vehicle cabin.

- **Mounting and flexible hoses**
  - Most engines are mounted on flexible mountings.
  - Reduces noise and vibration
  - The radiator is mounted to the vehicle body, so flexible hoses are needed.

- **Diameter of the hoses**
  - Vary in diameter depending on the volume of coolant passing through
  - Heater hoses carry a smaller volume.

- **Composition**
  - Most are made of rubber.
  - Subject to pressure, so reinforced with a layer of fabric

- **Shape**
  - Molded to a special shape to suit the model and make of the vehicle
  - Some heater coolant hoses have special shapes.

- **Hot coolant and high pressures**
  - All hoses are subject to hot coolant and high under-hood temperatures.
  - Can deteriorate and fail

Water Pumps

- **Location and layout of water pumps**
  - Usually located in front of the cylinder block
  - Belt-driven from the pulley on the front of the crankshaft
  - Connected by a hose to the bottom of the radiator where cooler liquid emerges

- **How it works**
  - The water pump has fan-like blades on the rotor or impeller.
  - Coolant enters the center of the pump.
  - The rotor spins.
  - Centrifugal force moves the liquid outward.
  - Coolant is driven through the outlet into cooling passages called water jackets.

- **Water jackets are passages in the engine block and cylinder head that surround cylinders, valves, and ports.**

- **Water jackets can direct coolant to hot spots to stop local overheating. Example: exhaust ports in the cylinder head**

Centrifugal Force

- **Centrifugal force is the force that pulls outward on a rotating body.**

- **Centrifugal force applied to a vehicle**
  - A vehicle turning a curve is a rotating body.
  - Subject to centrifugal force that resists turning
  - Tries to keep the vehicle moving in a straight line
  - Also, centrifugal force causes the out-of-balance wheel to vibrate.

- **Centrifugal force and the water pump**
  - Can be a useful force
  - When coolant enters, the center of the water pump and rotor spins.
  - Centrifugal force moves the liquid outward.

Types of Drives for Water Pumps

- **Water pumps have two types of drives.**
  - The belt drive is usually mounted at the front of the engine.

- **The gear drive is driven off the gear train and it may face the front or the rear of the engine.**
Types of Drive Belts

V-belt
- V-shaped
- The load is applied to both angled smooth surfaces.
- Typically used in:
  - Combination
  - Matched sets
  - Pairs
  - Commonly available as $\frac{3}{8}$ in. (9.5 mm) to $\frac{1}{2}$ in. (12.7 mm) wide

Poly V (serpentine)
- A flat belt with different surfaces on each side
- The side with the serpentine-ridged surface receives the load.
- The smooth-surface side receives no load.
- One belt is typically used to drive most or all the accessories.
- Commonly available as 1 in. (25.4 mm) to $1\frac{1}{2}$ in. (38.1 mm) wide

Cooling System Thermostat

Thermostat function and location
- The thermostat helps the engine to warm up.
- Found in different positions on different engines

Valve operation
- The thermostat is a valve.
- Operates according to the coolant temperature
- When the coolant is cold, a spring holds the valve closed.

The cold engine starts.
- Coolant circulates within the engine block and cylinder head.
- Circulates through the coolant bypass to the water pump inlet
- Cannot get to the radiator

The engine warms up.
- Coolant in the engine gets hotter and hotter.
- The valve starts to open.
- Wax-like substance in the thermometer
- Expands as the engine nears an operating temperature
- Starts to open the valve
- Coolant starts to flow to the radiator

Trapped air is released.
- Thermostats have a small hole or valve.
- Lets out air trapped in the engine block

Heated coolant is pumped.
- Heated coolant is pumped from an outlet in the cylinder head.
- Goes into upper radiator hose, then to radiator.

Waste of energy and fuel
- At high speeds, there is plenty of air flowing through the radiator.
- A fan always working at full speed wastes energy.
- Since the engine drives the fan, it also wastes fuel.
- Need a way to control the fan

Cooling Fans

Extra airflow
- With the vehicle moving at high speed, the coolant is cooled by airflow through the radiator.
- At low speed or with the engine idling, the fan provides the extra airflow.

Electric fans
- The fans are driven different ways.
- More and more modern vehicles use electric fans.
- Air-conditioned vehicles often have extra fans.
- Electric fan mounting
  - Behind the radiator
  - In front
  - Both
  - Arrangement is difficult with a belt-driven fan
  - Some fans are driven from the crankshaft.

Longitudinally-mounted engine
- The fan is usually mounted on the water pump shaft.
- The drive belt turns the water pump and fan.

- Some use a hydraulic link from the power steering system.
Heat-sensitive switch
- In contact with the coolant
- Works like a thermostat
- Turns the fan on and off according to the coolant temperature

Viscous hub
- Another way to alter the speed of the fan uses a viscous hub.
- The fan slips when it is cold.
- As the engine heats up, it grips more and more.

Temperature Indicators

Overheating
- Can seriously damage the engine
- Useful to have as a warning of trouble

Temperature indicator
- The device is sensitive to the engine temperature.

- Sends readings to the temperature gauge or warning lamp
- An accurate reading depends on the sensor always being immersed in liquid.
- When measuring the coolant levels, it warns if the level is too low.

Radiator Pressure Cap

Problem with boiling coolant
- Boiling coolant is as serious for the engine as having it freeze.
- Boiling coolant in the water jacket becomes vapor.
- There is no liquid left in contact with the cylinder walls or head.
- Heat transfer by conduction stops.
- Heat builds up.
- Can cause serious damage

Damage prevention
- A radiator-pressure cap is one way to prevent boiling coolant.
- Uses pressure to change the temperature at which water boils

Rising coolant temperature
- Coolant expands.
- Pressure in the radiator rises.
- Lifts the boiling point of water

Rising engine temperature
- Coolant expands further.
- Pressure builds against a spring-loaded valve in the radiator cap.
- At a preset pressure, the valve opens.

As the engine cools, the coolant contracts and pressure in the radiator drops.

Vacuum vent valve
- Atmospheric pressure in the overflow container opens a second valve (vacuum vent valve).
- Overflow coolant flows back into the radiator.

Stopping low pressure
- The system stops low pressure from developing in the radiator.
- Stops atmospheric pressure from collapsing the radiator hoses

Four Purposes of a Radiator Cap

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

Allows the cooling system to operate under positive pressure
- Raises the effective boiling point of coolant
- Minimizes coolant loss
- Minimizes cavitation erosion

Maintains system pressure at a preset level with the use of a pressure relief valve
- Prevents damage to the radiator core and hoses
- Maintains a consistent boiling point for coolant

Allows overflow coolant to reenter the radiator during cool-down with the use of a vacuum valve
- Maintains the correct coolant level in the radiator
- Eliminates 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.
  - 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.

## Recovery System

### READY FOR REVIEW

- The recovery system maintains coolant in the system at all times.
- The engine temperature rises and pressure builds.
  - As the engine temperature rises, the coolant expands.
  - Pressure builds against the valve in the radiator cap.
- The valve opens and coolant flows to the overflow container.
  - At a preset pressure, the valve opens.
  - Hot coolant flows out into the overflow container.

- As the engine cools, the coolant contracts, and the pressure in the radiator drops.
- Overflow coolant flows back to the radiator.
  - Atmospheric pressure in the overflow container opens the second valve.
  - Overflow coolant flows back into the radiator.
- Acts to prevent corrosion
  - No coolant is lost.
  - Excess air is kept out of the system.
  - Air and water contains oxygen.
  - Oxygen reacts with metals to form corrosion.
  - The system acts to prevent corrosion.

## Thermo-Switch

### READY FOR REVIEW

- Preset temperature levels
  - The thermo-switch opens and closes according to preset temperature levels.
  - Some thermo-switches are mechanical and others are electrical.

- Designs
  - May switch off when the temperature rises above a certain level
  - May switch on when the temperature reaches a certain level

- Bimetallic strip principle for heat switches
  - Two different metals or alloys are attached back to back.
  - As they are heated and cooled, they expand and contract differently.

- Effect of heating
  - Different metals and alloys are joined and heated.
  - The faster expansion of one forces the whole strip into a curved shape.

- Completing a circuit
  - The strip changes shape.
  - Can be designed to complete a circuit
  - The resulting electrical signal can do a range of tasks or it might have a mechanical effect such as opening a passageway.

- Effect of cooling
  - Cooling produces the opposite effect.
  - Breaks the circuit and closes the passage