Chapter 14

Lubricating and Cooling Systems

The life of an engine largely depends on its lubricating and cooling systems. If an engine does not have a supply of oil or cannot rid itself of high temperatures, it will be quickly destroyed.

LUBRICATION SYSTEM

An engine's lubricating system does several important things. The main components of a typical lubricating system **(Figure 14–1)** are described here.

Engine Oil

Engine oil is specially formulated to lubricate and cool engine parts. The moving parts of an engine are fed a constant supply of oil. Engine oil is stored in the oil pan or sump.

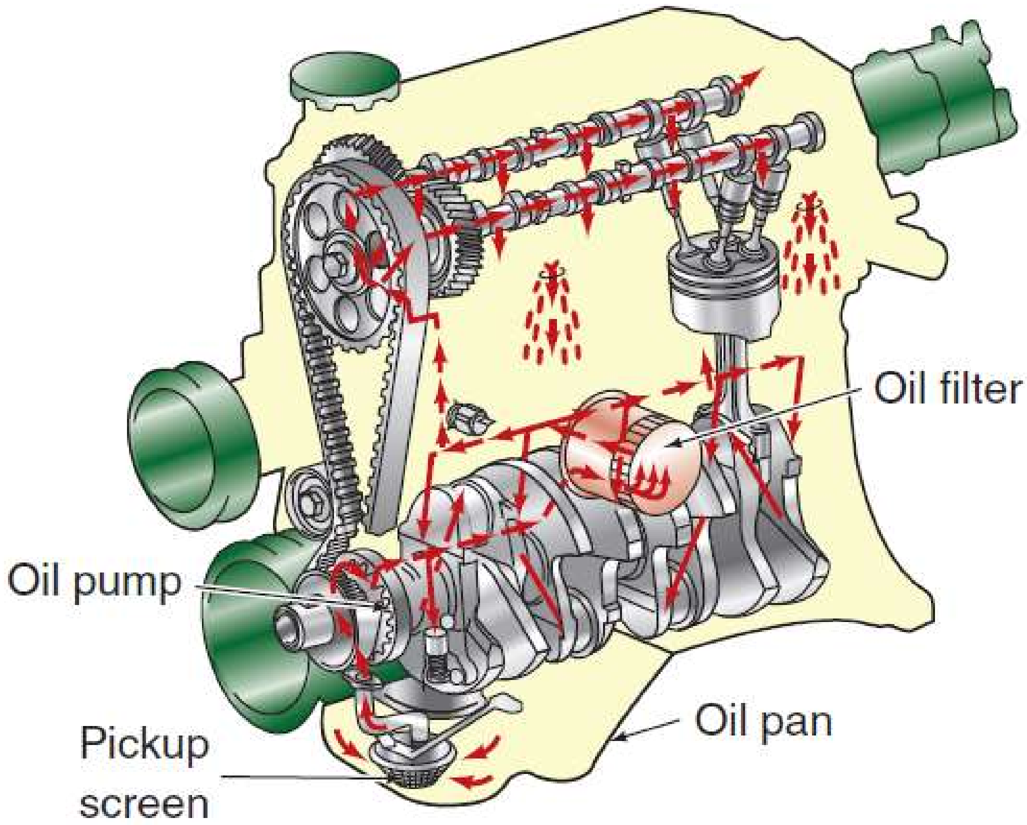


Figure 14–1 **The direction of oil flow through this engine.**

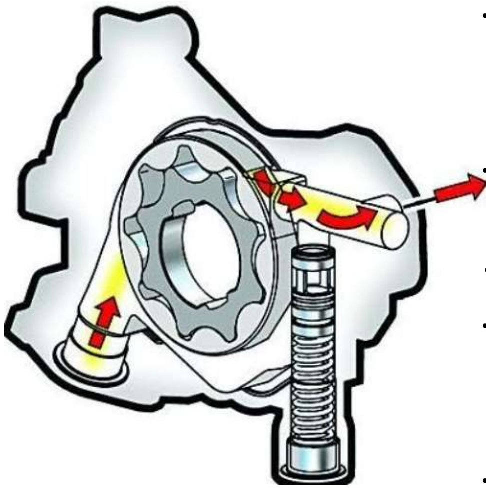
Oil Pump

The oil pump is the heart of the lubricating system. The oil pump pulls oil from the oil pan through a pickup tube.

The part of the tube that is in the oil pan has a filter screen, which is submerged in the oil.

The screen keeps large particles from entering the oil pump.

This screen should be cleaned any time the oil pan is removed. The pickup may also contain a bypass valve that allows oil to enter the pump if the screen becomes totally plugged.



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The oil pump may be located in the oil pan or mounted at the front of the engine

An oil pump does not create oil pressure; it merely moves oil from one place to another.

Oil pumps are positive displacement pumps; that is, the amount of oil that leaves the pump is the same amount that enters it

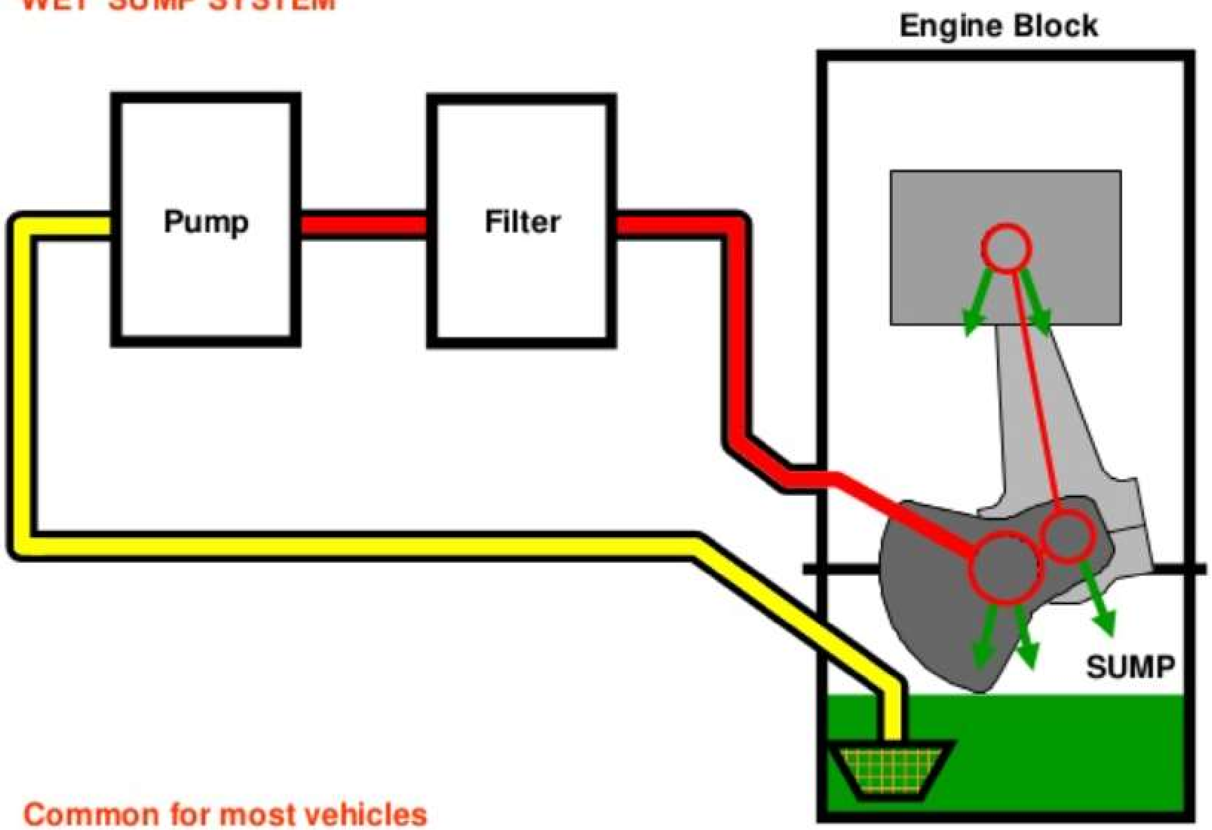
Oil Pan or Sump

The oil pan is mounted to the bottom of the engine block. It serves as the reservoir for the engine’s oil and is designed to hold a certain amount of oil.

The oil pan also helps to cool the oil through its contact with the outside air. Oil is drawn out by the oil pump. After the oil moves

through the engine’s lubrication circuits, it drains back into the pan. This is describes a **wet sump** oil system because the sump always has oil in it.

'WET' SUMP SYSTEM



Common for most vehicles

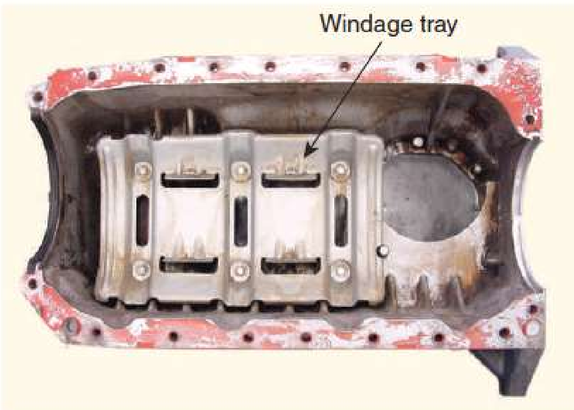


Figure 14-6 This oil pan was manufactured with a windage tray.

Pan Baffles

With a wet sump, oil can slosh around during hard cornering or braking.

During these times it is possible for the oil to move away from the oil pump's pickup.

This will cause a temporary halt in oil flow through the engine, which can destroy it.

To help prevent sloshing, many engines have baffles (windage

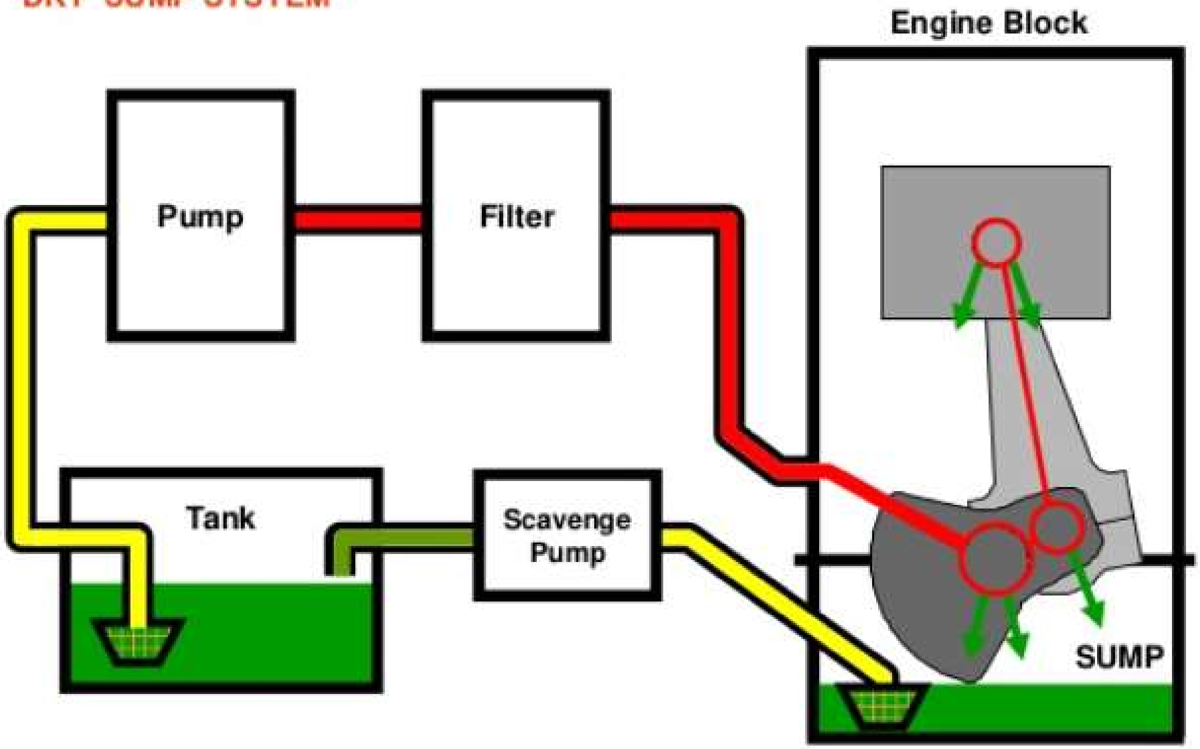
trays) in the oil pan to limit the movement of the oil

Dry Sump

To prevent oil sloshing, some OEM engines have a **dry sump** oil system, as do most race engines. In a dry sump system, the oil pan does not store oil.

A dry oil pan merely seals the bottom of the crankcase. The oil reservoir is a remote container set apart from the engine.

'DRY' SUMP SYSTEM



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Oil Filter

As the oil leaves the oil pump, it flows through an oil filter. The filter prevents the small particles of dirt and metal suspended in the oil from reaching the close-fitting engine parts.

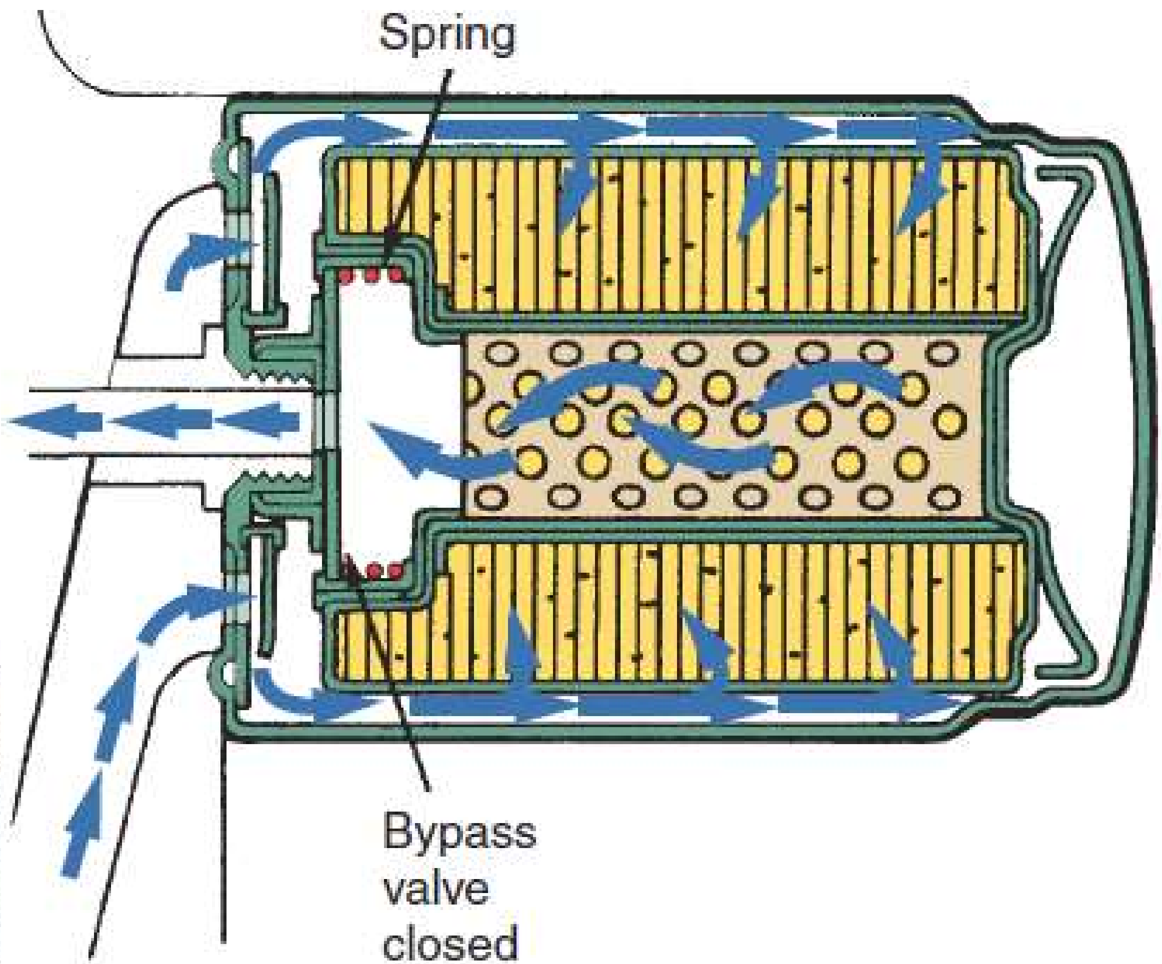
If the impurities are not filtered from the oil, the engine will wear prematurely and excessively.

Filtering also increases the usable life of the oil. The filter assembly threads directly onto the main oil gallery tube.

The oil from the pump enters the filter and passes through the element of the filter. From the element, the oil flows back into the engine's main oil gallery.

The oil filter is typically a disposable metal container filled with a special type of treated paper or other filter substance (cotton, felt, and the like)


FRAM
TOUGH GUARD



Ford Motor Company

Figure 14-11 Oil flow through the filter.

Engine Oil Passages or Galleries

From the filter, the oil flows into the engine's oil galleries. These galleries are interconnecting passages that were drilled into the block. The crankshaft also has oil passages (oilways) that route the oil from the main bearings to the connecting rod bearings. Engines with a remote oil filter, an oil cooler, or a dry sump system have external oil lines that move the oil to designated areas.

Dipstick

A dipstick is used to measure the level of oil in the oil pan. The end of the stick is marked to indicate where the oil level should be. Obviously, if the oil level is below that mark, oil needs to be added. Some late-model engines do not have a dipstick, instead, engine oil level is measured through the oil level sensor. The oil level is then displayed on the driver information center.

Oil Pressure Indicator

All vehicles have an oil pressure gauge and/or a low pressure indicator light. Oil gauges are either mechanically or electrically operated and display the actual oil pressure of the engine. The indicator light only warns the driver of low oil pressure.

In a mechanical gauge, oil travels up to the back of the gauge where a flexible, hollow tube, called a Bourdon tube, uncoils as the pressure increases. A needle attached to the Bourdon tube moves over a scale to indicate the oil pressure. Most pressure gauges are electrically controlled. An oil pressure sensor or sending unit is screwed into an oil gallery

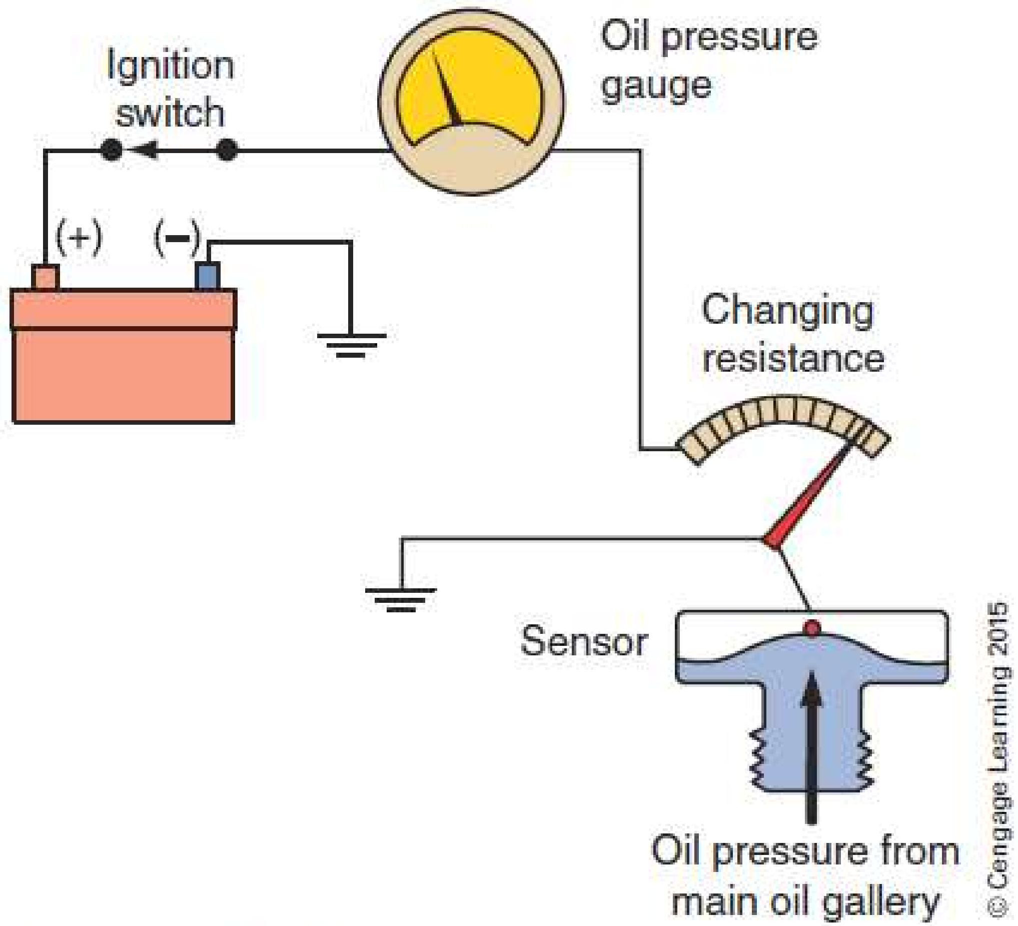


Figure 14-12 As oil pressure changes, the resistance in the oil pressure gauge circuit and the reading on the gauge change accordingly.

Sludge

A typical sign of poor maintenance is the buildup of yellow

sludge inside the engine.

Results from the oxidation of oil. When oil oxidizes, chemical compounds in the oil begin to break down and solidify,

forming a gel substance.

The gelled oil cannot circulate through the engine and collects on engine parts. This buildup of sludge can also block normal lubrication paths

Figure 14-22 Sludge buildup on the lower parts of an engine.

FLUSHING THE SYSTEM

Flushing the lubrication system periodically is recommended by some manufacturers. However, there are others that do not recommend flushing the engine.

Flushing involves running a solvent through the engine and then draining the system.

The ways to do this vary, as do the solvents used. The concern of those that do not recommend flushing is simply that the solvents may loosen up some dirt or sludge that will not drain out with the oil. These contaminants can block passages and restrict oil flow.

COOLING SYSTEMS

Today's engines create a tremendous amount of heat. Most of this heat is generated during combustion. Metal temperatures around the combustion chamber can run as high as 1 , 000 ° F (537.7 ° C) . This heat can destroy the engine and must be removed. This is the purpose of the engine's cooling system

The system must also allow the engine to quickly warm up to a desired operating temperature and keep it there regardless of operating conditions.

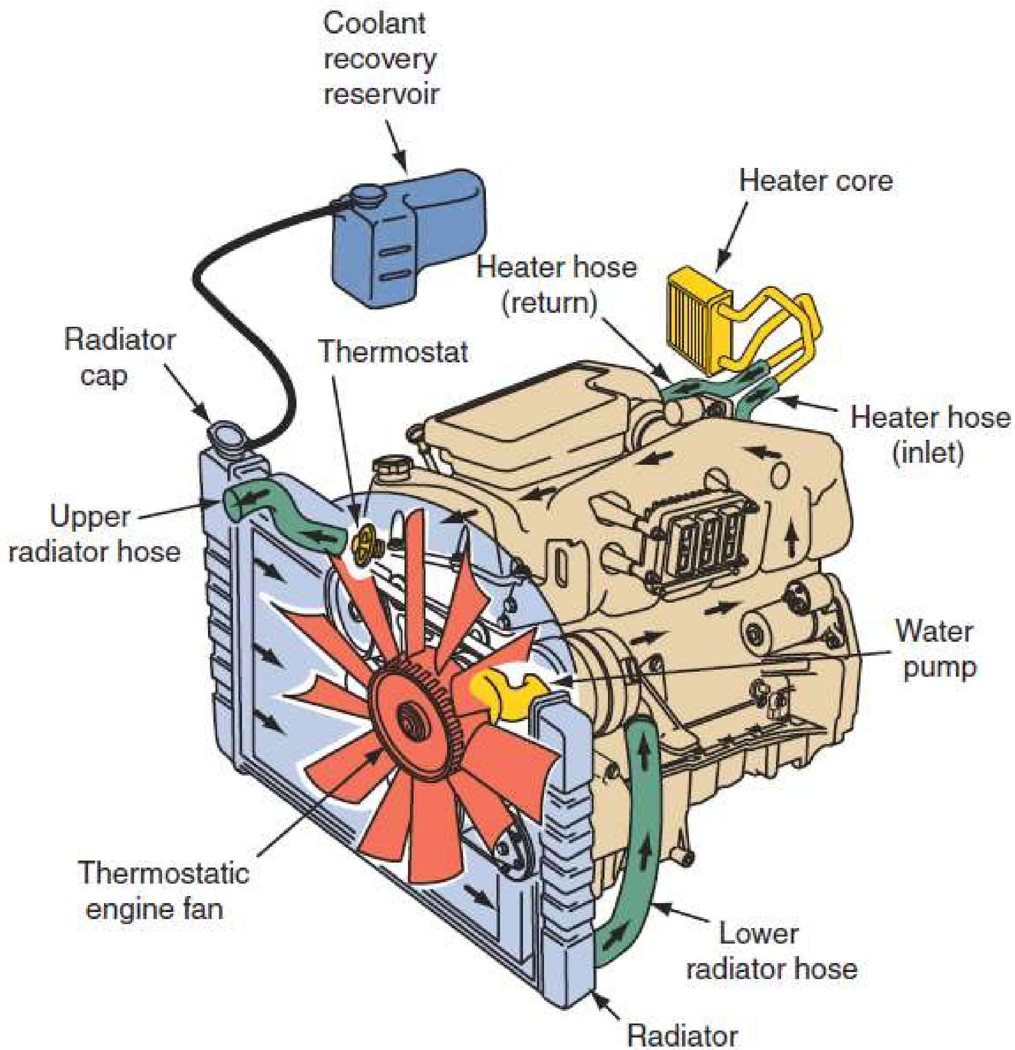


Figure 14-23 Major components of a liquid-cooling system. Arrows indicate the coolant flow.

Heat is removed by a heat-absorbing liquid (coolant) circulating inside the engine.

Coolant then flows to the radiator where its heat is transferred to the outside air.

A pump moves the coolant through the engine block and then through the cylinder head.

The coolant flows to the top of the radiator and loses heat as it flows down through the radiator.

Ram air and airflow from the cooling fan pass through the radiator to cool the coolant.

The cooled coolant leaves the radiator and enters the water pump and then is sent back through the engine.

Coolant

Engine coolant is a mixture of water and antifreeze/ coolant.

Engine coolant has a higher boiling temperature

and a lower freezing point than water.

The exact boiling or freezing temperatures depend on the mixture. The typical recommended mixture is a 50/ 50 solution of water and

antifreeze/coolant.

Thermostat

The **thermostat** controls the minimum operating temperature of the engine. The maximum operating temperature is controlled by the amount of heat produced by the engine and the cooling system's ability to dissipate the heat.

A thermostat is a temperature-responsive coolant flow control valve. It controls the temperature and amount of coolant entering the radiator.

While the engine is cold, the thermostat is closed , allowing coolant to only circulate in the engine. This allows the engine to uniformly warm up. When the coolant reaches a specified temperature, the thermostat opens and allows coolant to flow to the radiator. The hotter the coolant gets, the more the thermostat opens sending more coolant to the radiator. Once the coolant passes through

the radiator, it reenters the water pump. From there it is pushed through the engine and the cycle starts again.

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Figure 14-25 A typical thermostat located in the water outlet.

- **Water Pump**
- The heart of the cooling system is the water pump. Its job
- is to move the coolant through the system. Typically the
- water pump is driven by the crankshaft through pulleys
- and a drive belt **(Figure 14–26** and **Figure 14–27)** . On
- some engines the pump is driven by the camshaft, timing

Water Pump

The heart of the cooling system is the water pump. Its job is to move the coolant through the system. Typically the water pump is driven by the crankshaft through pulleys and a drive.

On some engines the pump is driven by the camshaft, timing belt or chain, or an electric motor. The pumps are centrifugal- type pumps with a rotating impeller to move the coolant. The shaft is mounted in the water pump housing and rotates on bearings.

The pump has a seal to keep the coolant from passing through it. The inlet of the pump connects to the lower radiator hose, and its outlet connects to the engine block.

Figure 14-26 A water pump bolted to the front of an engine.

Electric Water Pumps

Some engines have an electric water pump for the engine cooling system. The pump is driven by a brushless DC motor that is controlled by the ECM. The ECM regulates the amount of coolant circulating through the engine according to the operating conditions.

An electric water pump provides improved fuel efficiency, efficient cooling system operation, ideal flow rates at all times, improved heater performance, and decreased engine warm-up times. The operation of these pumps can be monitored with a scan tool.

Electric Water Pumps

Radiator

The radiator is a heat exchanger, transferring heat from the engine to the air passing through it. The radiator is a series of tubes and fins (collectively called the core) that expose the coolant’s heat to as much surface area as possible.

Attached to the sides or top and bottom of the core are plastic or aluminum tanks One tank holds hot coolant and the other holds the cooled coolant. Cores are normally comprised of flattened aluminum tubes surrounded by thin aluminum fins.

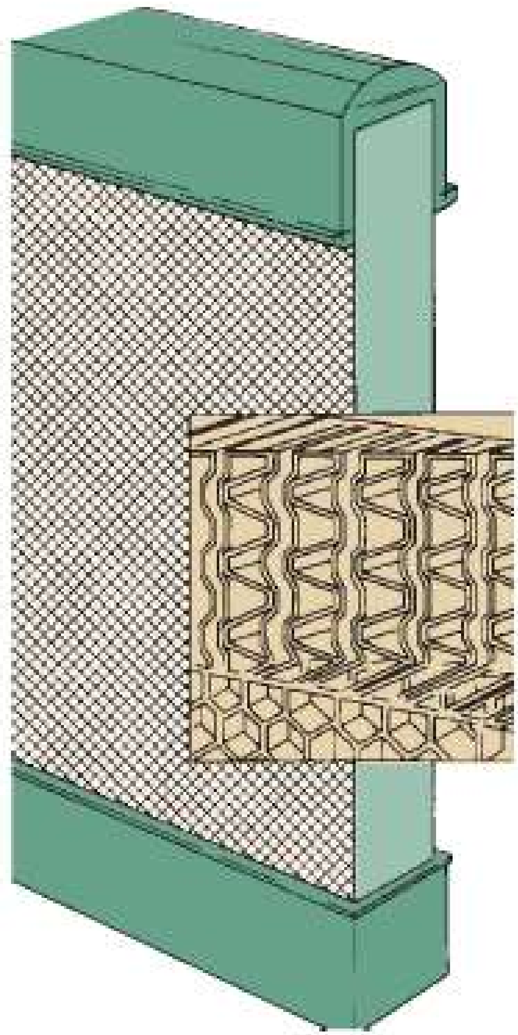

Figure 14-29 A radiator core is made of a series of tubes and fins that expose the coolant's heat to as much surface area as possible.

Transmission Cooler

Radiators used in vehicles with automatic transmissions have a sealed heat exchanger, or a form of radiator, located in the coolant outlet tank of the engine's radiator.

Metal or rubber hoses carry hot automatic transmission fluid to the oil cooler.

The coolant passing over the sealed oil cooler cools the fluid, which is then returned to the transmission. Cooling the transmission fluid is essential to the efficiency and durability of an automatic transmission.

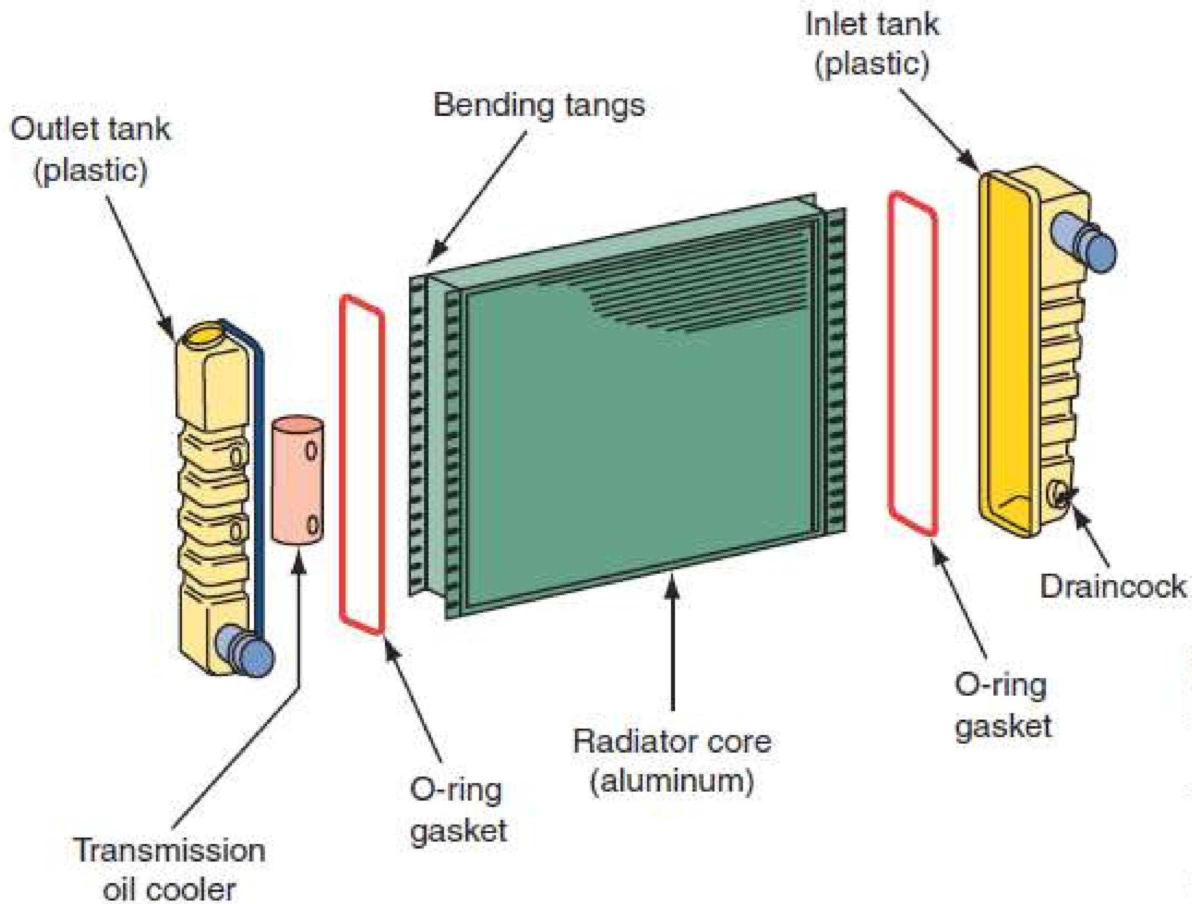

Figure 14-30 The core of a radiator is placed between plastic or aluminum tanks. One tank may contain the oil cooler for an automatic transmission and/or the engine.

Radiator Pressure Cap

Radiator caps **(Figure 14–31)** keep the coolant from splashing out of the radiator. They also keep the coolant's temperature within a desired range. It does this by keeping the coolant pressurized to a specified level.

The pressure in the system is regulated by a pressure relief or vent valve in the radiator cap **(Figure 14–32)** . When the cap is tightened on the radiator's filler neck, it seals the upper and lower sealing surfaces of the neck. The pressure relief valve is compressed against the lower seal.

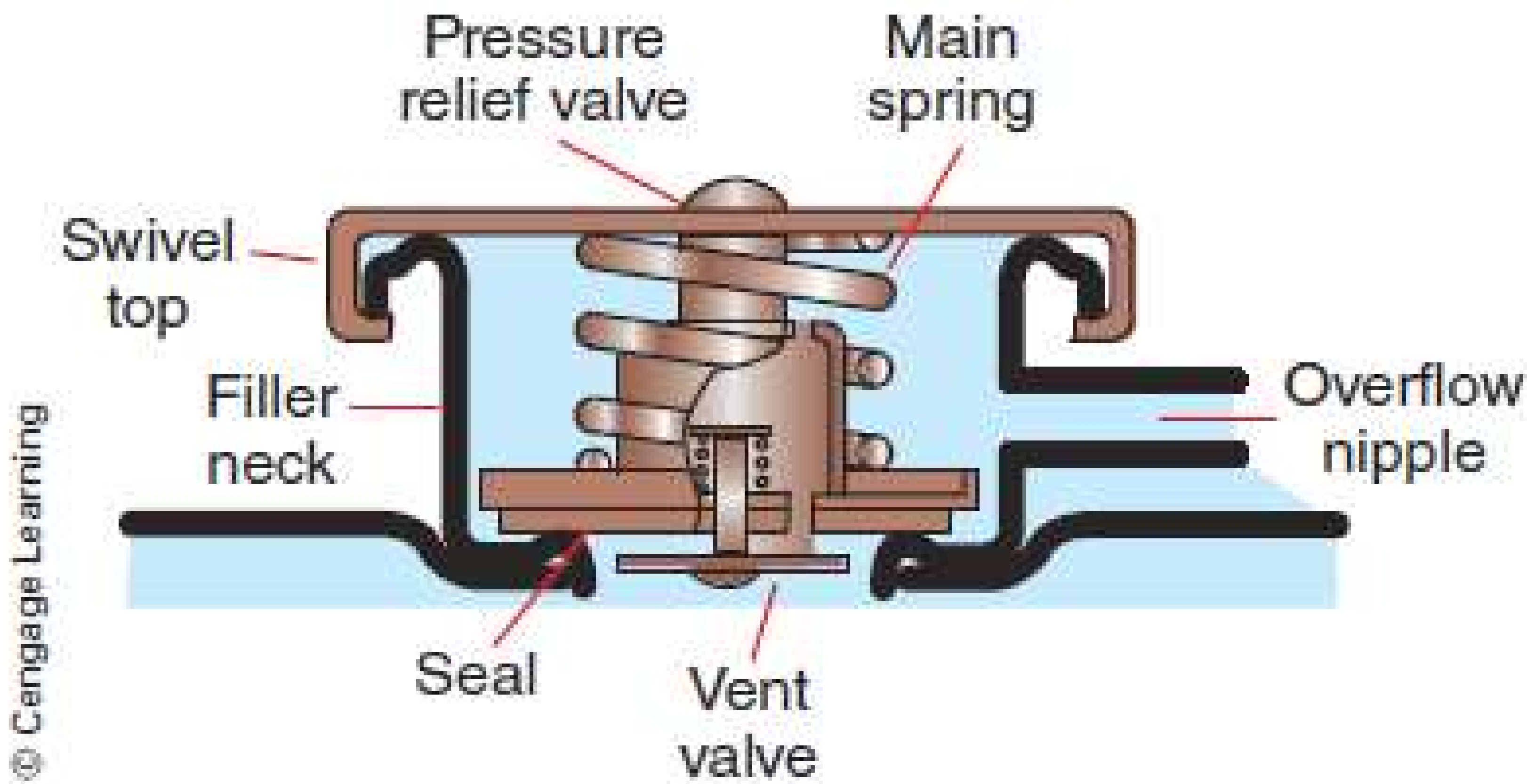

Figure 14-32 Parts of a radiator pressure cap assembly.

Expansion Tank

All late-model cooling systems have an **expansion** or **recovery tank (Figure 14–33)** . These systems are called closed-cooling systems. They are designed to catch and hold any coolant that passes through the pressure cap.

As the engine warms up, the coolant expands. This eventually causes the pressure cap to release and allows some coolant to move into the expansion tank. When the engine is shut down, the coolant begins to shrink. Eventually, the vacuum spring inside the pressure cap opens and the coolant in the expansion tank is drawn back into the cooling system.

Figure 14-33 A coolant expansion tank.

Hoses

Coolant flows from the engine to the radiator and from the radiator to the engine through radiator hoses. The hoses are usually made of rubber hoses to cushion engine vibrations and prevent damage to the radiator.

A hose is typically made up of three parts: an inner rubber tube, some reinforcement material, and an outer rubber cover.

Different covers and reinforcements are used depending on the application of the hose. All three parts are bonded together. Basically the difference in hose construction lies in what the hose will carry, where it is located, and the temperature and pressure it will face. Cooling system hoses must be able to endure heavy vibrations and be

resistant to oil, heat, abrasion, weathering, and pressure.

Most vehicles have at least four hoses in the coolingsystem

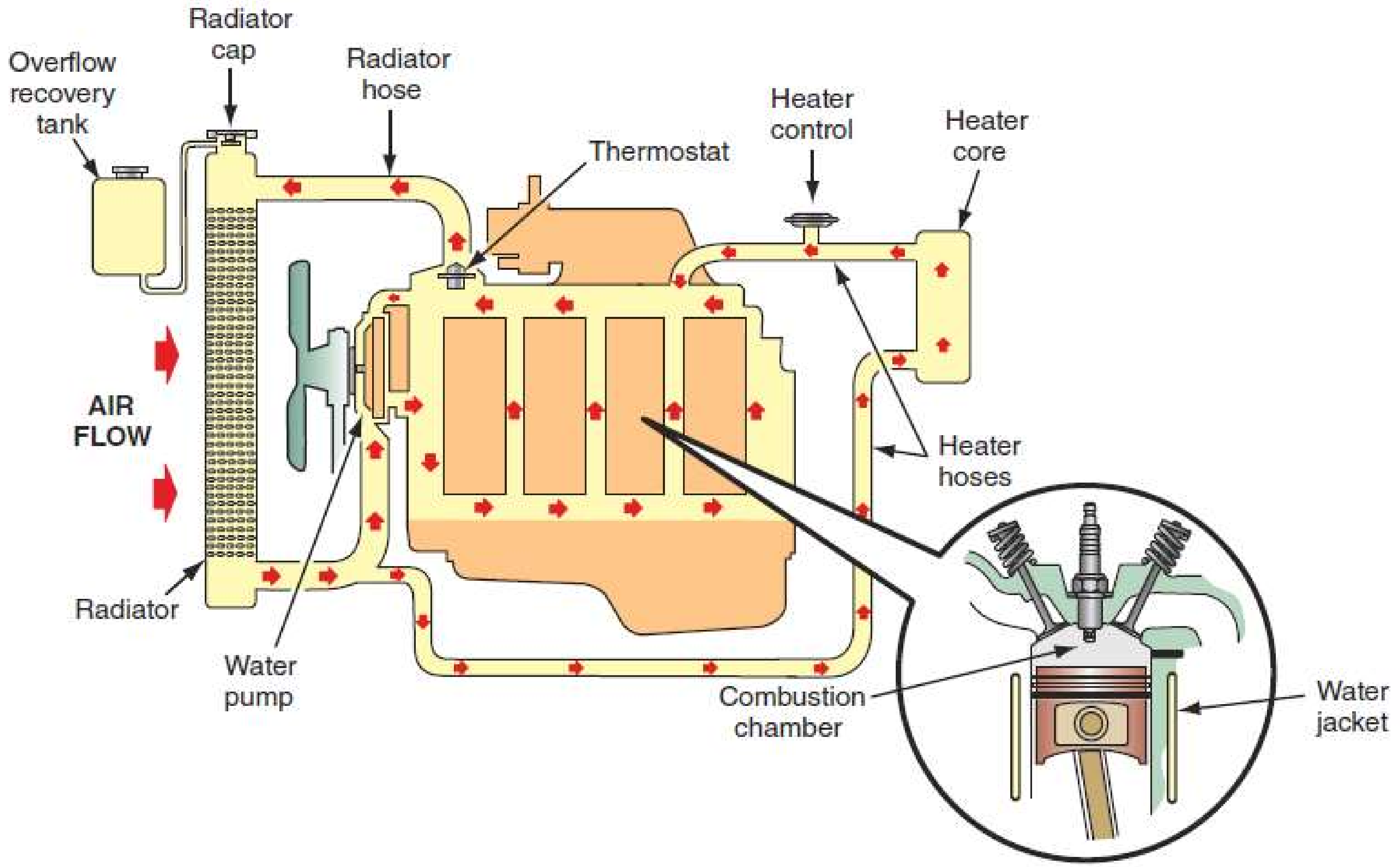

Figure 14-34 Routing of coolant through the cooling system hoses.

Heater System

A hot liquid passenger compartment heater is part of the engine’s cooling system. Heated coolant flows from the engine through heater hoses and a heater control valve to a heater core located on either side of the fire wall**(Figure 14–37)** .

Air is directed or blown over the heater

core, and the heated air flows into the passenger compartment.

Movable doors can be controlled to blend cool

air with heated air for more or less heat.

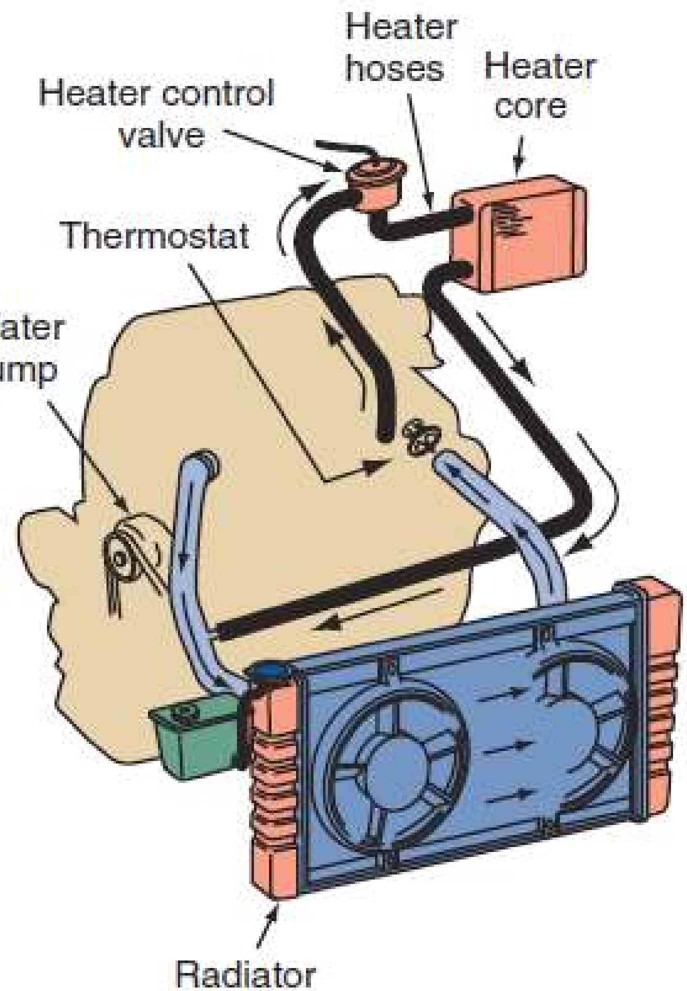

Figure 14–37 The coolant for the heater core is sent from the upper part of the engine through

Cooling Fans

The efficiency of the cooling system depends on the amount of heat that can be removed from the system and transferred to the air. At highway speeds, the ram air through the radiator should be sufficient to maintain proper cooling.

At low speeds and idle, the system needs additional air. This air is delivered by a fan. The fan may be driven by the engine, via a belt, driven by an electric motor, or hydraulically through the power-steering system.


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