Cooling Systems Testing, Maintenance & Repair

Chapter 40 – Modern Automotive Technology

Problem Diagnosis

The first step to diagnosing a cooling system problem is to gather information from the customer about the problem.

Ask questions like:

Can you describe the cooling system problem.

When does the problem seem to occur?

When was the last time the coolant was replaced?

Have any other repairs been performed?

Are there any unusual noises that might be related to the cooling system?

On-Board Diagnosis

Many on-board diagnostic systems will trip a trouble code when certain cooling-related circuits are operating out of range.

OBDII systems monitor coolant temperature, coolant level, engine oil temperature, belt tension, and other relate functions.

A cooling system diagnosis chart should be used when problems are difficult to locate.

Inspecting cooling system

A visual inspection will frequently reveal the source of the cooling system problem. Look for obvious troubles:

- Coolant leaks
- Loose or missing fan belts
- Low coolant level
- Abnormal water pump noises
- Leaves and debris covering the outside of the radiator
- Coolant in the oil (oil looks milky)
- Combustion leakage into the coolant (air bubbles in coolant)

Inspecting cooling system

WARNING

Keep your hands and tools away from a spinning engine fan.

Wear eye protection and stand behind - not over - the spinning fan blade

Then if tools are dropped into the fan or a fan blade breaks off, you are not likely to be hit and ingurted by playing parts.

Cooling System Problems

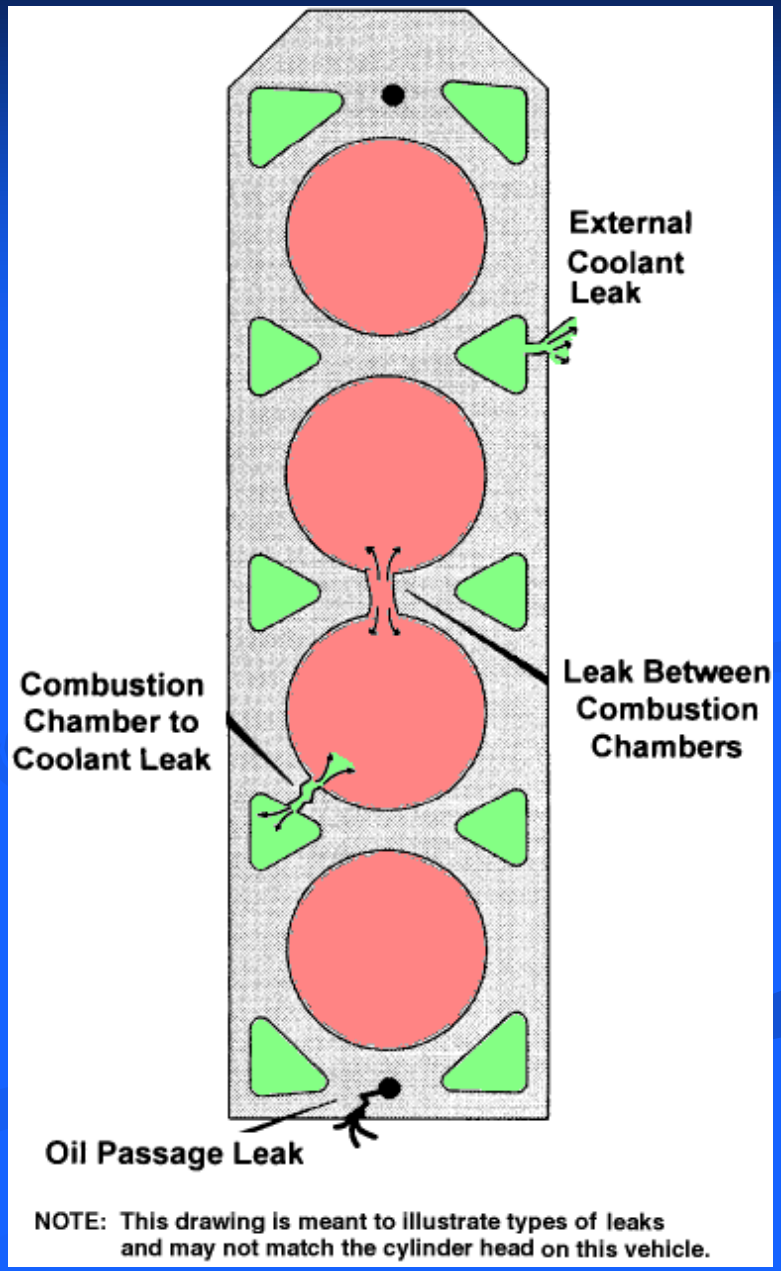
Coolant Leaks

- Show up as wet, discolored areas in the engine compartment or on the ground
- Leaking fluid will smell like antifreeze and will have the same general color
- Can occur anywhere but usually at hoses and from the radiator

Cooling System Problems

Coolant Leaks

- Low coolant level may indicate a leak. If not visible, the leak may be internal
- Internal leaks are possible at the following locations:
  - cracked block
  - cracked cylinder head
  - blown head gasket



Cooling System Problems

- Are there any coolant leaks?
- use a cooling system pressure tester

External leaks can be found at the:

- Radiator
- Rad hoses
- Heater hoses
- Water pump
- Frost plugs
- Rad Cap
- Thermostat housing
- Heater core

Internal engine leakage can happen through the HEAD GASKET

Inspecting cooling system

WARNING

Never open a radiator cap when the engine is hot.

The pressure released can make the coolant begin to boil and expand.

Boiling coolant could spurt out of the filler neck or reservoir, causing severe burns.

Pressure Testing a Cooling System

Cooling System Pressure Test

A pressure tester is a hand-operated air pump used to pressurize the cooling system for leak detection.

Install the tester on the radiator filler neck or the reservoir. Then pump the tester until the pressure gauge reads radiator cap pressure or maximum allowable pressure. (around 14psi)

NEVER EXCEED RADIATOR CAP PRESSURE RATING

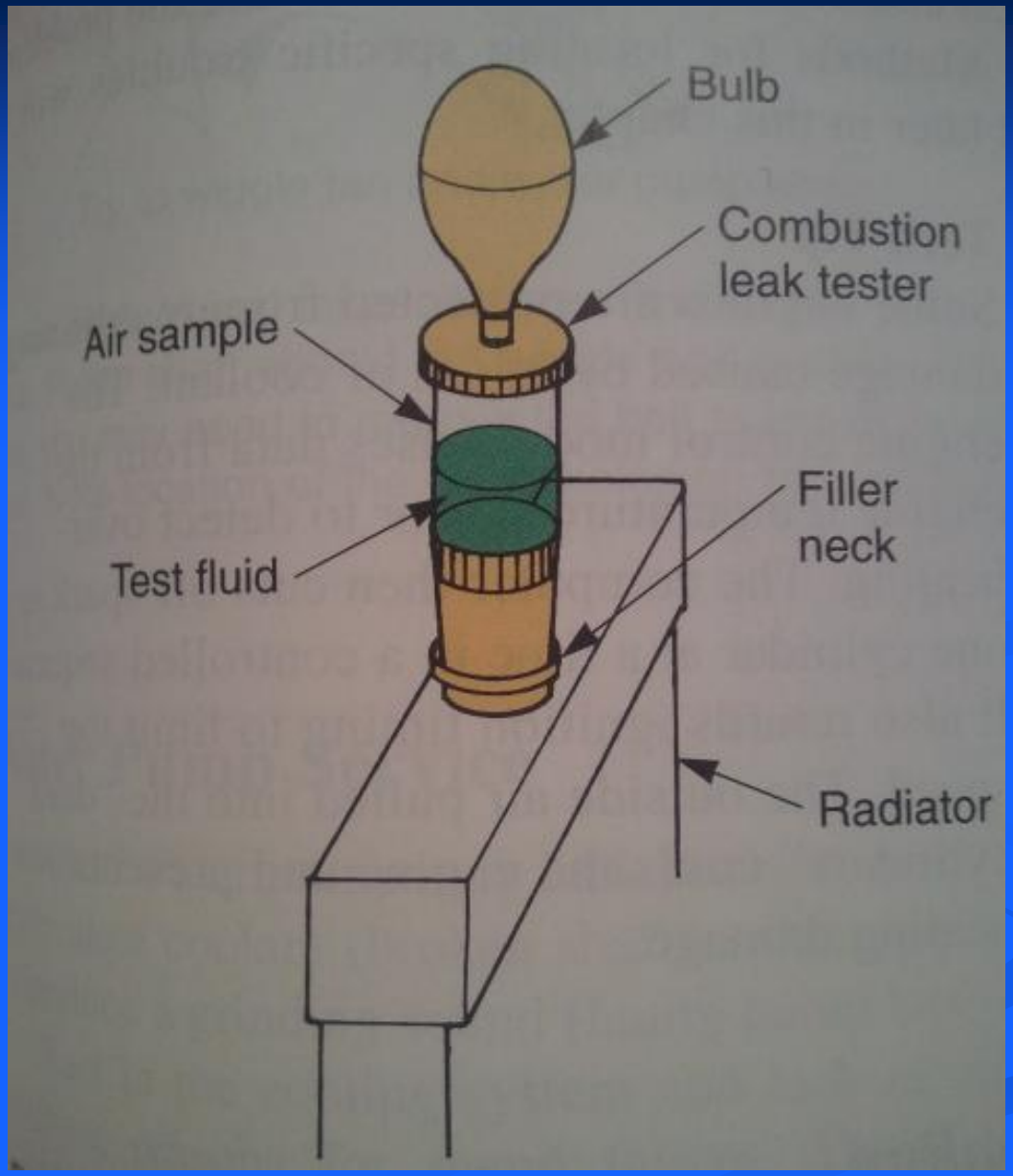
Combustion Leak Test

A combustion leak test checks for the presence of combustion gases in the coolant. It should be performed when signs point to a blown head gasket, cracked block or cracked cylinder head (overheating, bubbles in the coolant, or a rise in the coolant level upon starting.

Tester is placed in the radiator filler neck or reservoir. Engine is started and tester bulb is squeezed and then released. This will pull air from the cooling system through the test fluid.

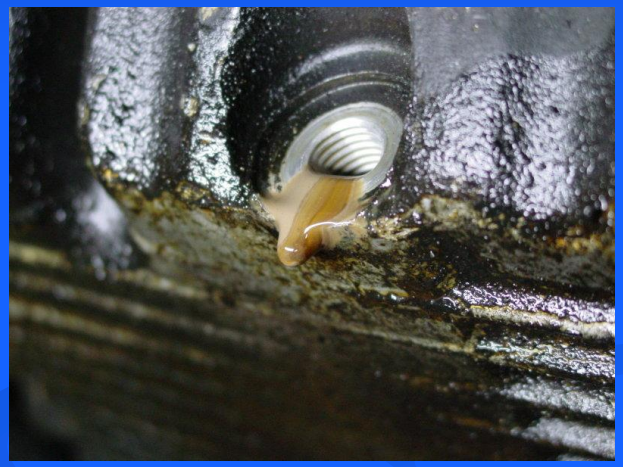
Fluid in tester is normally blue, a combustion leak will turn the fluid yellow. Short cylinders one at a time to find leaking cylinder. (Gas analyzer could also be used for this)

Combustion Leak Test



Coolant in Oil

When water, antifreeze, and oil mix, the solution turn milky white in color. If a milky white solution is found in the engine oil or in valve covers, it is an indication of a coolant leak.



Common problems include:

- Blown head gasket
- Cracked head
- Cracked Block
- leaking intake manifold gasket

Cooling System Troubleshooting

OVERHEATING is a serious problem that can cause major engine damage.

The driver may notice the engine temperature light glowing, the temperature gauge reading high or the coolant boiling.

Boiling coolant will expand and blow out through the overflow as steam.

Cooling System Troubleshooting

Common causes of overheating:

Rust or Scale – Mineral accumulations in the system have clogged the radiator core or built up in the water jackets

Stuck Thermostat – Thermostat fails to open normally, restricting coolant flow

Retarded ignition timing – Late ignition timing allows combustion flame to blow out through an open exhaust valve, transferring too much heat into exhaust valves, port and manifold.

Loose fan belt – Water pump drive belt slips under load and reduces coolant circulation.

Cooling System Troubleshooting

Common causes of overheating cont.:

Collapsed lower radiator hose – Suction from water pump may flatten the hose if the spring is missing or the hose is badly deteriorated.

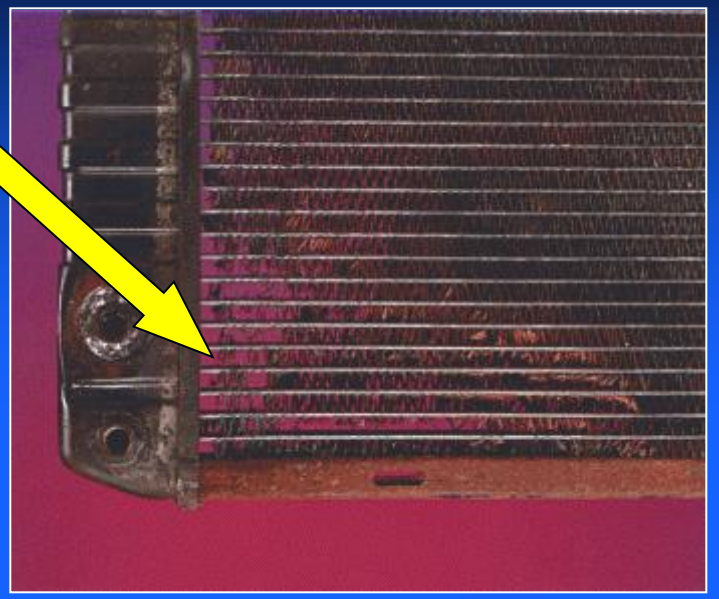
Missing fan shroud – Air circulates between the fan and the back of the radiator, reducing airflow through radiator

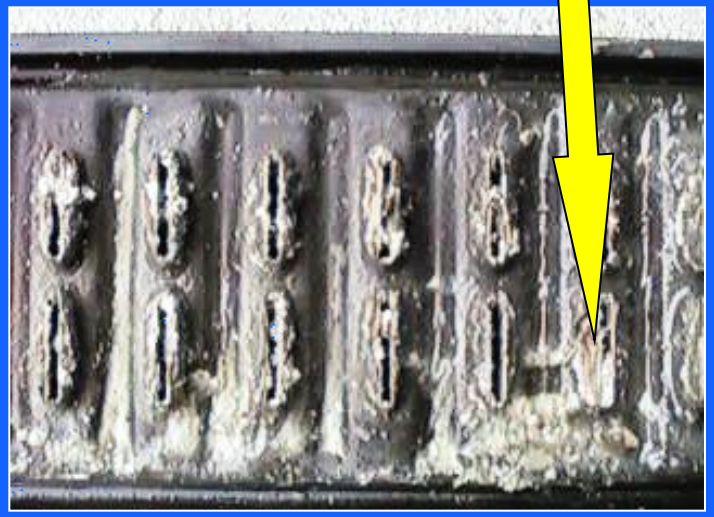
Ice in coolant – Coolant frozen due to lack of antifreeze can block circulation and cause overheating.

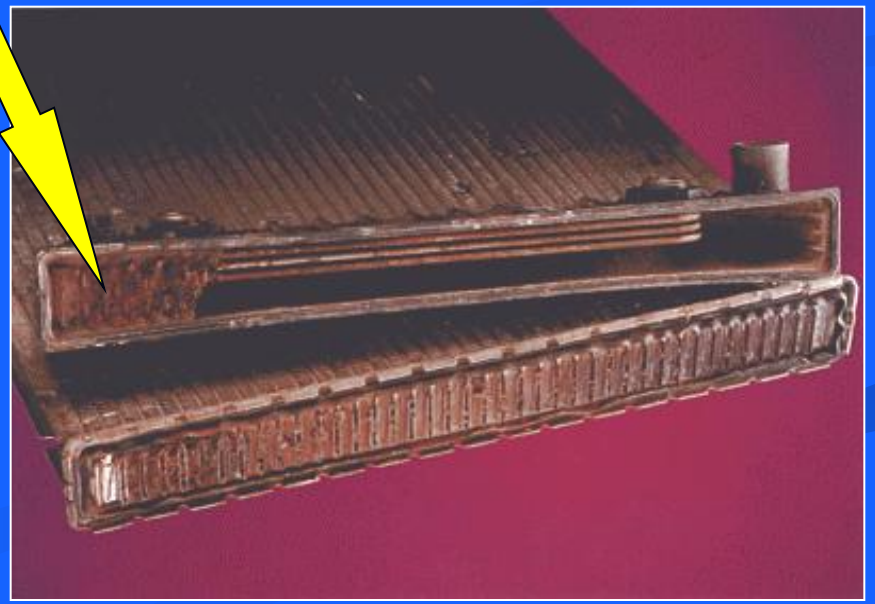
Engine fan problems – Fan clutch or electric fan troubles can prevent adequate airflow through the radiator.

Overheating

- **faulty radiator**
  - **check for loose or deteriorated fins**
  - **check for blockage of the tubes**

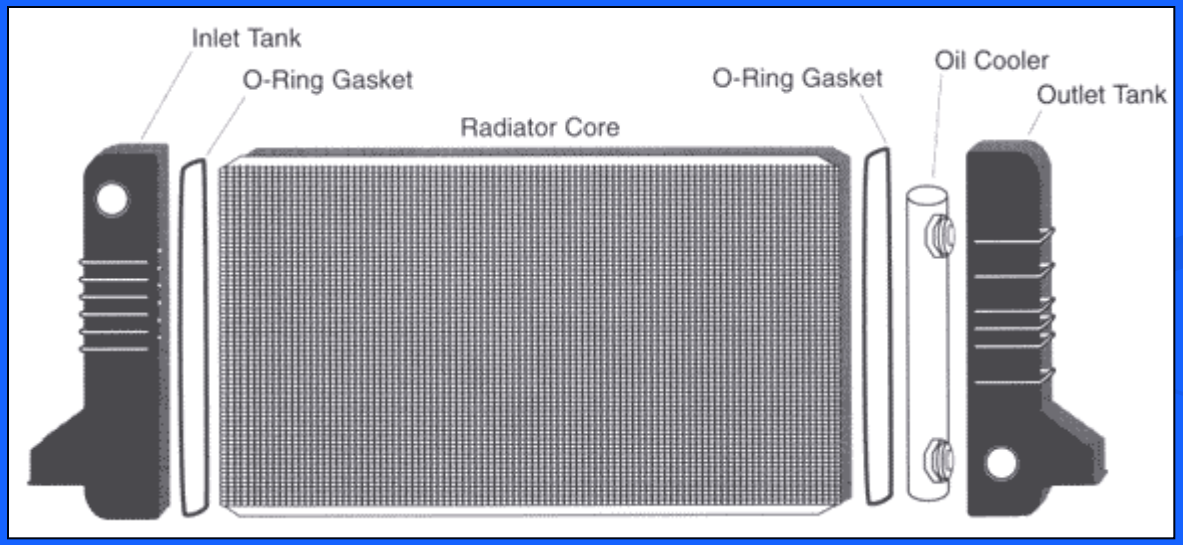






Testing Radiator

- To check the radiator, run your hand over the core
  - engine off & warmed up
- Temperature should be consistent.
- Cold areas indicate plugged tubes.



Cooling System Troubleshooting

OVERCOOLING may be indicated by slow engine warm up, insufficient warmth from the heater, low fuel economy, sluggish engine performance, or a low reading from the coolant temperature sensor.

Cooling System Troubleshooting

Common causes of overcooling:

Stuck Thermostat – Thermostat stuck open causing too much circulation

Locked fan clutch – Fan operates all the time, causing excess airflow through radiator

Shorted fan switch – Electric fan runs all the time increasing warm up time

Water Pump Service

Water Pump Service:

A bad water pump may leak coolant (worn seal), fail to circulate coolant (broken shaft or damaged impeller), or produce a grinding sound (faulty pump bearings).

Common causes of water pump failure:

- **Rust in the cooling system**
- **Lack of coolant (for lubricating bearings)**
- **Over tightened drive belt**

Water Pump Service

Checking a Water Pump seal:

Pressure test the system and watch for leakage at the pump

Checking for worn water pump bearings:

Try to wiggle the fan or pump pulley up and down (serpentine belt may need to be removed)

Use a stethoscope to listen for noise from the bearings

Checking water pump action:

Warm engine then turn off vehicle. Squeeze upper radiator hose while someone starts the engine; you should feel a surge of pressure (hose swelling) from the pressure from the water pump

Water Pump Service

Removing a Water Pump:

Remove necessary bolts

Never use excessive force when trying to remove an old water pump as you may bend or break parts.

Make sure all bolts are removed before trying to tap the pump loose from the block (some bolts are easily missed)

Scrape off old gasket material, surfaces must be perfectly clean to prevent coolant leakage (be careful not to scratch aluminum surfaces)

When if doubt refer to the service manual for instructions

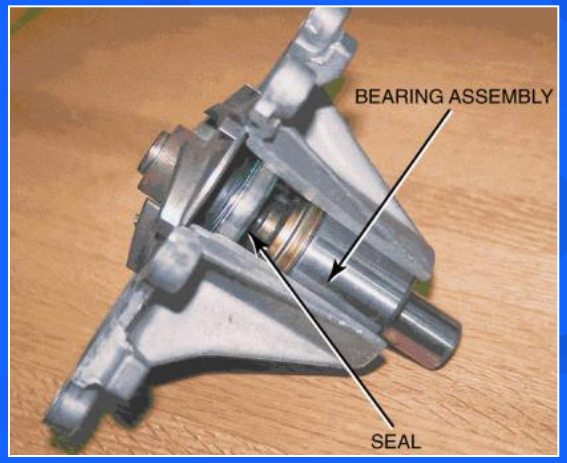
Water Pump Service

Water Pump Rebuild:

Requires pump disassembly, cleaning, part inspection, worn part replacement, and reassembly

Few technicians rebuild water pumps. Most purchase new or factory-rebuilt pumps.

Rebuilding takes too much time and would not be cost effective.



Water Pump Service

Installing a Water Pump:

Always use an approved sealer to adhere the new gasket to the pump, this will keep it aligned while installing.

Installation Procedure:

1. Fit pump straight onto engine without moving gasket

2. Start all bolts by hand, check that all bolts are in proper places (some are longer than others)

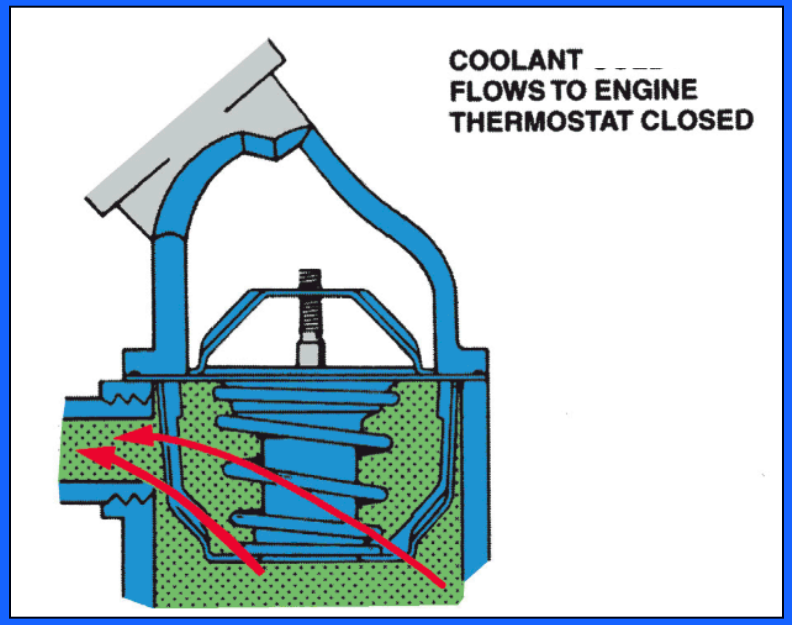
3. Torques all fasteners a little at a time in criss-cross pattern, go over all bolts several times to ensure proper tightening

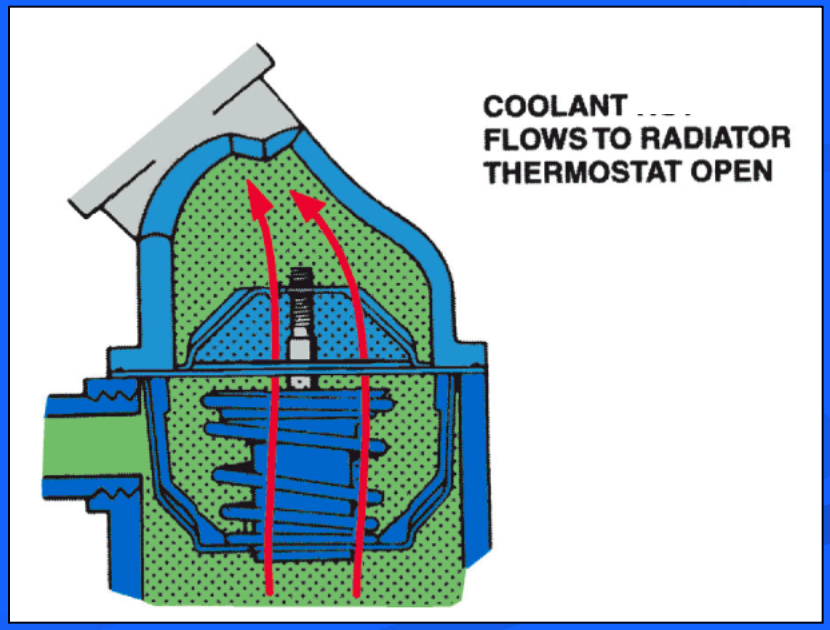
4. Install other components and tension belt properly

Thermostat Service

Thermostat Service:

A stuck thermostat can cause engine overheating (stuck closed) or engine overcooling (stuck open).





Thermostat Service

Thermostat Testing:

Watch for coolant flow in the radiator

You should have no flow when engine is cold – thermostat closed and flow when the engine is warm – thermostat open

Sometimes removal of the thermostat is needed to test in hot water to check for proper operation

A digital thermometer can be used to check thermostat operation by checking temperature on thermostat hosing and on upper radiator hose

Example: If thermostat housing is at operating temperature and upper radiator hose is still cold thermostat is stuck closed.

Thermostat Service

Faulty thermostat

- **old thermostat can be tested in a pot of boiling water using a temperature gauge**

Thermostat Service

Thermostat Testing:

Thermostat Service

Thermostat Replacement:

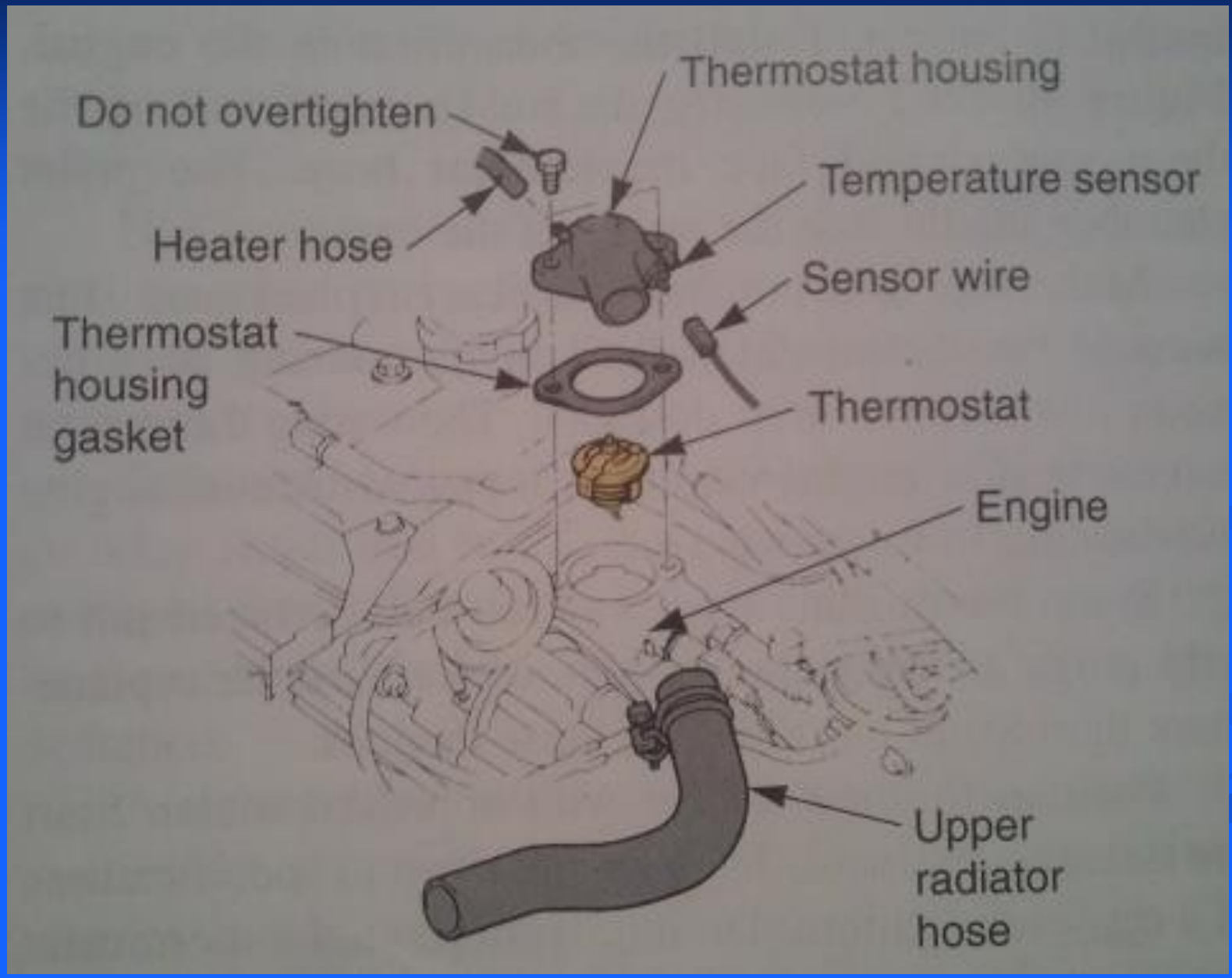
Usually located on the top of the engine under the thermostat housing (fitting for upper radiator hose)

Remove housing, scrape off gasket material, and check surface for flatness (can be filed or sanded flat if warped)

CAUTION: Be careful not to damage the thermostat housing. It is often made of aluminum or "pot metal" and will break easily.

When installing a rubber thermostat housing seal may be used instead of a gasket on some engine designs.

Thermostat Service



Thermostat Service

Bleeding the cooling system:

A bleed screw or bleed valve is sometime provided to help remove trapped air when refilling the cooling system.

Air trapped in the cooling system can cause engine overheating or damage to the parts near the air pocket (hot spot)

A hot spot is an area in the engine suffering from a buildup of combustion heat (often due to an air pocket in the cooling system)

Cooling System Service

Burping the cooling system:

Cooling System Hose Service

Coolant System Hose Service:

An old radiator hose may become soft and mushy or hard and brittle

If you cannot squeeze a hose with your hand replace it (it has become hard and brittle)

Softened hoses are usually caused by oil contamination and should also be replaced

Inspect hoses for cracks, bulges, cuts or any other signs of deterioration or damage

Cooling System Hose Service

Hose Replacement:

Loosen the hose clamps

Twist the hose while puling it from the fittings

Sometimes a flat screwdriver is needed to loosen the connection between the hose and the housing it is on

If the hose is going to be replaced it can be sliced off with a knife

Always check for leaks after replacing a hose or any other cooling system component and remember to burb/bleed the system

Radiator and Pressure Cap Service

If overheating occurs and a pressure test shows that the system is not leaking, check the radiator and the pressure cap.

Radiator pressure cap could have bad seals

Radiator could be clogged and not permitting adequate air or coolant flow.

Check for debris in the radiator such as leaves and road dirt, also make sure the radiator shroud is in place and unbroken. These problems can limit air circulation through the core

If the radiator is leaking it will need to be removed and repaired or replaced

Radiator and Pressure Cap Service

A radiator cap pressure test measures the cap opening pressure and checks the condition of the sealing washer.

Pump the tester to pressurize the cap, the cap should release pressure when the stamped rating is exceeded and hold the rated pressure for at least one minute.

Radiator and Pressure Cap Service

Removing a Radiator:

1. Place a catch pan under the petcock valve and drain coolant
2. Disconnect hoses, oil cooler lines & wires (electric fans)
3. Remove fan and any other necessary parts
4. Remove radiator

Fan Belt Service

A loose fan belt will slip, squeal & may rotate the water pump and fan too slowly

If belt is too tight it will fail quickly and damage other parts

Always check for belt condition and tension when servicing a cooling system (use a belt tension gauge to obtain proper tension)

Things to look for on belts (wear): (replace if present)

- Cracks
- Frayed edges
- Glazed (hard shi
- Oil soaked

Fan Belt Service

Drive belt(s):

- **check for damage or excessive play**
  - **Span less than 12” – 1/8” – 1/4”**
  - **Span more than 12” – 1/4” – 1/2”**

Engine Fan Service

A faulty engine fan can cause overheating, overcooling, vibration, and water pump damage.

Always check the fan for bent blades, cracks and other problems. If any are found replace the fan.

WARNING

A fan with cracked or bent blades is extremely dangerous. Broken blades can be thrown out with great force, causing severe lacerations!

Engine Fan Service

Testing a Thermostatic Fan clutch:

Start engine – Fan should slip (be off) when engine is cold

When engine warms fan should engage – Air should flow through the radiator and over the engine (you should be able to hear and feel the rush of air from the fan)

If the fan is on all the time (hot and cold) it is defective and should be replaced

Engine Fan Service

Electric Cooling Fan Service:

Most electric cooling fans are controlled by a heat sensitive switch or sensor located somewhere in the cooling system (radiator, engine block, thermostat housing)

When the engine is cold, the switch keeps the electric fan motor off to speed engine warm up

When a predetermined temperature is reached, the switch closes and the fan begins to cool the engine

Engine Fan Service

Testing an Electric Cooling Fan:

Observe whether the fan turns on when the engine is warm

Make sure the fan motor is pinning at a normal speed and is forcing enough air through the radiator

If the fan does not function check the fuse, electrical connections, relay and supply voltage to the motor

If the engine is warm and no voltage is supplied to the fan motor, check the operation of the electric cooling fan using a voltmeter or high-impedance test light

When in doubt refer to the factory service manual

Freeze Plug Service

A leaking engine freeze plug (core plug) is a frequent cause of coolant loss and overheating. Since the engine's freeze plugs are thinner than the metal in the engine block or head, they will rust through before the other parts of the engine.

Freeze Plug Service

To replace a freeze plug, use the following procedure:

1. Drive a drift or large full-shank screwdriver through the plug

2. Pry sideways, without scraping the engine block or cylinder head. The plug should pop out.

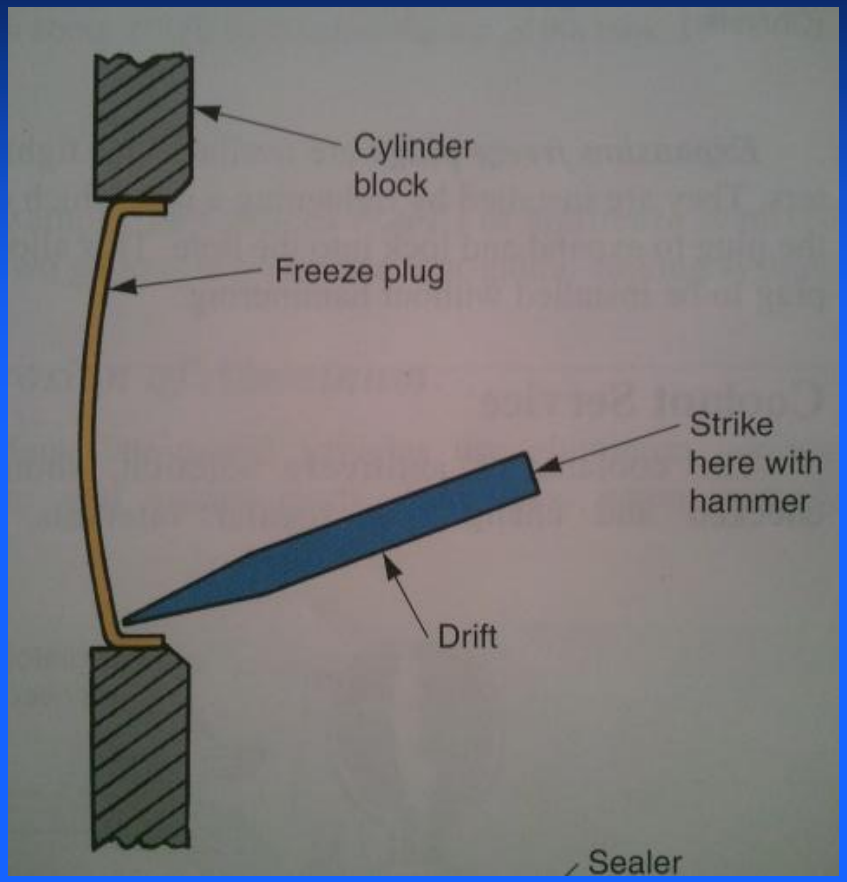
3. Sand the core plug hole in the engine and wipe it clean

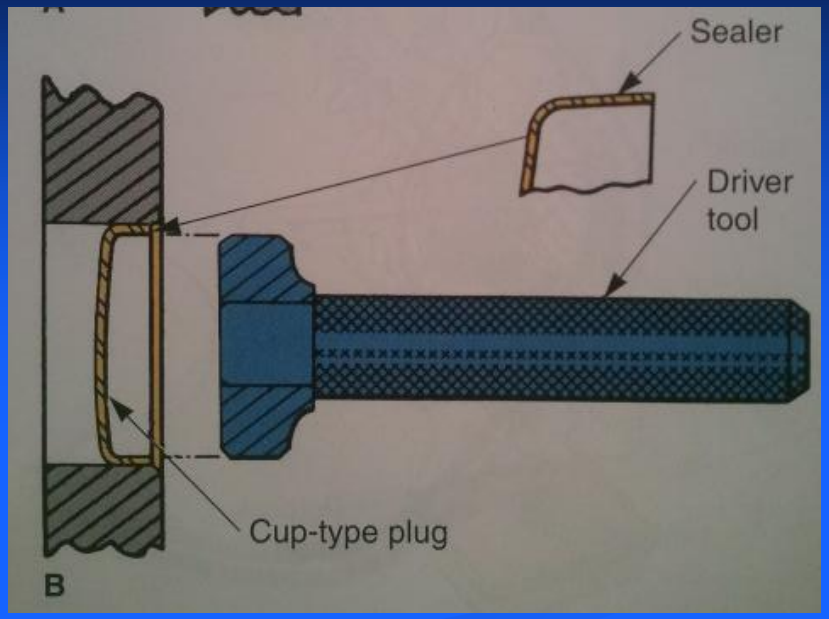
4. Coat the plug hole and plug with non-hardening sealer

5. Drive a new freeze plug squarely into position

(Pictures on next slide)

Freeze Plug Service





Expansion freeze plugs are available for tight quarters. They are installed by tightening a nut, which causes the plug to expand and lock into the hole. This allows the plug to be installed without hammering.

Coolant Service

The coolant, or antifreeze solution, should be checked and changed at regular intervals

After prolonged use, coolant will break down and become very corrosive. It can lose its rust preventative properties, and the cooling system can rapidly fill with rust.

Coolant Service

Inspecting Coolant:

Visually inspect coolant

Run your finger inside radiator filler neck to check for rust, oil (internal oil leak), scale, or transmission fluid (leaking oil cooler)

Also find out how long the coolant has been in service

Coolant Service

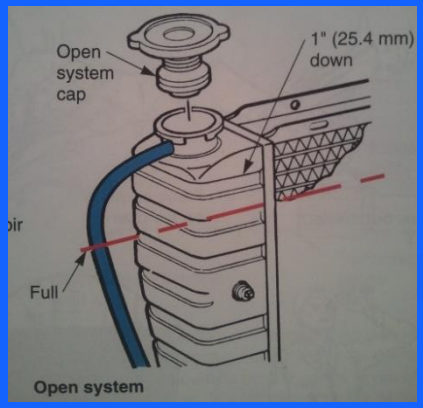
Changing Coolant:

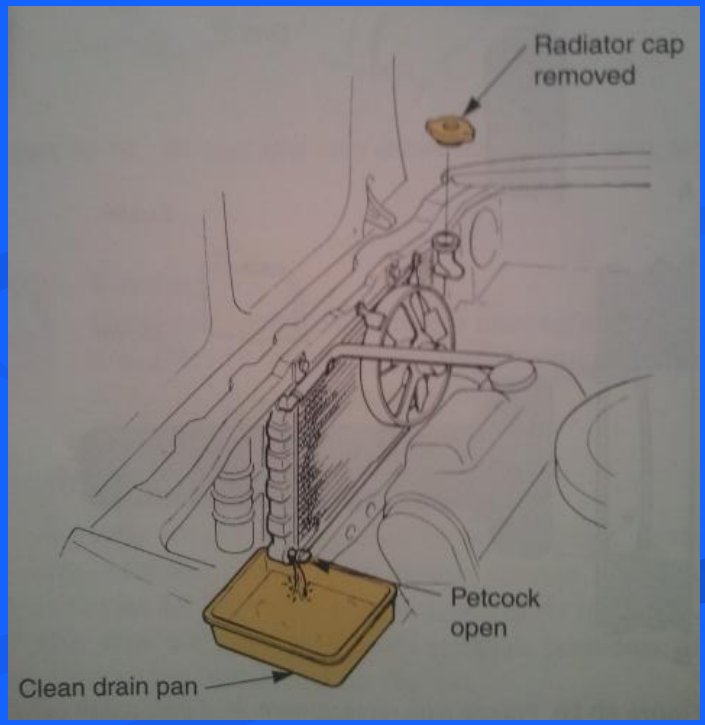
Coolant should be changed when contaminated or when two years old (check service manual for exact change schedules)

Filling the system:

Closed system fill to proper fill line on reservoir

Open system fill to 1” below top of radiator



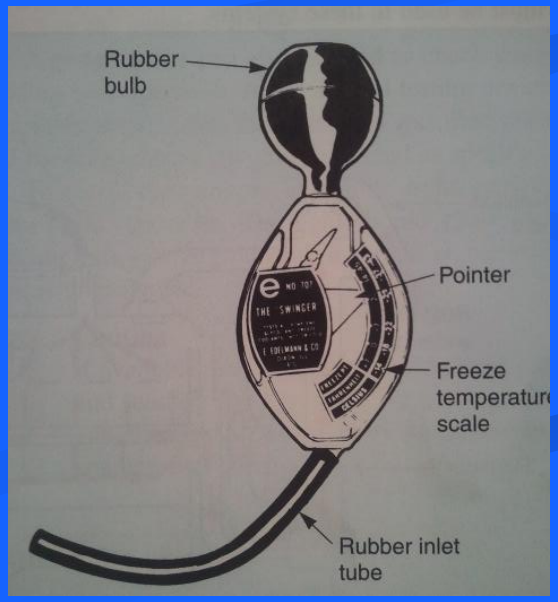


Coolant Service

Testing the coolant:

Coolant strength is measured of the concentration of antifreeze to water. It determines the freeze-up point of the solution

A cooling system Hydrometer is commonly used to measure the freezing point of the antifreeze solution.



Coolant Service

Testing the coolant:

A Refractometer is another type of coolant strength measuring device

Using the Refractometer:

Draw coolant into the tester

Place a few drops of coolant on the measuring window (surface)

Aim the tester at light and view through the tester

The scale in the refractometer will show freeze proction level

Coolant Service

Caution:

The most common reason for cracked blocks and cylinder heads is improper coolant protection

If the coolant in the engine freezes in cold weather, the ice will expand and break major engine parts.

Coolant Service

Corrosion of Aluminum:

Many late model vehicles use aluminum cooling system and engine parts.

Radiators, water pumps, cylinder heads, blocks, and intake manifolds can be made of aluminum.

Antifreeze designed for aluminum components must be used in theses systems.

Aluminum can be corroded from some types of antifreeze. Check the vehicle's service manual or the antifreeze label for details.

Most types of antifreeze are now "aluminum friendly"

Flushing a Cooling System

Flushing of a cooling system should be done when rust or scale is found in the system

Involves running a cleaning chemical through the cooling system. This dissolves and washes out contaminants.

What damage can rust do to the cooling system???

- Premature wear in the water pump
- Clogging the radiator / heater core tubes

Coolant Service

Fast Flushing:

Commonly used because the thermostat does not have to be removed

A hose is connected to a heater hose connection

Radiator cap is removed and petcock valve is opened

Water pressure from hose removes loose rust and scale from system

Coolant Service

Reverse Flushing:

Requires a special adapter that is connected to the radiator outlet tank by a piece of hose

Another hose is attached to the inlet tank

Compressed air under low pressure, is used to force a cleaning solution through the core backwards

Can be done on the engine block or the radiator

Coolant Service

Chemical Flushing:

Needed when scale buildup in the system is causing engine overheating.

A chemical cleaner is added to the coolant. The engine is operated for a specific amount of time to allow the chemical to act on the scale, then the system is flushed with water.

WARNING

Always follow manufacturer's instructions when using a cooling system cleaning agent. The chemical may cause eye and skin burns.

Wear rubber gloves and full face protection

Temperature Gauge Service

A defective temperature gauge may read hot or cold when the engine is actually at its proper operating temperature.

Gauge always reads hot or cold or may have erratic movement

To quickly test a temperature gauge, disconnect the wire going to the temperature gauge sending unit (usually located on the engine)

Using a ground wire, ground the gauge wire to the engine block. Then, turn the ignition key switch on and watch the temperature gauge. It will normally swing to hot with the wire grounded.

If the gauge begins to function when grounded, the sending unit is defective and should be replaced. If the gauge does not function when grounded, either the gauge circuit or the gauge is faulty.

Temperature Gauge Service

A gauge tester can also be used to check gauge and sending unit operation.

It is a special testing device with a variable resistor.

Set the tester to a specified resistance and the temperature gauge should read as specified.

To test a temperature indicating light, perform the same basic operation. The light should glow when the sending unit wire is grounded. It should go out when the wire is ungrounded

CAUTION

If available, use a gauge tester to check gauge and sending unit operation. Some temperature gauges could be damaged by grounding the sending unit wire

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

Name 3 causes of engine overcooling

Stuck thermostat

Locked fan clutch

Shorted electric fan switch

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

A _____ can be used to test the freezing point of a cooling systems coolant

Hydrometer

or

Refractometer

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

Name the 3 types of cooling system flushes

Fast flush

Reverse flush

Chemical flush

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

Name common indicators that the engine is overheating

Boiling coolant

Glowing temperature light

High temperature gauge reading

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

A cooling system pressure tester is a hand operated air pump

True

False

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

When water, antifreeze and oil mix, it turns what color?

Milky white

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

A bad water pump may leak coolant, fail to circulate coolant and/or produce a grinding sound

True

False

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

A stuck thermostat can cause overcooling or overheating

True

False

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

When should coolant be changed?

After 2 years

Or

When contaminated

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

What is used to quickly check for leaks in the cooling system?

Pressure tester

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

An engine can still operate for an extended period without a cooling system

True

False

COOLING SYSTEM TESTING, MAINTENANCE & REPAIR - REVIEW

Are you ready for the test???

If yes, Great!

If no, start studying

Test on Ch. 39 & 40 combined on Thursday Dec. 19