DIESEL MECHANIC

MINING QUALIFICATIONS AUTHORITY

CODE: PDW

MAINTAIN COOLING SYSTEMS

Created : 01 February 2003
Revised : March 2015
Owner : Learnership Department

First Published : March 2003
Revision No: 002
TRG 9

INDEX

The following elements are contained in this learning guide:

MODULE OBJECTIVE

- To enable the learner to maintain cooling systems of diesel engines.

LEARNING OBJECTIVES

- On completion of this module the learner must be able to:
- State the functions of the various components of the cooling system.
- Name eight faults, which may cause overheating in the cooling system.
- Flush the cooling system of a diesel engine.
- Remove and replace the radiator and water pump.

ASSESSMENT AND EVALUATION CRITERIA

- A practical and theory test will be set at the end of the module and must be completed without using references.
- All the answers to the theory test must be correct.

THE LEARNER WILL BE REQUIRED TO

- Replace the radiator and water pump of a diesel engine.
- Flush the cooling system of a diesel engine.

The following standards must be achieved:

- The pump shaft must rotate freely in the pump housing.
- There must not be any damage to the water hoses and clamps.
- There must not be any damage to the radiator core and it must be clean.
- There must not be any damage to the fan belt.
- The fan belt must be adjusted to the required specifications.
- The water pump must not be damaged.
- All the fasteners must be replaced and tightened without being damaged.
- The radiator must be filled with clean water up to the filler cap seal.
- There must not be any water leaks when the cooling system is pressurised.
- There must not be any damage to the fan.
- The radiator and engine block must be flushed with water before the radiator is replaced.
- The fan must be fitted so that the blades draw the cool air through the radiator and blow it over the engine.
- All safety procedures must be adhered to.

ADDITIONAL RESOURCES

- A demonstration by a competent person e.g. a Training Officer.
- Workshop manual.
- Audio-visual aids if available.

HAZARD IDENTIFICATION AND CONTROL (HIAC) FORM

PDW

MAINTAIN COOLING SYSTEMS

STEPS IN OPERATION / PROCESS	POTENTIAL ACCIDENT / INCIDENT	CONTROLS (BY RESPONSIBLE PERSON)
• Use hand tools	• Using damaged tools or wrong tools for the job can cause injury and damage to equipment.	• Always use the correct tool for the job. • Ensure tools are in good condition. • Use tools correctly. • Wear appropriate PPE where necessary. • Always take good care of tools. Maintain, clean and store it properly.
• Work on machinery	• Working on moving machinery can cause serious injury.	• Switch off, and where appropriate, lock out the vehicle engine before commencing work on it.
• Remove radiator and/or water pump	• Severe burns may be caused by hot engine parts or hot water under pressure in radiator.	• Allow engine to cool down before working on it. • Release pressure before removing radiator cap

NOTE: Before doing the practical work contained in this module, the learnermust study the content of the above HIAC form again and then sign the statement below.

The above risks, which will be encountered in this module, are fully understood and will be controlled during the practical work.

Signature of Learner: _____

Signature of Training Officer: _____

Date: _____

1. PURPOSE OF A COOLING SYSTEM

ITEM / TASK: Introduction

DESCRIPTION:
Purpose of a cooling system on a diesel engine

- The temperature in a cylinder, when combustion takes place, is approximately 2000 C°, i.e. similar to the temperature in a furnace.
- Clearly if the metal of the cylinders were heated to this high temperature it would become red hot and severe damage could result.
- Lubrication would be impossible under these circumstances and even the valves and valve springs would lose their hardness.
- In order to avoid this happening, sufficient heat has to be removed to lower and control the temperature of the engine.
- This excess heat is removed by an engine cooling system, the essential components of which are shown in Fig. 1 and are described in the next section.

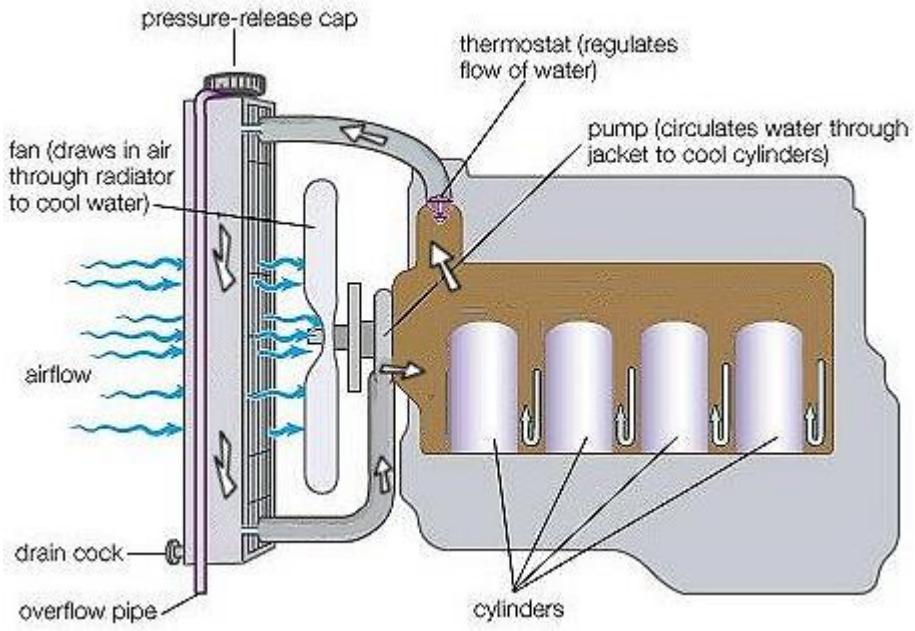


Fig. 1

- Water is drawn from the radiator and forced through the water jackets of the engine. The water absorbs heat from the cylinders and conveys it to the radiator where it is cooled by an air stream passing through the radiator.

2. PARTS OF THE COOLING SYSTEM OF A DIESEL ENGINE

ITEM / TASK: Parts of the cooling system of a diesel engine

DESCRIPTION:

Water Jackets

- The water jackets consist of an outer wall around the cylinders. Between the cylinders and the wall is a space through which the water runs. The water jackets enable the water to circulate around the cylinders, valve seats, valve guides and the cylinder head (Fig. 1 above).

The radiator

- The radiator acts as a heat exchanger. It consists of a bank of finely finned, flat tubes connecting the upper and lower tanks, and through which the water flows (Fig. 2).

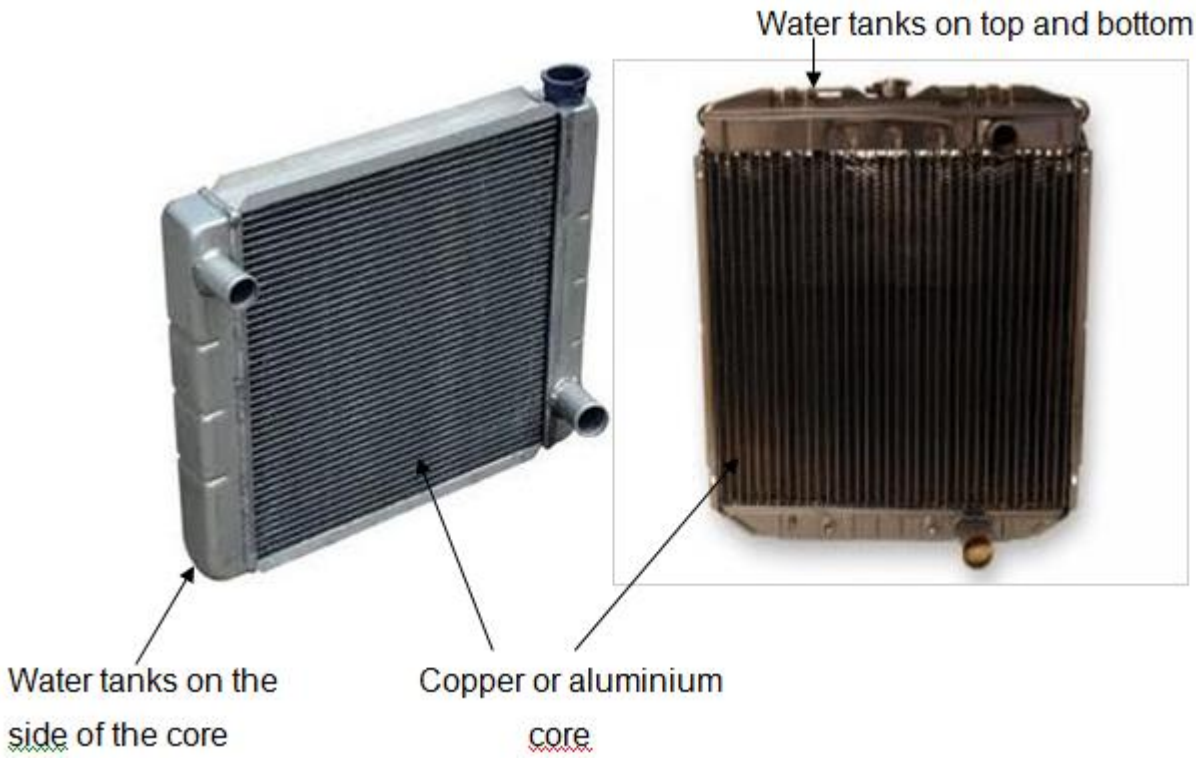


Fig. 2

- The cooling surface is formed by the outer walls of the pipes. Thin metal strips are used to bind these tubes together. The fins or metal strips provide narrow spaces through which air can circulate.

- The water is cooled by the air drawn across the surface of the tubes by the forward motion of the vehicle at high speeds, and by the fan at low speeds.

The water pump

- A centrifugal pump is used to circulate the water through the water jackets and the radiator.

- It consists of an impeller with vanes. When the impeller rotates, the water moves as a result of centrifugal force and flows through the outlet side of the pump. This creates a lower pressure in the pump, causing more water to be drawn to the centre of the rotor through the water side of the pump (Fig. 3 on the next page).

- The pump is normally driven by a V-belt from the crankshaft pulley.

Fig. 3

The Fan

- The fan, which is fitted onto the pump, draws the cool air through the radiator core and blows it over the engine.
  (Fig 3.1 next page)

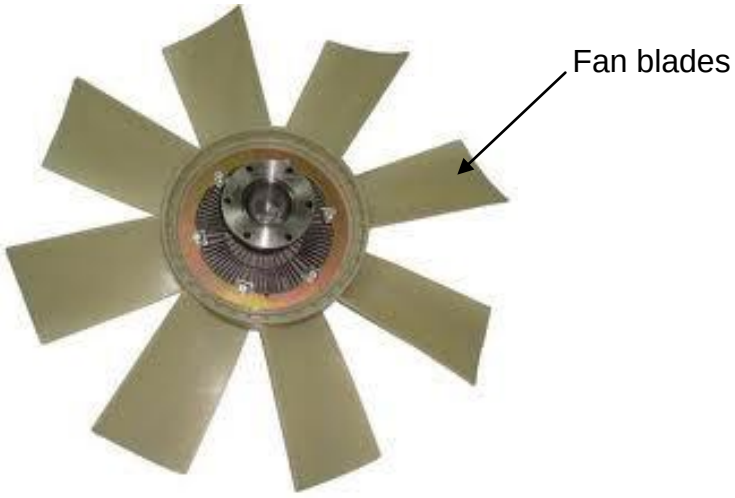


Fig. 3.1

The Thermostat

- It is obviously dangerous for an engine to run at too high a temperature. It is also dangerous for it to run at too low a temperature. The cooling system, therefore, includes a thermostat to control the temperature of the water.

- The thermostat is made of thin metal, which is very sensitive to heat and therefore reacts according to temperature variations. It is fitted in the circulating water.

- When the engine is started the thermostat is closed and the water will only circulate through the water jackets. Fig. 4 (next page) illustrates how the thermostat limits the water circulation to the water jackets by shutting off the water flow through the radiator when the temperature is low.

- When the engine has reached its normal operating temperature the thermostat will open and the water will start to flow through the radiator. Fig. 4 illustrates the circulation of the water through the radiator and the engine when the temperature of the engine rises, causing the thermostat to open.

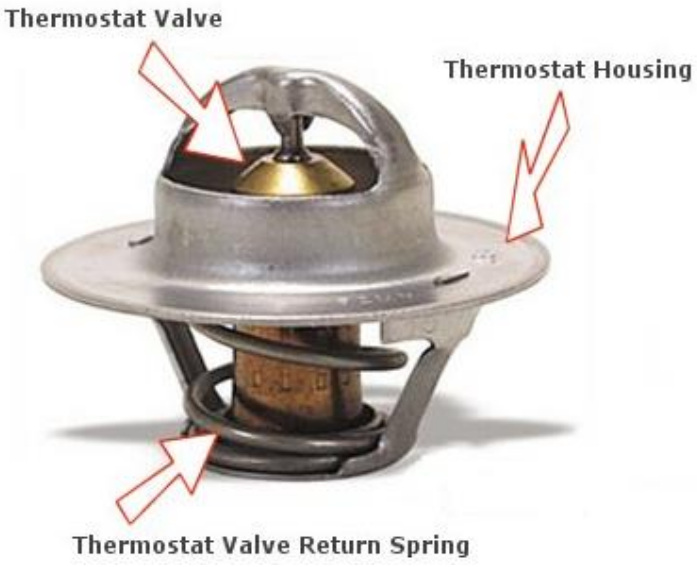


Fig. 4

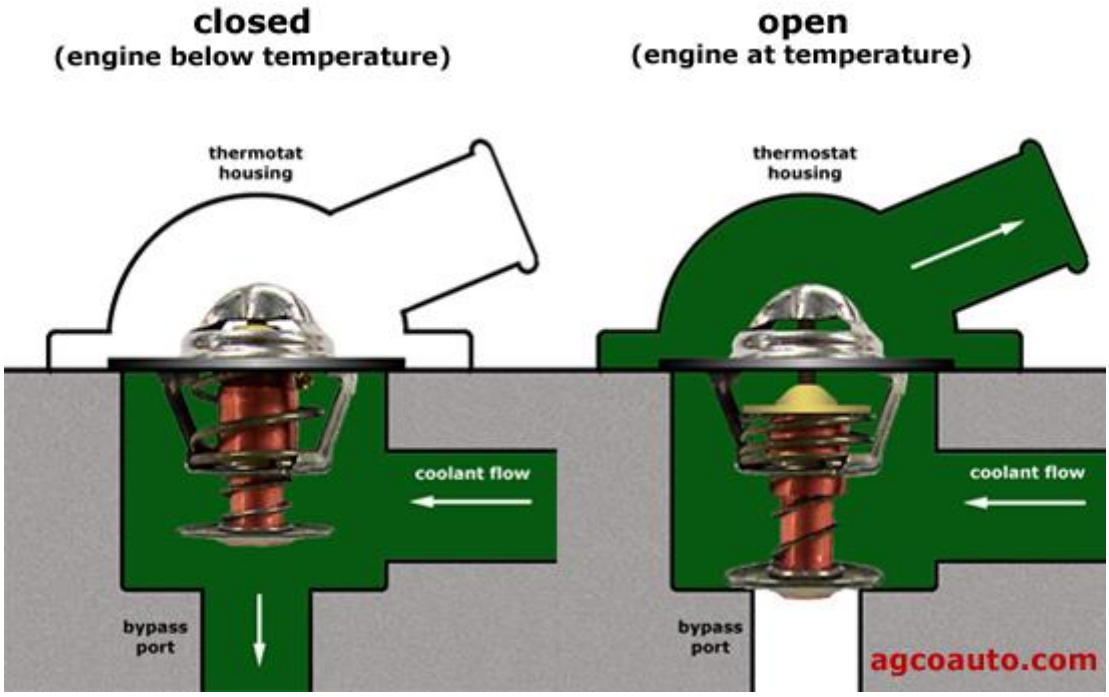


Fig. 4.1

The Radiator Cap

Fig. 5

- The cooling system is subjected to a certain pressure to increase the boiling temperature of the water. Water at the atmospheric pressure (sea level) boils at 100°C. When a pressure of 90 kPa is maintained in the cooling system the boiling temperature is increased to 122°C. This provides a considerable safety margin.

- The cap acts as a relief valve and so maintains the pressure. As soon as the pressure in the cooling system overcomes the pressure of the spring in the radiator cap, the valve is lifted off its seat and releases the excess pressure through the overflow pipe (Fig. 6).

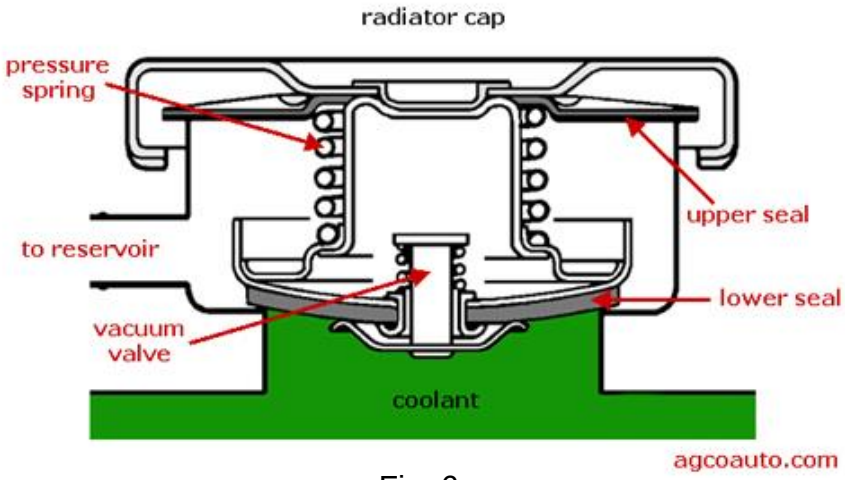


Fig. 6

3. FAULT FINDING ON A COOLING SYSTEM

ITEM / TASK: Fault finding on a cooling system

DESCRIPTION:
The following possible faults may cause overheating in the cooling system of a diesel engine:

- The fan blades are damaged so that they cannot draw sufficient air through the radiator.
- The fan is installed the wrong way around. Instead of drawing cool air through the radiator, it blows hot air from the engine, through the radiator.
- The thermostat sticks in the closed position.
- There is a restriction in the water jackets.
- The fan belt is too loose and slips on the pulley. This results in the pump not being able to circulate sufficient water.
- The tubes in the radiator are blocked which results in insufficient cooling.
- The water pump is damaged.
- The coolant level is too low.

DO THE SELF-TEST BEFORE CONTINUING WITH THE REST OF THE MODULE.

SELF TEST 1

1. What is the function of the following components?

   (a) The radiator?

   _____

   _____

   (b) The fan?

   _____

   _____

   (c) The water pump?

   _____

   _____

   (d) The thermostat?

   _____

   _____

2. What are the eight faults that can cause overheating in the cooling system?

   (a) _____

   (b) _____

   (c) _____

   (d) _____

   (e) _____

   (f) _____

   (g) _____

   (h) _____

Ask your Training Officer to check your work and if it is correct, to sign below and then go on to the next section.

LEARNER	TRAINING OFFICER
DATE :	DATE :
SIGNATURE :	SIGNATURE :

4. FLUSHING THE COOLING SYSTEM

ITEM / TASK: Flushing the Cooling System

DESCRIPTION:

Drain the coolant

- Remove the radiator cap.
- Unscrew the radiator drain plug (Fig. 7).

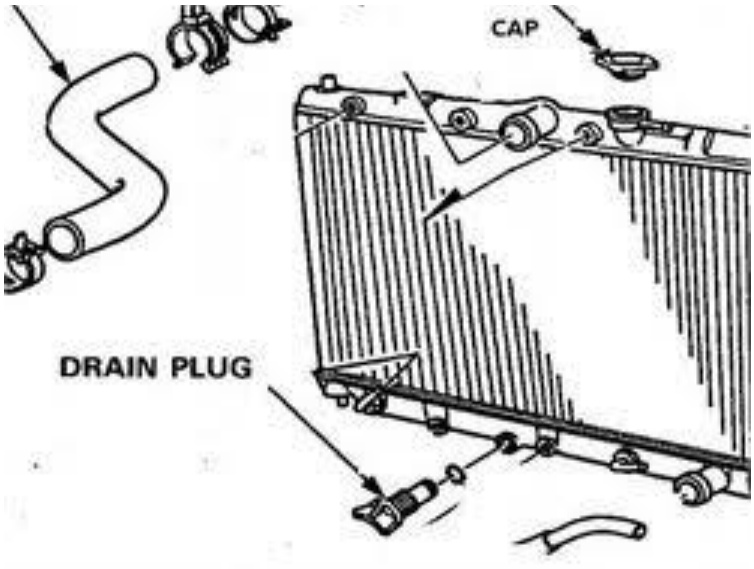


Fig. 7

- Drain the water from the engine block. The drain cock is situated on the side between the fuel injector pump and the bell housing

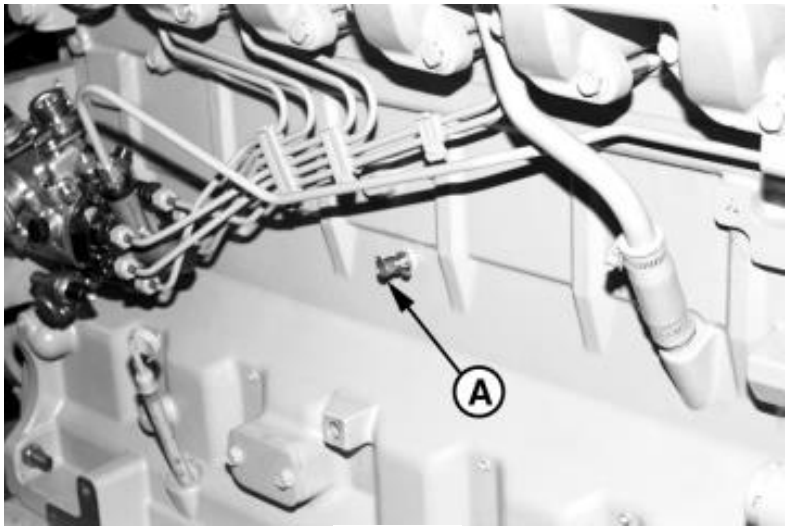


Fig. 8

- Unscrew the clamps nearest the radiator on both the top and bottom hoses shown in (Fig. 9).
- Pull the hoses off the radiator pipes.

  NB: Do not try to pry them off with a screwdriver as this could damage the radiator pipes as well as the hoses.
- Remove the thermostat, which is fitted in the cylinder head water outlet (Fig. 10 next page).

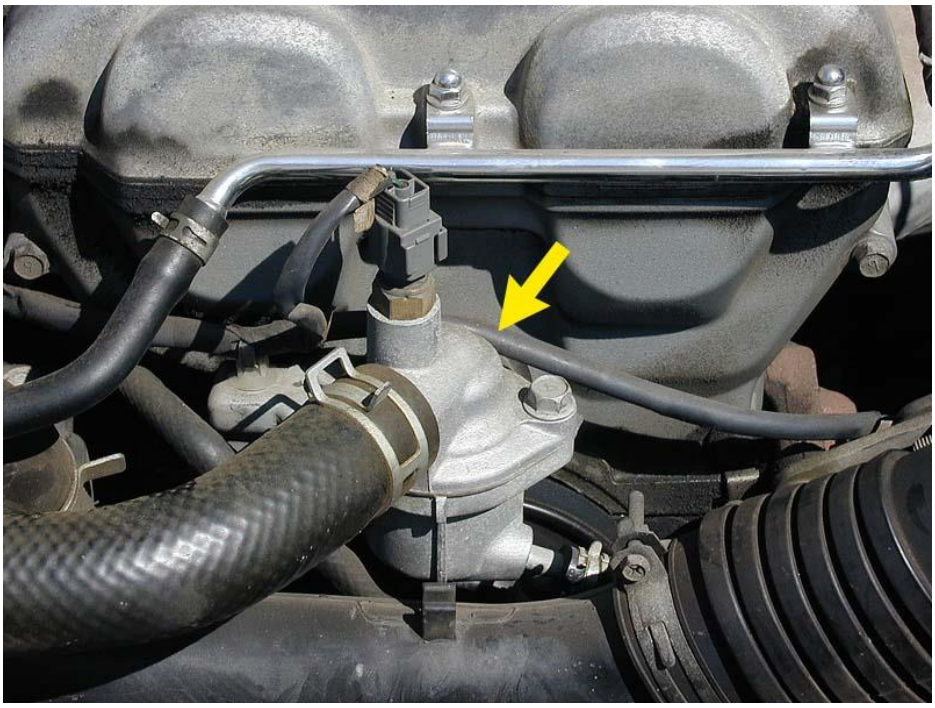


Fig. 9

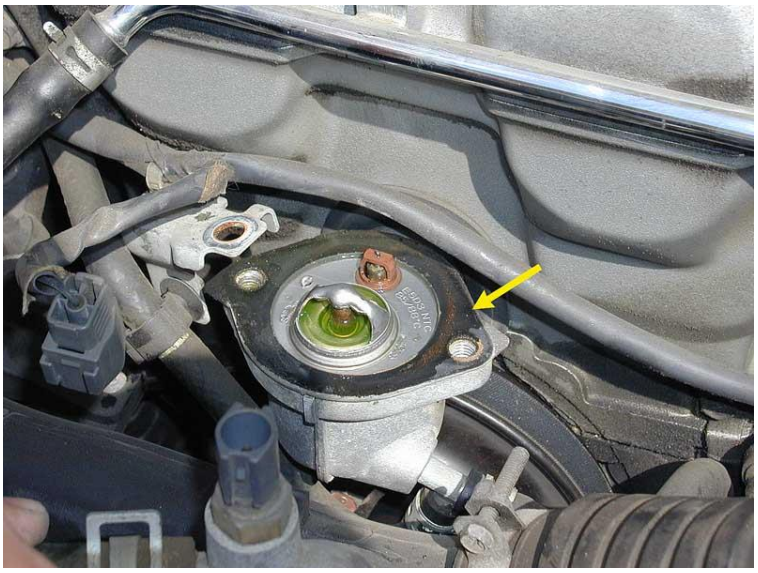


Fig. 10

- Insert a hose into the opening where the thermostat is fitted.

- Open the water tap to force water through the water jackets of the engine until they are clean (Fig. 11).

Insert hosepipe and flush with water until clean water is visible at lower radiator hose

Fig. 11

- Remove the hose and insert it into the lower radiator hose. This will force the water upward through the radiator until it is flushed clean (Fig. 12).

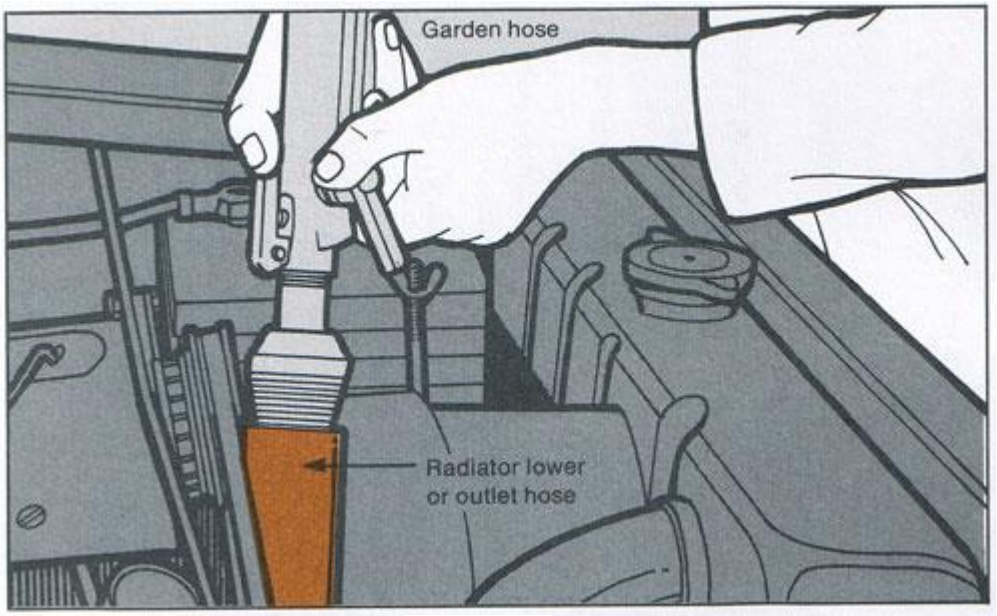


Fig. 12

NB: The cooling system must always be flushed before replacing the radiator.

5. TEST THE THERMOSTAT

ITEM / TASK: Test the thermostat

DESCRIPTION:

- Gently ease open the thermostat valve and place a 0,05mm feeler gauge between the valve and seat.
- Suspend the thermostat by the feeler gauge in a container filled with clean water.
- Gradually heat the water, and check the temperature at frequent intervals.
- Note the temperature at which the feeler gauge is released by the thermostat. It should be between 77°C and 84°C.

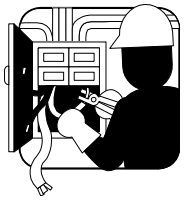
NB: If the temperature is not specified, the thermostat should be replaced.

- Replace the thermostat into the cylinder head water outlet.

Fig. 13

DO THE PRACTICE BEFORE CONTINUING WITH THE REST OF THE MODULE.

PRACTICE



Flush the cooling system of a diesel engine and test the thermostat.

Ask your Training Officer to check your work and if it is correct, to sign below and then go on to the next section.

LEARNER	TRAINING OFFICER
DATE :	DATE :
SIGNATURE :	SIGNATURE :

6. REMOVE AND REPLACE THE RADIATOR AND WATER PUMP

ITEM / TASK: Remove and Replace the Radiator and Water Pump

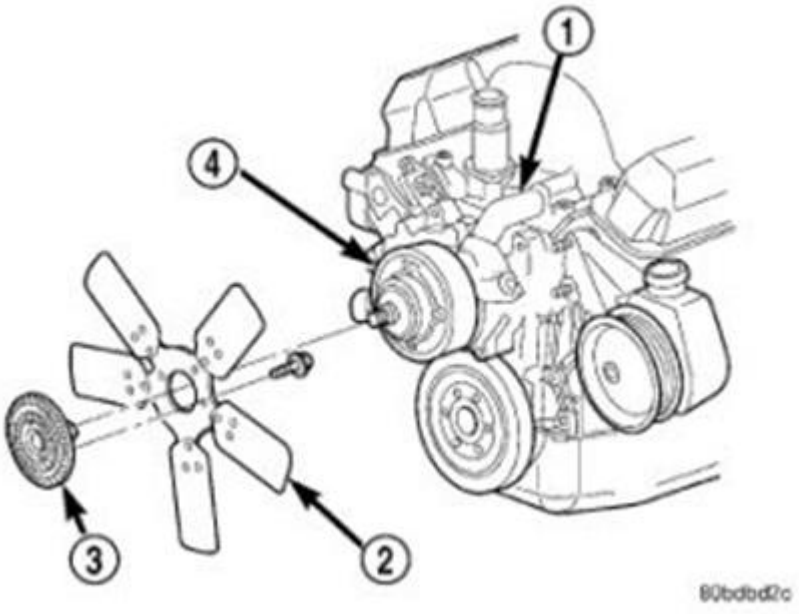
DESCRIPTION:

Remove the radiator

- Remove the bolts securing the radiator to the frame.
- Disconnect the top radiator bracket.
- Carefully pull the radiator away from the engine.

NB: Take care that the radiator cowling does not catch and bend the fan blades. Do not drop the radiator when it comes off the stand.

- Remove the fan by unscrewing the four bolts, which secure it to the water pump (Fig. 14).



1 - WATER PUMP BYPASS HOSE
2 - FAN BLADE ASSEMBLY
3 - VISCOUS FAN DRIVE
4 - WATER PUMP AND PULLEY

Fig. 14

Remove the fan belt

- Loosen, but do not remove, the fan belt adjusting screw (B) on the front of the generator and screw (C) on the front of the engine (Fig. 15).

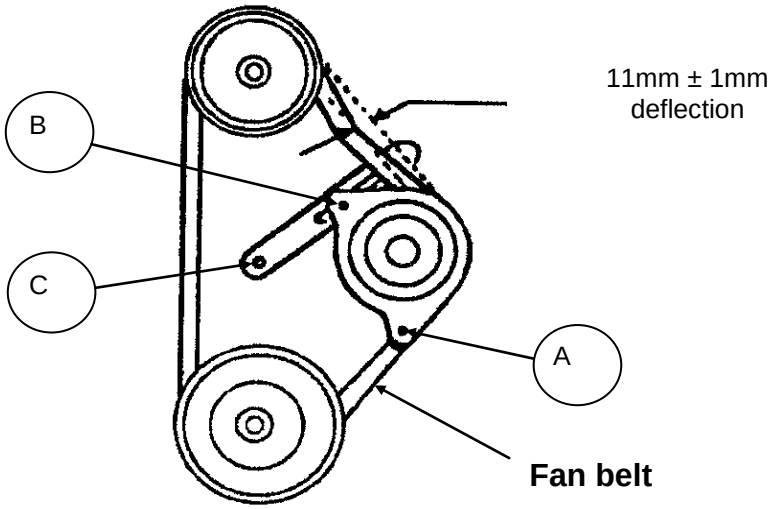


Fig. 15

- Slacken off both the generator mounting bolts (A).
- Push the generator so that it hinges towards the engine.
- Wind the fan belt from the pulleys.
- Remove the water pump
- Remove all the water hoses from the pump.
- Loosen and remove the pump securing bolts from the pump (Fig. 16 Next page).

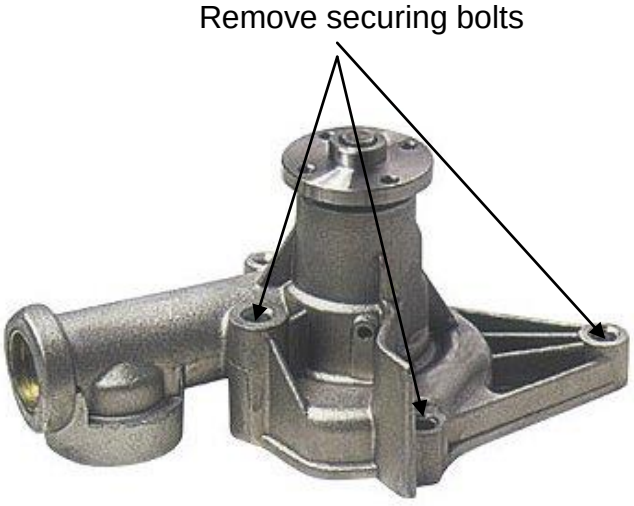


Fig. 16

- Remove the pump from the engine.

Replace the Radiator and Water Pump

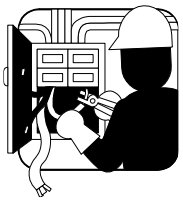
- Spin the pulley of the pump to ensure freedom of rotation.
- Check the radiator for damage.
- Clean the outside of the core with a solvent and compressed air.
- Check the pump gasket and replace it if necessary.
- Apply a soap solvent to the inside of the hoses and replace them on the pump.
- Replace the pump on the engine.
- Tighten the pump bolts evenly.
- Replace the fan.
- Replace the fan belt.

- Adjust the fan belt so that the belt can be depressed 11mm ± 1mm with the thumb applying pressure at a point midway between the water pump and generator pulley. Refer back to (Fig. 15).

- Replace the radiator.
- Replace the water hoses on the radiator using a soap solvent.
- Fill the radiator and engine with water.
- Start the engine and let it run until it has reached its normal temperature.
- Check for any water leaks.

DO THE PRACTICE BELOW BEFORE ATTEMPTING THE ASSESSMENT FOR THE MODULE.

PRACTICE



Remove the radiator and water pump from the engine, clean and inspect all the components and then replace the water pump and radiator onto the engine.

Ask your Training Officer to check your work and if it is correct, to sign below.

LEARNER	TRAINING OFFICER
DATE :	DATE :
SIGNATURE :	SIGNATURE :

7. COOLANT

ITEM / TASK: Properties of coolant (anti-freeze)

DESCRIPTION:

Ethylene Glycol Heat-Transfer Fluid

What is Coolant?

Generally, coolant is a half-and-half mixture of a form of glycol and water. The glycol represents the antifreeze element of the mix, guaranteeing that the fluid doesn't turn into ice under harsh winter conditions. On the other hand, glycol also prevents the coolant from reaching the boiling point in Death Valley heat; it keeps engine temperatures stable under all climate extremes and driving conditions.

Interestingly, pure water actually transfers heat better than coolant (that's why you see straight water used in the radiators of some types of race cars). However, coolant/antifreeze includes additional additives that prevent rust and corrosion in the radiator, engine and the vehicle's heater

Until recently, the most common glycol in antifreeze was ethylene glycol, a toxic material that can cause birth defects, reproductive damage or even death if ingested, and requires very specific handling. Ethylene glycol has a sweet odour and flavour, which makes it dangerously appealing to animals and/or small children.

An alternative antifreeze base is propylene glycol. There is very little difference in the performance of either substance; the advantage is the toxicity level. Propylene glycol is significantly less toxic than ethylene glycol. This doesn't mean children or pets can ingest it without harm, but, like alcohol, propylene glycol is not toxic at low levels.

Any antifreeze, whether ethylene or propylene glycol based, picks up heavy-metal contamination during use. For this reason, special care must be taken to dispose of used

antifreeze. It's safer to have a repair facility flush your cooling system since they are required by law to dispose of the material safely.

Most communities have procedures for disposing of hazardous waste; so, if you do your own repairs and maintenance, take advantage of these procedures. Don't pour coolant down your sink or into storm drains.

Maintenance

Like any other engine fluid, the coolant needs to be checked on a regular basis. You're checking for two things: quantity and condition. Since the 1970s, most vehicles have a coolant recovery tank or overflow reservoir, which makes checking the fluid level a lot easier and safer. The configuration of the radiator and tank/reservoir lets hot coolant expand into the tank as the engine temperature rises. When the engine cools down, a slight vacuum forms in the radiator and the fluid is drawn out of the tank/reservoir and back into the radiator. As long as the radiator cap remains sealed, the coolant can expand and contract without losing a drop.

You can check your coolant level simply by looking at this overflow tank. There are two level indicators on the side of the tank: one indicates the safe level when the engine is hot, the other when cold. If your coolant level is slightly low, it's safe to add a few ounces of plain water to bring the level back up to the appropriate mark. If you have to add more than a quart of liquid to the cooling system, use a glycol/water antifreeze mixture.

Nothing is ever all that simple, though. Some vehicles' recovery tanks are pressurized when the engine is hot, making the caps as dangerous to remove as radiator caps. Pressurized recovery tanks are clearly marked with warning decals and their caps is a system pressure cap, rather than a simple plug or twist-off cap.

Adding Antifreeze

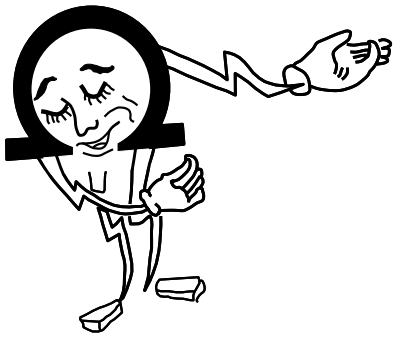
If the recovery tank is completely empty, you'll need to add a mixture of antifreeze/water to the radiator. Make sure your vehicle has had at least 30 minutes, and preferably longer, to cool off, so that the radiator hose is not hot to the touch. Remove the radiator cap, checking to make sure the cap's rubber seal is in good shape, and add the mixture to the top of the radiator neck. Put the radiator cap back on securely, and add the coolant to the cold level in the recovery tank.

In addition to checking for an adequate amount of fluid, you should examine the condition of the fluid. Coolant that's still working looks like clear, slightly thick lemonade, a pale greenish-yellow colour. Long-life coolants are orange, like pale orangeade. Some vehicle manufacturers employ a beige-coloured fluid. No matter what the colour, the key is that it's not brownish or dirty looking and that flecks of rust aren't floating around in it.

If the coolant is in bad condition, it's time to have the system flushed. The most common service interval for flushing the system is every two to three years, or 24,000 to 36,000 miles. When your vehicle goes longer than that timeframe without fresh fluid, you're engine may suffer some damage. So take care of your coolant—and your engine will keep its cool.

Freezing Point								
Ethylene Glycol Solution (*% by volume*)		**0**	**10**	**20**	**30**	**40**	**50**	**60**
Temperature	*(^{o}F)*	32	23	14	2	-13	-36	-70
	(^{o}C)	0	-3	-8	-16	-25	-37	-55

LEARNER	TRAINING OFFICER
DATE :	DATE :
SIGNATURE :	SIGNATURE :



REMEMBER ALWAYS WORK SAFE

Once you have passed the entire practices, you are now at liberty to request a Formative Assessment from your Assessor.