RQF LEVEL 3

AUTEC301

AUTOMOBILE TECHNOLOGY

Engine Cooling System Repairing

TRAINEE'S MANUAL

December 2023

ENGINE COOLING SYSTEM REPAIRING

2023

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LIST OF ABBREVIATIONS AND ACRONYMS

% **:** Percentages

°C : Degree Celsius

°F : Degree Fahrenheit

AC : Air Conditioning

CBET : Competency-Based Education and Training

cm : Centimeter

DMM : Digital Multimeter

Km/h : Kilometer per Hour

mph **:** Miles per Hour

RQF **:** Rwanda Qualification Framework

RTB: **:** Rwanda TVET Board

TVET **:** Technical and Vocational Education and Training

INTRODUCTION

This trainee's manual encompasses all necessary skills, knowledge and attitudes required to repair engine cooling system. Students undertaking this module shall be exposed with practical activities that will develop and nurture their competences. The writing process of this training manual embraced competency-based education and training (CBET) philosophy by providing enough practical opportunities reflecting real life situations.

The trainee's manual is subdivided into units, each unit has got various topics, trainee will start with a self-assessment exercise to help him/her rate him/herself on the level of skills, knowledge and attitudes about the unit.

A discovery activity is followed to help trainee discover what you already know about the unit.

After these activities trainee will learn more about the topics by doing different activities by reading the required knowledge, techniques, steps, procedures and other requirements under the key facts section, trainee may also get assistance from the trainer. The activities in this training manual are prepared such that they give opportunities to students to work individually and in groups.

After going through all activities, trainee shall undertake progressive assessments known as formative and finally conclude with his/her own self-reflection to identify your strengths, weaknesses and areas for improvements.

Trainee not forget to read the point to remember section which provides the overall key points and takeaways of the unit.

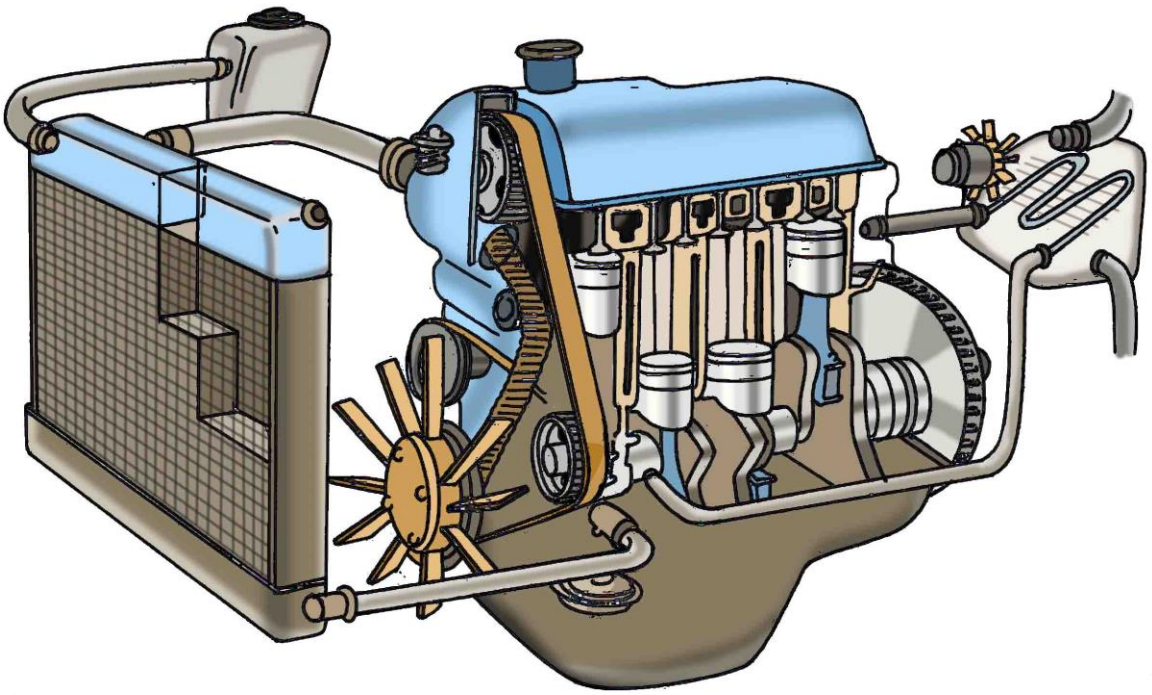
Module Units:

Unit 1: Describe engine cooling systems

Unit 2: Prepare the workplace and apply safety

Unit 3: Repair engine cooling system components

UNIT 1: DESCRIBE ENGINE COOLING SYSTEMS



Unit summary:

This unit provides you with the knowledge, skills and attitudes to describe the engine cooling systems. It covers the classification of engine cooling system and description of engine cooling system components.

Self-Assessment: Unit 1

1. **Examine the unit illustration above, then respond** to **the following inquiries.**
    a. What do you see in the illustration?
    b. What topics do you think will be covered under this unit based on the illustration?
2. **Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.**
    a. There are no right or wrong ways to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
    b. Think about yourself: do you think you have the knowledge, skills or attitudes to do the task? How well?
    c. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.
    d. At the end of this unit, you will assess yourself again.

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify the types of cooling system					
Describe the components of water- cooling system					
Describe the components of air-cooling system					
Explain the function of cooling system					
Explain the function of cooling system components					
Explain the construction materials of cooling system components					

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Explain the operating principles of cooling system components					
Comply with safety precautions at the workplace					
Demonstrate team spirit while working with others					
Comply with national and international standards at the Workplace					

Key Competencies:

Knowledge	Skills	Attitudes
1. Identify engine cooling systems	1. Describe engine water cooling systems	1. Comply with safety precautions at the workplace
2. Identify engine cooling system components	2. Describe engine air cooling system	2. Demonstrate team spirit while working with others
3. Explain the operating principles of cooling system components	3. Describe engine cooling system components	3. Comply with national and international standards at the workplace

Discovery activity

Task 1

In your home area there are garages that help people to repair and maintain their vehicles among others engine cooling systems. You have a chance to visit those garages and make several observations. Based on this experience answer the questions below:

1. What is an engine cooling system?
2. State the function of the engine cooling system.
3. What are the types of engine cooling systems do you know?
4. What is the difference between those engine cooling systems?
5. Enumerate the components of the engine cooling system.

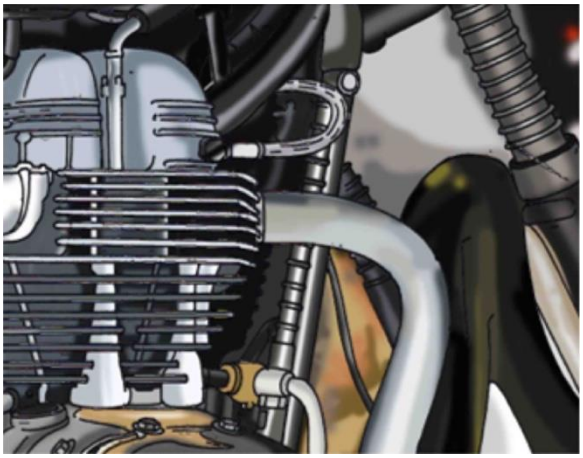
☞ Share your responses with the rest of the class.

Topic 1.1: Identification of Engine Cooling System

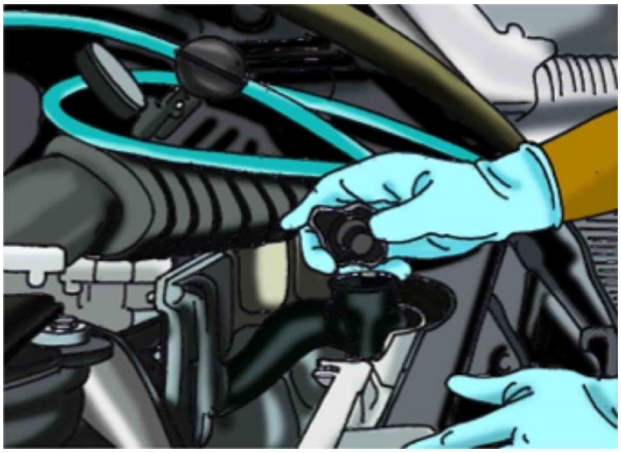
Activity 1: Problem Solving

Task 2:

Analyze the illustrations below and answer the questions:



Engine A



Engine B

1. What do you understand by engine cooling system?
2. Enumerate the functions of engine cooling system.
3. Categorize the engine cooling systems.
4. Mention the types of engine cooling systems shown in the above figure.

   A: …….

   B: …….

5. What are the advantages and disadvantages of each cooling system?

Key Facts 1.1 a: Identification of engine cooling system

- **Definition of engine cooling system**

An engine cooling system is a system integral with the engines. It carries away excess heat from the engine with the help of a flowing fluid.

The car cooling system cools the engine as it generates much heat. The engine of a small car traveling on a highway at 50 miles per hour will generate approximately 4,000 explosions per minute.

An engine continuously produces heat while running and converts it into power. If this heat energy is not transmitted into the atmosphere, the engine overheats which results in engine seizing.[1]

Along with all the friction from moving parts, this is a lot of heat that needs to be concentrated in one place. Without an efficient cooling system, the engine will heat up and stop running within minutes. A modern cooling system should ensure the coolness of the car at an ambient temperature of 115 degrees.[2]

- **Functions of engine cooling system**

Below are the functions of a cooling system in internal combustion engines:

- ✓ **The essence of the cooling system in IC engines is that the temperature of the burning gases (combustion gas) in the engine cylinder is up to 1500 to 2000 degree centigrade.**

[1] https://clubtechnical.com/engine-cooling-system

[2] https://www.idolz.com/en/2021/05/27/engine-cooling-system-how-it-works-and-main-components/#:~:text=The%20cooling%20system%20works%20by,absorbs%20heat%20from%20the%20engine

This is above the melting point of the material of the cylinder head and body of the engine. Therefore, if the heat is not dissipated, serious problems and failure occur to the cylinder material.

- ✓ **Reduce the temperature of lubricating oil that lubricates and cools the moving parts.**

  Very high temperature causes the film of the lubricating oil to get oxidized, which produces carbon deposit on the surface. This often results in piston seizure.

- ✓ **To remove heat at a fast rate when the engine is hot**

  Because too much heat removal lowers the thermal efficiency of the engine.

  The system is designed to remove at least 30% of the heat generated by the combustion chamber. A functional cooling system should be able to remove heat at a fast rate when the engine is hot. Engines are cool during the starting; much cooling is not needed so that the working parts can reach their working temperature in a short time.

- ✓ **To keep the temperature variation normal**

  Higher temperatures lower the volumetric efficiency of the engine. And because of overheating, larger temperature differences will result in distortion of the engine components due to the thermal stresses set up. For this, a functional cooling system is required to keep the temperature variation normal.

- **Categories of engine cooling system**

Engine cooling systems are categorized as follows: air cooled engine and water-cooled engine system.

- ✓ **Air-cooled engine system**

Here the engine relies on passing air to cool it down. These engines have fins on the outside to maximize surface area.

As the figure shows here, air is in direct contact with the engine hence it is also known as direct cooling system.

Air-cooled system is generally used on motorcycles. In this system, fins or extended surfaces are provided on the cylinder walls, cylinder head, etc. Heat generated due to combustion in the engine cylinder will be conducted to the fins and when the air flows over the fins, heat will be dissipated to air.

Figure 1:Air – Cooled engine

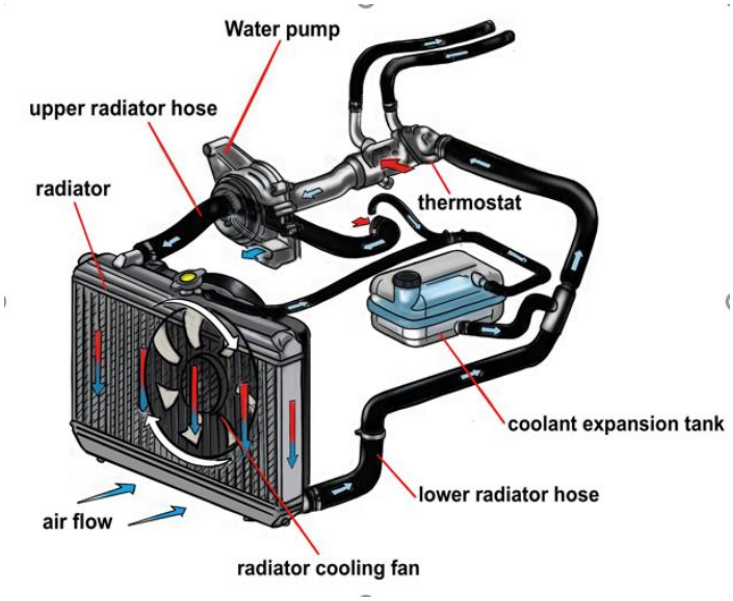


Figure 2: Water cooled system

Water cooled system

This is the most efficient way of cooling the engine. It is incorporated in most modern car engines and larger capacity motorcycles. Water-cooling uses a coolant fluid, which circulates throughout the engine and radiates the heat out through a larger radiator. These engines do not have fins. Instead, they have wider passages for free flow of the coolant.

In this method, cooling water jackets are provided around the cylinder, cylinder head, valve seats etc. The water when circulated through the jackets, it absorbs heat of combustion. This hot water will then be cooled in the radiator partially by a fan and partially by the flow developed by the forward motion of the vehicle. The cooled water is again recirculated through the water jackets.

There are two types of water-cooling system:

- **Thermosiphon System:** In this system the circulation of water is due to difference in temperature (i.e., difference in densities) of water. So, in this system a pump is not required but water is circulated because of density difference only.

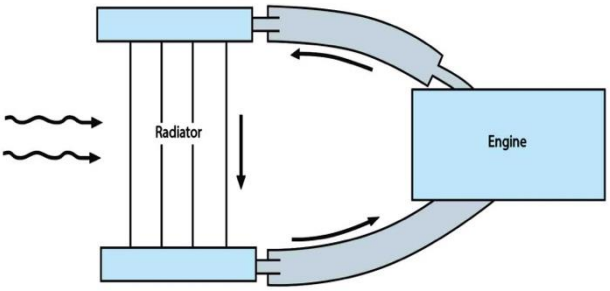


Figure 3: Thermosiphon System of cooling

- **Pump Circulation System:** In this system circulation of water is obtained by a pump. This pump is driven by means of engine output shaft through V-belts, timing belt, timing chain or timing gear.

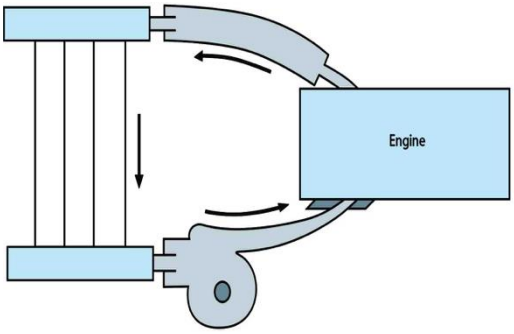


Figure 4: Pump circulation system

- **Difference between Air and water engine cooling system**

No.	Air cooling system	Water cooling system
1	In this system cooling medium used is **Air**	In this system cooling medium used is **Water**
2	The engine design is simple	The engine design is complex
3	The air-cooled engine is less sensitive to climate conditions.	Engine performance becomes more sensitive to climate conditions
4	Air cooling system has no maintenance	It requires maintenance. Slight leakage of radiator may result in engine breakdown
5	The warm up performance is better this results in low cylinder wear	The warm up performance is poor this results in greater cylinder wear

6	Size of engine is small and weight is less as there is no water jacket, radiator and water pump	Size and weight of engine is increased to use of due radiator, water jacket and water pump
7	Air cooled engine must be installed in front side of the vehicle	Water cooled engine can be installed anywhere on the vehicle
8	Volumetric efficiency is lower due to high cylinder head temperature	Volumetric efficiency is greater than air cooled engine.
9	Examples: Bikes, Scooters etc.	Examples: Cars, Buses, Trucks etc.

- **Advantages and disadvantages of air and water engine cooling system**

No.	Advantages of Air cooling system	Disadvantages of air cooling system
1	**Simplicity and Cost-Effectiveness**: Air cooling systems are generally simpler and more cost-effective to manufacture and maintain compared to liquid cooling systems.	**Limited Cooling Capacity**: Air cooling is less efficient than liquid cooling, especially under heavy load or high-temperature conditions. This can lead to overheating in certain situations.
2	**Lightweight Design**: Air-cooled engines tend to be lighter because they lack the additional weight of a liquid cooling system, making them suitable for certain applications where weight is a critical factor.	**Temperature Fluctuations:** Air-cooled engines may experience temperature fluctuations, especially in extreme conditions, which can affect performance and efficiency.
3	**Reduced Complexity**: Air-cooled engines have fewer components, which can result in a reduction of overall system complexity and fewer potential points of failure.	**Noise Level:** Air-cooled engines can be noisier due to the direct exposure of components to air, which can impact overall comfort, especially in applications where noise is a concern.
4	**Quick Warm-Up**: Air-cooled engines warm up faster since there's no need to wait for a	**Limited Cooling Control**: Air cooling provides less control over the engine's operating temperature compared

	liquid to reach operating temperature.	to liquid cooling systems, potentially impacting overall engine efficiency and lifespan.
No	**Advantages of water-cooling system**	**Disadvantages of water-cooling system**
1.	**Efficient Heat Dissipation:** Water cooling systems are highly effective at dissipating heat from the engine, preventing overheating and ensuring optimal performance.	**Complexity and Cost:** Water cooling systems are more complex and costlier to manufacture and maintain compared to air cooling systems, adding to the overall cost of the vehicle.
2.	**Temperature Control:** Water-cooled engines offer precise temperature control, maintaining a stable operating temperature for improved efficiency and longevity.	**Weight:** The additional components of a water-cooling system, such as the radiator, water jackets and water pump, contribute to the overall weight of the vehicle, which may impact fuel efficiency and handling.
3.	**Quieter Operation:** Water cooling systems generally operate more quietly than air cooling systems, contributing to a quieter driving experience.	**Maintenance Requirements:** Water cooling systems require regular maintenance, including monitoring coolant levels and periodic flushing, to prevent issues like corrosion and scale build up.
4.	**Adaptability to High Temperatures:** Water-cooled engines can handle higher operating temperatures without the risk of overheating, making them suitable for demanding driving conditions.	**Vulnerability to Freezing:** In cold climates, the water in the cooling system can freeze, potentially causing damage to the engine and components. The use of antifreeze helps address this issue but requires careful attention.
5.	**Consistent Performance:** The stable temperature maintained by water cooling systems helps ensure consistent engine performance, contributing to fuel efficiency and overall reliability.	**Potential for Leaks:** Water cooling systems are susceptible to leaks, which can lead to coolant loss and overheating if not promptly addressed. Regular inspections are necessary to identify and fix potential leaks.

- **Characteristics of an efficient engine cooling system**

The following are two main characteristics of an efficient engine cooling system.

- ✓ It should be capable of removing about 30% of the heat generated in the engine, while maintaining optimum working temperature in the engine.
- ✓ It should remove heat at a faster rate when the engine is hot and remove engine at slow rate when engine is cold.

Key Facts 1.1 b: Working principle of water-cooling system

The engine water cooling system operates by circulating a mixture of water and antifreeze through the engine and radiator to manage heat generated during combustion. Here's a concise resume of its working principle:

- ✓ **Circulation Pump**: Driven by the engine, a water pump circulates coolant through the system.
- ✓ **Engine Block and Cylinder Head**: Coolant absorbs heat in the engine block and cylinder head, stemming from combustion.
- ✓ **Thermostat**: Regulates coolant flow based on engine temperature, ensuring optimal operating conditions.
- ✓ **Radiator**: A heat exchanger positioned at the front of the vehicle facilitates heat dissipation as hot coolant passes through.
- ✓ **Cooling Fans**: Electric or engine-driven fans assist in cooling during low-speed conditions.
- ✓ **Coolant Recovery Tank/expansion tank**: Excess coolant and pressure are directed to a recovery tank, maintaining system integrity.
- ✓ **Repeat Cycle**: Continuous circulation maintains the engine at an optimal temperature, preventing overheating and ensuring efficient combustion.

Activity 2: Guided Practice

Task 3

Visit the school workshop and perform the following tasks, under the guidance of your trainer.

1. What are the cooling systems used for the vehicles and motorcycles in the workshop?
2. Mention the differences of the cooling systems from the above.
3. Mention the working principle of the water-cooling system.

Activity 3: Application

Task 4

Read the following scenario and answer the questions

1. Visit the nearest garage and observe the engine's cooling systems being repaired by mechanics.
2. Analyze the engines' cooling systems and make a report focusing on:
    a. Engine cooling system description and its function in the engine
    b. Air cooling system description
    c. Water cooling system description
    d. Differences between the two systems
    e. Advantages and disadvantages of the two systems
    f. Working principle of water-cooling system description

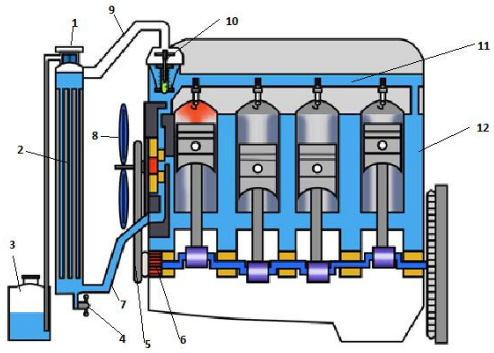
Topic 1.2: Description of Engine Cooling System Components

Activity 1: Problem Solving

Task 5

Analyze the illustrations below and answer the questions that follow.

Mention the engine cooling system components bellow labelled from 1 to 12.



1. Mention the function of each component
2. Are there any other components of an engine cooling system BUT NOT shown in the figure? If YES, mention them.

Key Facts 1.2: Description of engine cooling system components

- **Engine cooling system components**

Below are the components of the cooling system in an internal combustion engine and their functions:

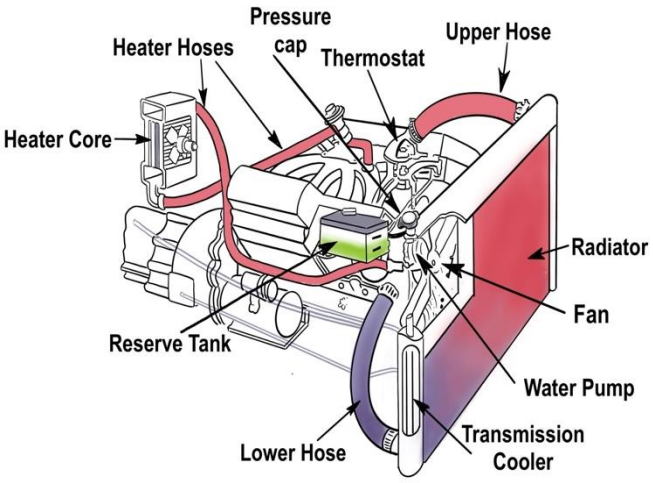


Figure 5: Engine water cooling system components

Radiator

This engine cooling part is made up of aluminium tubes and strips that zigzag between the tubes.

High-temperature fluid flows inside the radiator through a hose. This heated fluid is then transferred from the tube to the air stream, which is then blown away into the atmosphere.

It mainly consists of an upper tank and lower tank and between them is a core. The upper tank is connected to the water outlets from the engine's jackets by a hose pipe and the lover tank is connected to the jacket inlet through a water pump by means of hose pipes.

- ✓ The two types of radiator cores in common use in most vehicles are:
  - Serpentine fin core
  - Plate fin core

In each of these types, the coolant flows through oval-shaped core tubes. Heat is transferred through the tube wall and soldered joint to cooling fins. The fins are exposed to the air that flows through the radiator, which removes heat from the radiator and carries it away.

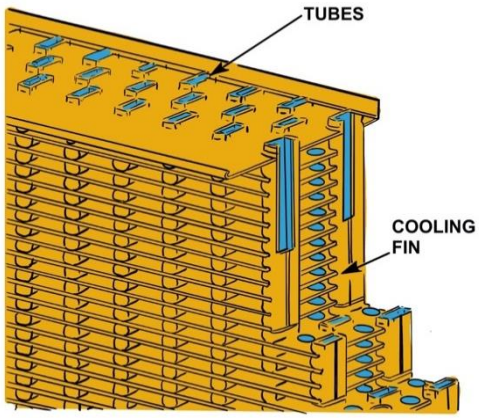


Figure 6: The tubes and fins of the radiator core

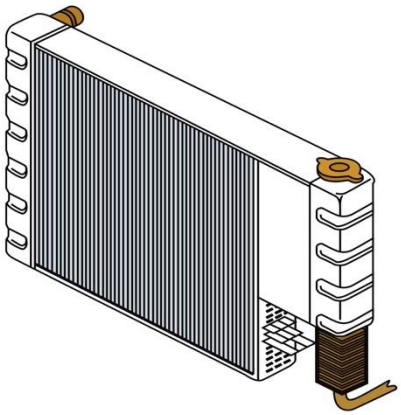


Figure 7: Types of radiators (down-flow or a crossflow type)

- **Radiator fan**

The cooling fan is located a bit after the radiator, which is closest to the engine. The part is designed to protect fingers and direct airflow. It blows air to the radiator to cool the hot fluid while the engine is running, so the fan helps to cool down the temperature of the radiator.

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 or driven by an electric motor. A belt-driven fan is bolted to a pulley on the water pump and turns constantly with the engine. Thus, belt-driven fans always draw air through the radiator from the rear. The fan has several blades made of steel, nylon or fiberglass, which are attached to a metal hub.

Because fan air is usually only necessary at idle and low-speed operation, various design concepts are used to limit the fan's operation at higher speeds. Horsepower is required to turn the fan. Therefore, the operation of a cooling fan reduces the available horsepower to the drive wheels as well as the fuel economy of the vehicle. Fans are also very noisy at high speeds, adding to driver fatigue and total vehicle noise.

✓ **Fan clutch**

To eliminate this power drain during times when fan operation is not needed, many of today's belt driven fans operate only when the engine and radiator heat up. This is accomplished by a **fan clutch** located between the water pump pulley and the fan. When the engine and fan clutch are cold, the fan moves independently from the clutch and moves little air. The clutch locks the fan to its hub when the temperature of the air around the fan reaches a particular point. In most cases, the clutch slips at high speeds; therefore, it is not turning at full engine speed. The clutch assemblies rely on a thermostatic spring or silicone fluid.

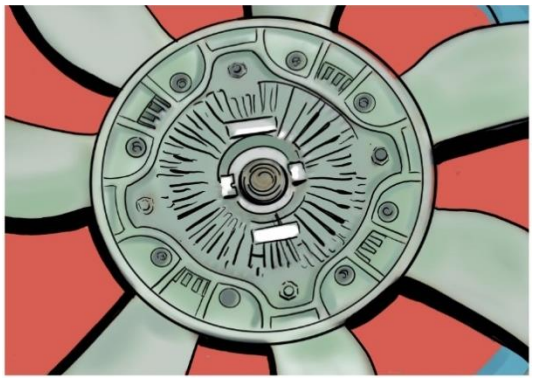
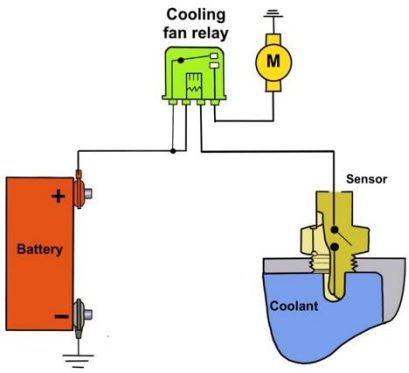


Figure 8: A viscous-type fan clutch

✓ **Electric Cooling Fans**



In most late-model applications, to save power and reduce the noise level, the conventional belt-driven, water pump-mounted engine cooling fan has been replaced with an electrically driven fan. This fan and motor are mounted to a shroud. The 12-volt, motor-driven fan is electrically controlled by an engine coolant temperature switch and/or the air conditioner switch.

Figure 9: A simple schematic for an electric cooling fan

As the schematic shows, the cooling fan motor is connected to the battery through a normally open (NO) set of contacts in the cooling fan relay.

During normal operation, with the air conditioner off and the engine coolant below a predetermined temperature of approximately 215°F (101.6°C), the relay contacts are open and the fan motor does not operate.

When coolant temperatures exceed approximately 230°F (110°C), the coolant temperature switch closes This energizes the fan relay coil, which in turn closes the relay contacts. The contacts provide 12 volts to the fan motor.

✓ **Electronically controlled cooling fan**

Most electric cooling fans are computer controlled. To save energy, most cooling fans are turned off whenever the vehicle is traveling faster than 35 mph (55 km/h). The ram air caused by the vehicle speed is enough to keep the radiator cool. Of course, if the computer senses that the temperature is still too high, the computer will turn on the cooling fan, too high, if possible, in an attempt to cool the engine to avoid severe engine damage.

- **Thermostat**

The thermostat is simply a valve that senses or measures the temperature of the coolant and, if it is hot enough, opens to allow the coolant to flow through the radiator. If the coolant is not hot enough, the flow to the radiator is blocked and fluid is directed to a bypass system that allows the coolant to return directly back to the engine.

The bypass system allows the coolant to keep moving through the engine to balance the temperature and avoid hot spots.

Because flow to the radiator is blocked, the engine will reach operating temperature sooner and, on a cold time, will allow the heater to begin supplying hot air to the interior more quickly. **(A) Closed** **(B) Open**

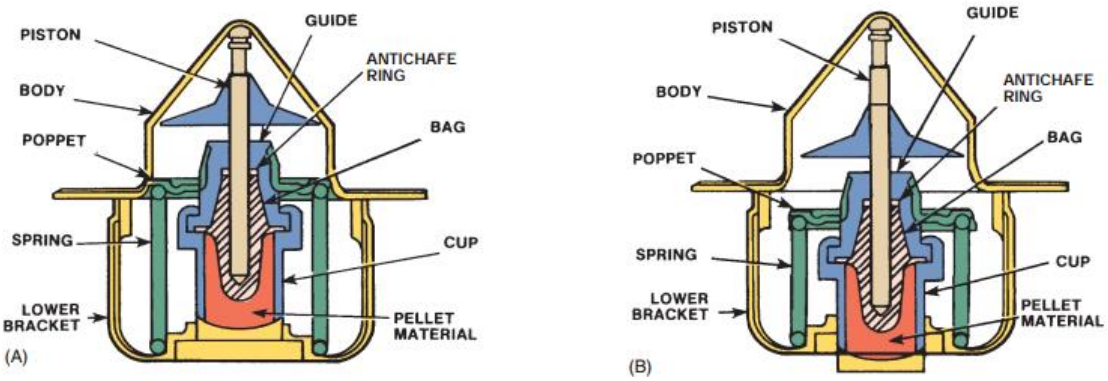
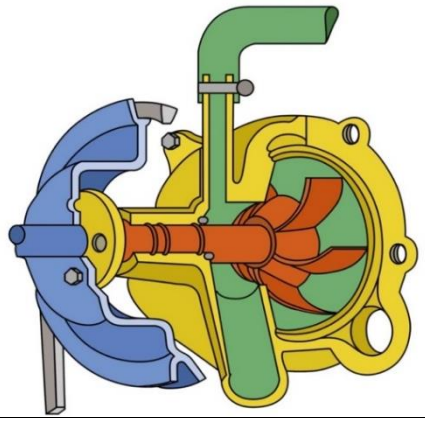


Figure 10: Thermostat

- **Coolant pump/water pump**

The water pump is a centrifugal pump that can move a large volume of coolant without increasing the pressure of the coolant.



The pump pulls coolant in at the center of the impeller. Centrifugal force throws the coolant outward so that it is discharged at the impeller tips.

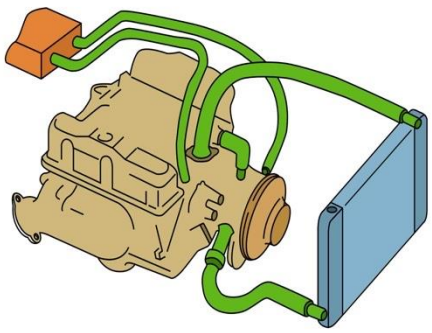
Figure 11: An impeller-type water

The water pump is driven by the engine through one of the following:

- ✓ A V belt that will also be responsible for driving an additional component like an alternator or power steering pump, a serpentine belt, which also drives the alternator, power steering pump and AC compressor among other things.
- ✓ The timing belt that is also responsible for driving one or more camshafts.
- ✓ Timing chain
- ✓ Timing gear

- **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 butyl or neoprene 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.

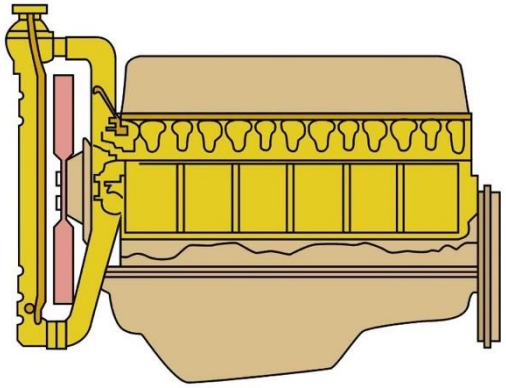


All three parts are bonded together. Basically, the difference in hose construction lies in what the hose will carry, where it is located and the temperature and pressure it will face.

Cooling system hoses must be able to endure heavy vibrations and be resistant to oil, heat, abrasion, weathering and pressure.

Figure 12: Routing of coolant through the cooling system hoses

- **Water jacket**



Hollow passages in the block and cylinder heads surround the areas closest to the cylinders and combustion chambers. Included in the water jackets are soft (core) plugs and a block drain plug. Some engines are equipped

with plastic liners that direct coolant flow around critical areas.

Figure 13: Engine's water jacket

The soft plugs and drain plugs are usually removed during engine teardown. New ones are installed during reassembly. Core plugs are prone to rust and corrosion and, therefore, will weep coolant or rust through completely. When this happens, the core plugs should be replaced.

- **Radiator cap/pressure cap**

Radiators are now designed with a pressure cap so that pressurized coolant flows out as it expands. Thus, the function of the pressurized cap is to maintain pressure in the cooling system up to a certain point. This cap featured a spring valve, calibrated to the correct pounds per square inch (psi).

If the pressure is up higher than the set pressure points, it opens and a small amount of coolant is bleed off. The reserve tank is a reservoir that collects the coolant bled off from the pressurized cap. The tank is typically made of plastic and it can indicate the temperature of the coolant.

The pressure in the system is regulated by a pressure relief or vent valve in the radiator cap. 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. Coolant pressure builds up as the temperature of the coolant rises. When the pressure reaches the pressure rating of the cap, it pushes up on the spring in the pressure relief valve. This opens the valve and allows excess pressure to exit the radiator through a bore between the upper and lower seals. The bore is connected, by a tube, to the expansion or recovery tank. When enough pressure has been released to drop system pressure below the cap's rating, the spring will close the pressure relief valve. When the coolant cools, its pressure drops. The low pressure opens the vacuum relief valve. The low pressure then draws coolant from the expansion tank to refill the radiator. All radiator caps are designed to meet SAE standards for safety. This standard specifies that there shall be a detent or safety stop position allowing pressure to escape from the system without allowing the hot coolant to blow out of the radiator's neck. Only after all pressure has been relieved should the cap be removed from the filler neck.

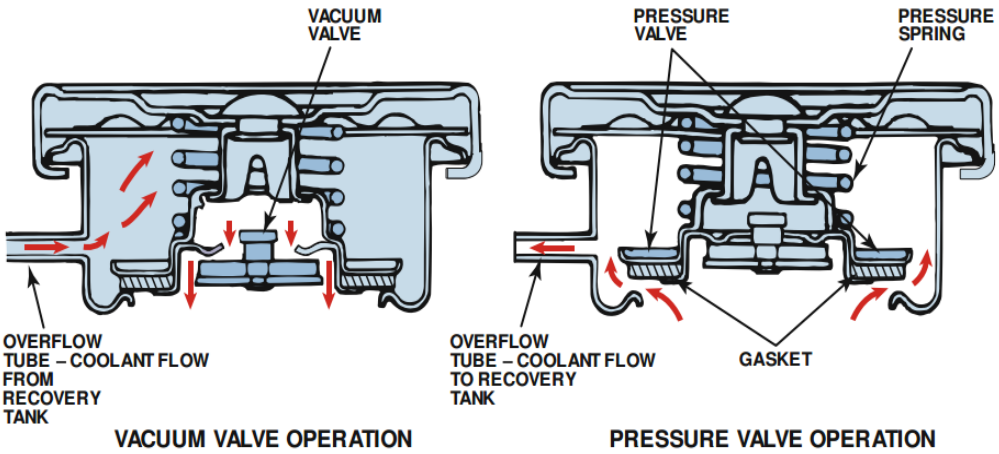


Figure 14: Vacuum valve operation and pressure valve operation

The pressure valve maintains the system pressure and allows excess pressure to vent. The vacuum valve allows coolant to return to the system from the recovery tank.

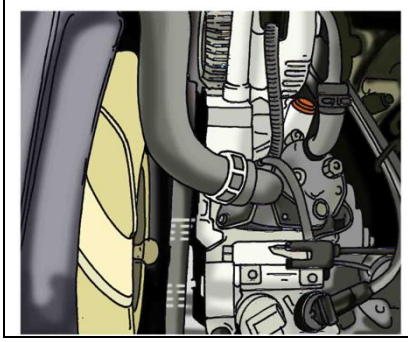
- **Reservoir tanks/expansion tank**

All late-model cooling systems have an expansion or recovery tank. Cooling systems with expansion tanks 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. The coolant passes to an expansion tank.

When the engine is shut down, the coolant begins to shrink.

Figure 15: A coolant expansion tank

Eventually, the vacuum spring inside the pressure cap opens and the coolant in the expansion tank is drawn back into the cooling system.



- **Belt**

Belt drives are used to power the water pump and/or cooling fan on many engines. The belts must be in good condition and properly tensioned in order to drive this at the correct speed.

Figure 16: A belt-driven cooling fan

- **Core plugs**

The plugs are set in various places around the engine block and cylinder head. Their purpose is to seal holes left in the block and head when those components were cast. They also provide weak points which can give way under the pressure of expanding coolant if the engine freezes or overheats. They could possibly prevent frozen coolant cracking the casting.

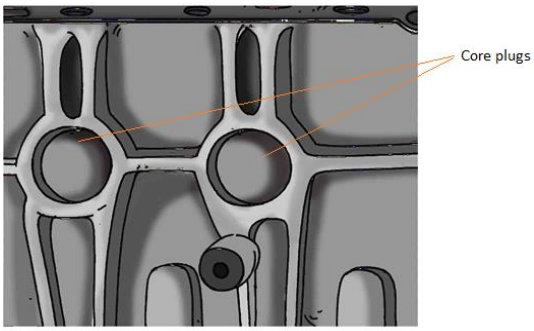


Figure 17: Core plugs

Activity 2: Guided Practice

Task 6

Visit the school automotive workshop, where you are requested to do the following:

1. Identify the cooling system components for the various engines.
2. Explain the operation of each system component.

Activity 3: Application

Task 7

Visit a nearby garage with various engines and compile the report showing the following:

1. Engine cooling system components,
2. Functions of engine cooling system,

3. Is the engine cooling system effective or not? Why?

Formative Assessment

1. In a thermo-siphon system, the radiator should be kept well above the engine, to provide a height for natural circulation.
   a) True
   b) False
2. All of the following statements are TRUE about Radiator Caps EXCEPT:
   a) Caps relieve pressure to prevent freezing
   b) Caps are spring-loaded to pressurize the cooling system
   c) Pressurizing the cooling system raises the temperature at which coolant boils
3. What is the role of a thermostat?
   a) Regulates the operating temperature of the engine
   b) Affects the operation of the computerized engine control system
   c) Reduces the time it takes the engine to warm up following a cold start
   d) All of the above
4. Technician A says the water pump pulls coolant from the engine and pushes it to the radiator.
   Technician B says the water pump in a “Reverse Flow” cooling system routes coolant to the cylinder heads first and then the engine block.
   Who is right?
   a) Technician A only
   b) Technician B only
   c) Both Technician A and B
   d) Neither one
5. Where heat deposition takes place in the water-cooling system?
   a. Radiator
   b. Water pump
   c. Water jackets
   d. Fan
6. The purpose of thermostat is to keep engine
   a) Warm
   b) Cool
   c) At desired temperature
   d) Hot
7. The center section of the radiator made up of tubes and cooling fins is called
   a) Water pump
   b) Fan
   c) Radiator filler cap

d) Core

Points to Remember

- An engine cooling system is a system integral with the engines. It carries away excess heat from the engine with the help of a flowing fluid.
- There are two types of cooling systems
  - ✓ water cooling system and
  - ✓ air cooling system
- Water flowing in the jackets takes out heat from the engine. This hot water then flows through a radiator, where it gets cooled from the cold heat blown through a fan.
- In an air-cooling system, an engine is cooled directly with the help of air flowing through it. Air cooling system is used for small engines, like that of bikes and grass cutters.
- Both systems have advantages and their limitations.

Self-Reflection

1. Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes after covering this unit.

   There are no right or incorrect answers for this evaluation. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
2. Think about yourself:

   a) Do you think you have the knowledge, skills or attitudes to do the task?

   b) How well?

3. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

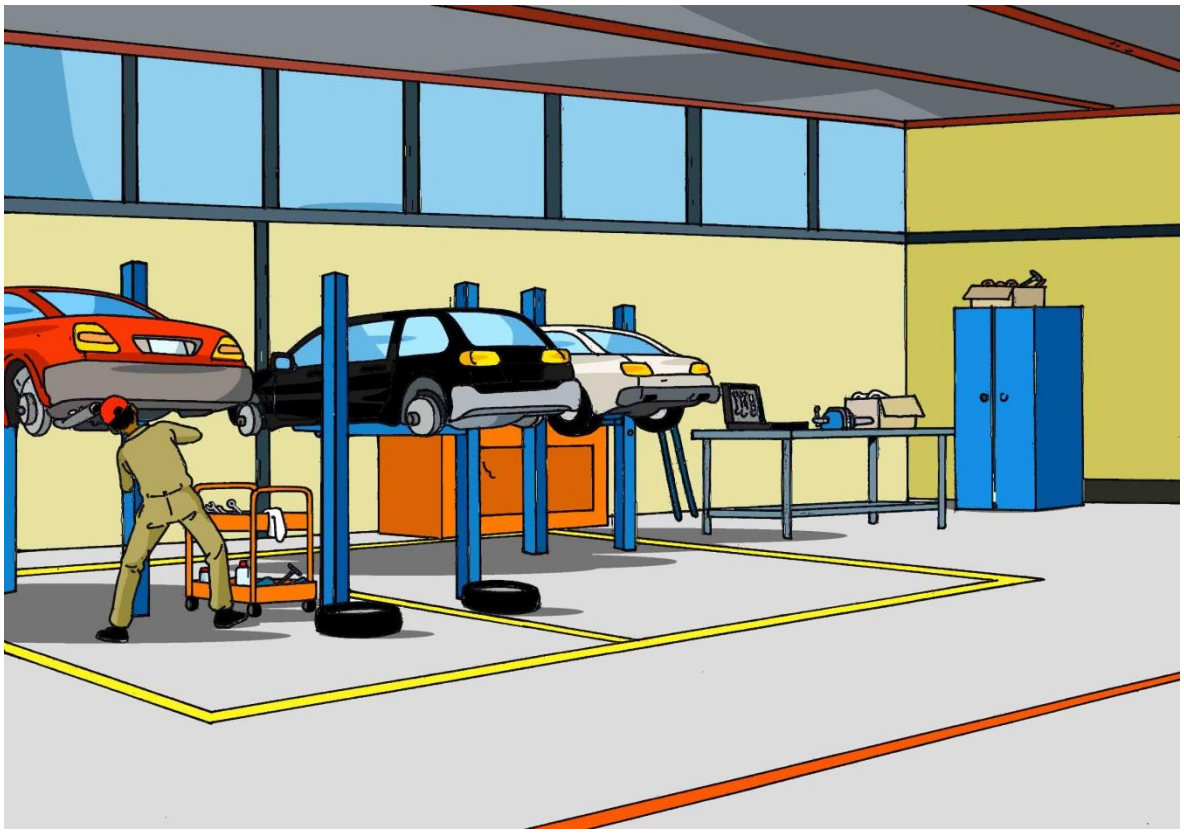
My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify the types of cooling system					
Describe the components of water cooling system					
Describe the components of air-cooling system					
Explain the function of cooling system					
Explain the function of cooling system components					
Explain the construction materials of cooling system components					
Explain the operating principles of cooling system components					
Comply with safety precautions at the workplace					
Demonstrate team spirit while working with others					
Comply with national and international standards at the workplace					

4. Fill in the table below and share the results with the trainer for further guidance.

Areas of strength	Areas for improvement	Actions to be taken to improve

1.	1.	1.
2.	2.	2.
3.	3.	3.

UNIT 2: PREPARE WORKPLACE AND APPLY SAFETY



Unit summary:

This unit provides you with the knowledge, skills and attitudes to prepare for the workplace. It covers the identification of safety precautions at workplace, selection of personal protective equipment (PPE) and cleaning and arrangement of the workplace.

Self-Assessment: Unit 2

1. **Study the unit illustration above and answer the following questions:**
    a. What do you see in the illustration?
    b. What topics do you think will be covered under this unit based on the illustration?
2. **Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.**
    a. a. There are no right or incorrect answers for this evaluation. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
    b. Think about yourself: do you think you have the knowledge, skills or attitudes to do the task? How well?
    c. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.
    d. At the end of this unit, you will assess yourself again.

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Identify personal safety at workplace					
Describe the work area safety at workplace					
Describe the tools and equipment safety					
Classify personal protective equipment (PPE)					
Use of personal protective equipment (PPE)					
Identify types of cleaning method at workplace					
Describe the procedures for cleaning the workplace, tools and equipment					

Key Competencies:

Knowledge	Skills	Attitudes
1. Identify the personal Safety precautions at workplace	1. Describe the Safety precautions at workplace	1. Pay attention to details while describing the procedures for cleaning the workplace, tools and equipment
2. Classify personal protective equipment (PPE)	2. Use of personal protective equipment (PPE)	2. Demonstrate team spirit while working with others
3. Identify types of cleaning method at workplace	3. Describe the procedures for cleaning the workplace, tools and equipment	3. Pay attention to details while usage of personal protective equipment (PPE)
	4. Apply cleaning techniques	

Discovery activity

Task 8:

Analyze the figure below and answer the following questions:

1. What do you see in the picture?
2. Explain the personal protective equipment you see in the picture.
3. In the picture below explain the types of hazards an employee must prevent at the workplace.
4. Describe the type of cleaning the person is performing in the picture. Are there others that are not shown in the picture? If YES, state them.

Topic 2.1: Application of Safety Precautions at Workplace

Activity 1: Problem Solving

Task 9:

Talk about the image below and provide answers to the following questions

FLOOR CARE

Don't slip up! Oil, transmission fluid and other liquids can leave mechanics at risk of falls so be sure to clean up spills immediately.

Give work hazards the boot. All mechanics should wear proper steel toe work boots for protection, with non-slip soles to reduce the risk of falling on the job.

Sweep up regularly. Dust particles from drum lathes and the residue of chemical substances can be hazardous to the health if inhaled, so be sure to sweep & clean the floors daily.

PROTECTIVE CLOTHING

Too Hot to Handle. Engines and other auto parts can get very hot, so be sure to wear gloves before you handle them.

Don't turn a blind eye to safety. Protective safety goggles should be worn when welding grinding, or working with chemicals to prevent eye injury.

Not just a fashion statement. Overalls protect the body coming into contact with dangerous chemicals. Keep them on at all times.

CHEMICAL CARE

Don't take lunch on the job. Try not to consume food and drink on the shop floor, as it can be at risk of being contaminated, and always eat off clean surfaces.

Dispose of waste wisely. Follow proper guidelines for disposing of chemical waste such as gasoline, especially if it's flammable.

Breathe easy. Make sure that your shop is properly ventilated in order to limit inhalation of harmful fumes.

VEHICLE SAFETY

Don't get a shock! Cut the power supply to all electrical components before working on them to prevent electrocution.

Don't lift more than you carry. Use proper lifting techniques when handling heavy parts. Lift in pairs, and use hoists when necessary.

Make sure the vehicle is stopped. Ensure a car's brakes are engaged before working on it. If you are jacking a car, make sure the wheels are properly blocked first.

SHOP ORGANIZATION

Fire safety is crucial! Mechanical work is full of fire hazards, so make sure that your shop has working fire extinguishers and test fire alarms regularly.

Organize your storage properly. Make sure all parts and tools are stored securely, especially if they are up high.

Keep exits clear! Make sure the path to your main entrance and the emergency exits are clear at all times, so that staff can easily evacuate in the event of a fire.

[3]

[3] https://www.autotrainingcentre.com/blog/infographic-mechanics-guide-shop-safety/

Questions:

1. What is happening on the various pictures above?
2. Explain the personal protective equipment you see on the picture above.
3. Explain the types of hazards in the workplace.
4. Describe the personal safety, cleaning safety and work area safety.
5. Describe the equipment and tools for safety.
6. How to prevent injuries that can happen at workplace?

Key Facts 2.1: Work area safety

- **Safety guidelines**

The work area should be kept clean and safe. These include but not limited to the following:

- **The floor and bench**

The floor and bench tops should be kept clean, dry and orderly. Any oil, coolant or grease on the floor can make it slippery. Slips can result in serious injuries. To clean up oil, use a commercial oil absorbent. Keep water off the floor. Water is slippery on smooth floors and electricity flows well through water. Aisles and walkways should be kept clean and wide enough to move through easily.

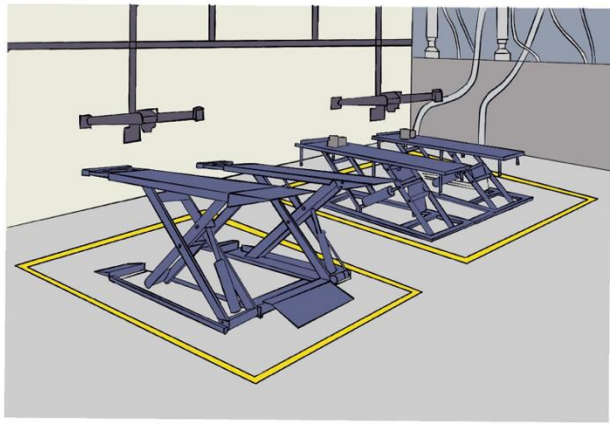


Figure 18: Safety zone markings

Make sure the work areas around machines are large enough to operate the machine safely.

- **Ventilation**

Proper ventilation of space heaters, used in some shops, is necessary to reduce the CO levels in the shop. Also, proper ventilation is very important in areas where volatile solvents and chemicals are used. (A volatile liquid is one that evaporates very quickly.) Keep an up-to-date list of emergency telephone numbers clearly posted next to the telephone. These numbers should include a doctor, hospital and fire and police departments.

- **First-Aid kit availability**

Also, the work area should have a first-aid kit for treating minor injuries. There should also be eye flushing kits readily available. Gasoline is a highly flammable volatile liquid. Always keep gasoline or diesel fuel in an approved safety can and never use it to clean your hands or tools. Oily rags should also be stored in an approved metal container. When these oily, greasy or paint-soaked rags are left lying about or are not stored properly, they can cause spontaneous combustion.

- **Fire extinguishers and blanket availability**

Car repair shops pose a range of fire risks, from flammable liquids to high tech equipment, plus a potentially combustible mix of dust, swarf and lubricants.

Therefore, the shops should always equip themselves with at least two different types of fire extinguisher. As spontaneous combustion results in a fire that starts by itself, without a match. Make sure that all drain covers are snugly in place.

Open drains or covers that are not flush to the floor can cause toe, ankle and leg injuries. Know where the fire extinguishers are and what types of fires they put out.

A multipurpose dry chemical fire extinguisher will put out ordinary combustibles, flammable liquids and electrical fires. Never put water on a gasoline fire. The water will just spread the fire. Use a fire extinguisher to smother the flames. Remember, during a fire, never open doors or windows unless it is absolutely necessary; the extra draft will only make the fire worse.

A good rule is to call the fire department first and then attempt to extinguish the fire. To extinguish a fire, stand 6–10 feet from the fire. Hold the extinguisher firmly in an upright position. Aim the nozzle at the base and use a side-to-side motion, sweeping the entire width of the fire. Stay low to avoid inhaling the smoke. If it gets too hot or too smoky, get out.

Remember, never go back into a burning building for anything.

	Class of Fire	Typical Fuel involved	Type of Extinguisher
Class A Fires (green)	**For Ordinary Combustibles** Put out a Class A fire by lowering its temperature or by coating the burning combustibles	Wood Paper Cloth Rubber plastics Rubbish Upholstery	Water*1 Foam* Multipurpose dry chemical[4]
Class B Fires (red)	**For Flammable Liquids** Put out a Class B fire by smothering it. Use an extinguisher that gives a blanketing, flame-interrupting effect; cover whole flaming liquid surface.	Gasoline Oil Grease Paint Lighter fluid	Foam* Carbon dioxide[5] Halogenated agent[6] Standard dry chemical[2] Purple K dry chemical[3] Multipurpose dry chemical[4]
Class C Fires (blue)	**For Electrical Equipment** Put out a class C by shutting off power as quickly as possible and always using a nonconducting extinguisher agent to prevent electric shock	Motors Appliances Wiring Fuse boxes Switchboards	Carbon dioxide[5] Halogenated agent[6] Standard dry chemical[2] Purple K dry chemical[3] Multipurpose dry chemical[4]
Class D Fires (yellow)	**For Combustible Metals** Put out class D fire of metal chips,turnings, or shavings by smothering or coating with a specially designed extinguishing agent.	Aluminium Magnesium Potassium Sodium Titanium Zirconium	Dry power extinguishers and agents only

1st Class Fire Protection
01603 742741
enquiries@1stclassfireprotectionnorfolk.co.uk

Fire Extinguisher Type

Fire Type		Powder	Foam	CO^2	Water	Wet Chemical
CLASS A	**Solids** (e.g. wood, plastic, paper)	✓	✓	✗	✓	✗
CLASS B	**Flammable Liquids** (e.g. solvents, paint, fuels)	✓	✓	✓	✗	✗
CLASS C	**Gases** (e.g. butane, propane, LPG)	✓	✗	✗	✗	✗
CLASS D	**Metals** (e.g. lithium, magnesium)	✓	✗	✗	✗	✗
ELECTRICAL	**Equipment** (e.g. computers, servers, TVs)	✓	✗	✓	✗	✗
CLASS F	**Cooking Oils** (e.g. cooking fat, olive oil)	✗	✗	✗	✗	✓
Some examples of businesses that may need this extinguisher		Outdoor locations, garages, welding workshops, forecourts.	Schools, offices, hotels, shops, hospitals, apartments.	Offices, server rooms.	Schools, hospitals, shops, apartment blocks.	Kitchens, canteens, restaurants.

Figure 19: Guide to fire extinguisher selection

- **Storage of tools and equipment**

Properly store all parts and tools by putting them away in a place where people will not trip over them. This practice not only cuts down on injuries, but also reduces time wasted looking for a misplaced part or tool.

- **Use of warning signs**

Always be familiar with evacuation routes and where to gather outside the building. Always know the location of all safety equipment in the shop and be familiar with the operation of this equipment.

- **Vehicle operation**

If the engine must be running while working on the car, block the wheels to prevent the car from moving. Place the transmission into park for automatic transmissions or in neutral for manual transmissions. Set the emergency brake. Never stand directly in front of or behind a running vehicle. Run the engine only in a well-ventilated area, to avoid the danger of poisonous carbon monoxide (CO) in the engine exhaust. If the shop is equipped with an exhaust ventilation system, use it. If not, use a hose and direct the exhaust out of the building.

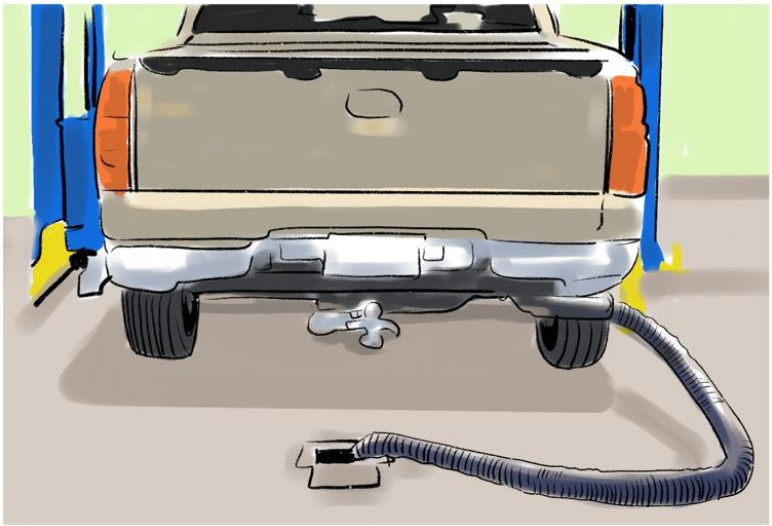


Figure 20: Exhaust vent hose to a tailpipe

Activity 2: Guided Practice

Task 10:

Read the scenario below and perform the tasks related to it.

IPRC NGOMA has a mechanic workshop and is expecting the fall intake for short course candidates. Within 40 minutes, you have been tasked to prepare the workshop by applying the safety precautions for the workplace.

1. Ensure the work area is safe
2. Ensure the tools and equipment are safe
3. Ensure the personal safety is ready to be applied
4. Explain to the users the proper usage of fire extinguishers in the event of a fire.

Activity 3: Application

Task 11:

Visit auto repair shops neigbhouring your school, participate in the application of safety precautions at the workplace.

Make a report on the safety measures put in place by focusing on the following:

1. Work area safety
2. Tools and equipment safety
3. Personal safety
4. Types of fire extinguishers at the place
5. Recommendations on what to improve for a safer environment.

Topic 2.2: Selection of Personal Protective Equipment (PPE)

Activity 1: Problem Solving

Task 12:

Analyse the picture below and answer the questions that follow:

Questions:

1. What do you see on the picture?
2. Name the types of PPEs.
3. Explain the functions of these PPEs.
4. Describe when and why to wear these PPEs.

Key Facts 2.2: Selection and use of PPEs

- **Use of PPEs**

Employees in the vehicle repair industry are subjected to risks like falling, flying, abrasive, and splashing materials, as well as dangerous dusts, fumes, mists, vapors, and gases. As a result, it is imperative that they have access to the personal protective equipment required to keep them safe.

- **Selection of PPEs**

When choosing and utilizing personal protective equipment (PPE) at a repair shop and while operating portable power tools, the following factors should be taken into account. PPEs used for power and hand tools have certain similarities, but they can differ greatly.

- ✓ **Safety glasses or goggles must be worn in order to protect the eyes from projectiles.** A face-shield may be used in addition to safety glasses or goggles to provide additional protection. A face-shield will protect the face and neck from hot metal fragments created during such tasks as grinding;
- ✓ **Cut resistant gloves,** while capable of preventing lacerations due to hand tools, will not protect against blades and bits of power tools;
- ✓ **Safety shoes** should also be worn while working with power tools to prevent injury from dropped tools.
- ✓ **Ear protection** may be necessary due to the increased noise levels produced by power tools.
- ✓ **Respiratory protection** might be necessary when workers are exposed to dusts and fumes.

Figure 21: (A) Safety goggles, (B) face shield and (C) safety glasses

- **Function of PPEs**

Personal safety simply involves those precautions you take to protect yourself from injury. These include wearing protective gear, dressing for safety and correctly handling tools and equipment.

- ✓ **Safety goggles and face shields**

Face and Eye protection PPEs includes safety goggles and face shields and should be used for tasks that can cause eye damage or loss of vision, sprays of toxic liquids, splashes and burns.

- ✓ **Eye Protection**

Your eyes can become infected or permanently damaged by many things in a shop.

Some repair procedures, such as grinding, result in tiny particles of metal and dust that are thrown off at very high speeds. These metals and dirt particles can easily get into your eyes, causing scratches or cuts on your eyeball. They can also get into your lungs if you are not properly protected. Pressurized gases and liquids escaping a ruptured hose or fuel line fitting can spray a great distance.

If these chemicals get into your eye, they can cause blindness. Dirt and sharp bits of corroded metal can easily fall down into your eyes while you are working under a vehicle. Eye protection should be worn whenever you are exposed to these risks.

Figure 22:eye wash

To be safe, you should wear safety glasses whenever you are working in the shop. There are many types of eye protection available. To provide adequate eye protection, safety glasses have lenses made of safety glass.

If chemicals such as battery acid, fuel or solvents get into your eyes, flush them continuously in an eyewash station or with sterile water from an eye wash bottle. Have someone call a doctor and get medical help immediately.

- ✓ **Safety overall**

PPE includes safety overall, vests and overcoat that can be used for tasks that can cause body injuries from extreme temperatures, flames and sparks, toxic chemicals, insect bites and radiation.

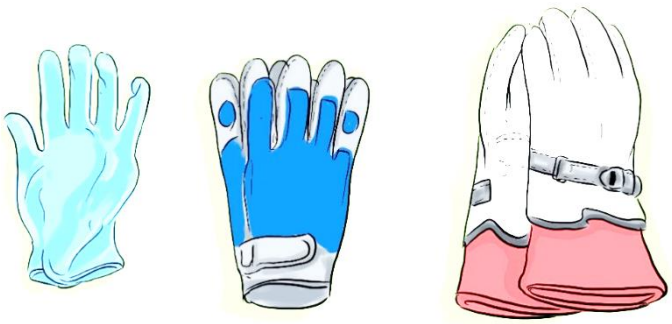
Your clothing should be well-fitted and comfortable and made with strong material. Loose, baggy clothing easily can get caught in moving parts and machinery. Cut-offs and short pants are not appropriate for shop work.

- ✓ **Safety boots**

PPE includes knee pads and safety boots and should be used for tasks that can cause serious foot and leg injuries from falling or rolling objects, hot substances, electrical hazards and slippery surfaces.

Automotive work involves the handling of many heavy objects that can be accidentally dropped on your feet or toes. Always wear shoes made of leather or a similar material or boots with nonslip soles. Steel-tipped safety shoes can give added protection for your feet. Sports sneakers, street shoes and sandals are not appropriate in the shop.

- ✓ **Safety gloves**



These tight-fitting latex gloves keep your skin safe from dangerous fluids. PPE includes safety gloves and should be used for tasks that can cause hand and skin burns, absorption of harmful substances, cuts, fractures or amputations.

Figure 23:Safety gloves

Good hand protection is often overlooked. A scrape, cut or burn can limit your effectiveness at work for many days. A well-fitted pair of heavy work gloves should be worn during operations such as grinding and welding or when handling high-temperature components. Always wear approved rubber gloves when handling caustic chemicals. Caustic chemicals are strong and dangerous chemicals. They can easily burn your skin. Be very careful when handling this type of chemical.

Close-fitting surgical gloves that offer some protection from toxic chemicals such as engine oil, gasoline, brake fluid and cleaning chemicals. It is important to remember that the skin is an organ and it absorbs some of the fluids that are placed on it. Close-fitting surgical gloves are very inexpensive, disposable and come in different versions, such as latex, powdered and nitrile.

There are thicker, padded gloves too, these gloves are a little bit thicker than the surgical gloves, but offer better protection to sharp or hot objects. Most of the higher-quality gloves of this type offer padded protection in high-wear areas, such as the palm and fingers. They are also very comfortable when you have to work on a very hot engine

component and you cannot wait for it to cool down. It is a good practice to have many different types of gloves in your toolbox so you can switch to the one that fits the job.

- ✓ **Safety harnesses**

PPE includes safety harnesses and lanyards and should be strictly used for tasks that can cause falling from heights and serious injury or death.

- ✓ **Ear muffs**

PPE includes ear muffs and plugs and should be used for tasks that can cause hearing problems and loss of hearing.

Exposure to very loud noise levels for extended periods of time can lead to a loss of hearing. Air wrenches, engines running under a load and vehicles running in enclosed areas can all generate annoying and harmful levels of noise. Simple ear plugs or earphone-type protectors should be worn in constantly noisy environments.

Figure 24: ear muffs and plugs

- ✓ **Beware of long hair and hanging jewellery.**

Long hair and loose, hanging jewellery can create the same type of hazard as loose-fitting clothing. They can become caught in moving engine parts and machinery. If you have long hair, tie it back or cover it with a cap. Never wear rings, watches, bracelets or neck chains. These easily can get caught in moving parts and cause serious injury.

- ✓ **Face masks**

These PPEs including full-face respirators, self-contained breathing apparatus, gas masks and surgical masks are used for a task that can cause inhalation of harmful materials to enter the body. This includes harmful gas, chemicals, large-particle droplets, sprays, splashes or splatter that may contain viruses and bacteria such as COVID-19, viral infections and more. Technicians often work with chemicals that have toxic fumes. Air or respiratory masks should be worn whenever you will be exposed to toxic fumes. Cleaning parts with solvents

and painting are the most common times when respiratory masks should be worn. Masks should also be worn when handling parts that contain asbestos or when handling hazardous materials.

- ✓ **Hard hat**

PPE includes hard hats and headgears and should be required for tasks that can cause any force or object falling to the head.

- **Importance of PPEs**

Here are some benefits of using PPEs:

- ✓ Prevent injury in the workplace;
- ✓ Protect employees from excessive chemical exposure;
- ✓ Prevent the spread of germs and infectious diseases
- ✓ Help businesses comply with regulatory requirements
- ✓ Improve employee productivity and efficiency.

PPEs types	How to use them
Face and Eye protection	a) Check if safety glasses comply with the eye protection standard. b) Ensure that there are no cracks or deformities on the lenses. c) Ensure the strap is in good working condition and is firmly sealed to the cheek and forehead. d) Ensure that the eye protection fully covers the eye and surrounding soft tissues e) Eye wear should fit properly, covering from the eyebrow to the cheekbone and across from the nose to the bony area on the outside of the face f) Face shields should extend below the chin and above the eyes, wrapping around the sides of the face g) Clean and disinfect after use.
Respiratory protection	a) Ensure that the equipment is fit-tested and the employee has undergone proper training before wearing one. b) Carefully read the instructions to determine if it is designed to help protect against the hazards you may face. c) Change filters on half-mask or full-mask respirators frequently. d) Replace disposable respirators with every use. e) Surgical masks are not to be shared with anyone. f) Avoid touching the surgical mask after wearing it. g) Change surgical mask timely and should be disposed of after use. h) Replace the mask immediately if it is damaged or soiled.
Skin and Body protection	These PPE includes the following categories to protect employees from physical hazards: head, body and hand protection.

	i. Head a) Ensure that there are no dents or deformities on the shell and connections are tightened inside. b) Do not store in direct sunlight as extreme heat can cause damage. c) Choose appropriate cleaning agents as it can weaken the shells of hard hats and may eliminate electrical resistance. d) Always replace a hard hat if it was used for any kind of impact, even if the damage is unnoticeable. **ii. Body protection** a) Ensure that they are clean and free from cuts and burns. b) Always get a good fit to ensure full body protection. c) Ensure bodysuit is heat-resistant clothing when working with high-temperature hazards. **iii. Hand protection** a) Ensure hand protection fits perfectly with no spaces and is free from cuts, burns and chemical residue. b) Always replace them if any sign of contamination was observed. c) Use rubber gloves when working with heat and electricity to reduce the risk of burn or electrical shock.
Foot protection	a) Ensure boots have slip-resistant soles that can protect against compression and impact. b) Ensure the sole plate is in good condition to prevent punctures.
Fall protection	a) Ensure that the straps are free from tears, deformities and burn marks. b) Check the buckles if connected securely and tightly. c) Dispose of the equipment if used after a falling incident.
Hearing protection	a) Ensure the equipment fit the ear canal perfectly. b) It is recommended to use formable earplugs to fit on different sizes of ear canals. c) Use protectors that reduce noise exposure to an acceptable level to have a room for communication. d) Ensure earplugs are clean and in good condition.

Be familiar with the location of all safety equipment when you enter a new shop.

Activity 2: Guided Practice

Task 13:

Discuss on the workshop harzards listed below and identify PPEs needed for it.

1. Slips, trips and falls
2. Electrical
3. Fire
4. Working in confined spaces
5. Physical hazards (potential)
6. Chemical hazards
7. Biological hazards
8. Asbestos
9. Noise
10. Lack of guards or screens on equipment or around dangerous areas.

Activity 3: Application

Task 14:

Visit Mr.MUHIRE's garage where there is a vehicle TOYOTA Carina-E for the engine cooling system leaking repair. You, as a mechanic for engine cooling system repair, prepare needed PPEs for the interns and demonstrate how to use them properly.

Compile a report on what was done and how you have proceeded

Topic 2.3: Cleaning and Arrangement of the Workplace

Activity 1: Problem Solving

Task 15:

Analyse the picture below and answer the questions that follow:

Questions:

1. What is happening in the picture above?
2. What types of cleaning method is this employee using?
3. Explain the benefits of workplace cleaning and arrangement.

Key Facts 2.3: Cleaning and arrangement of the workplace

- **Why cleaning the workplace?**

The following benefits will explain why cleanliness is important for workplaces:

✓ **Well-being:**

Keeping the workplace tidy contributes to the wellbeing of the workers. Employees use fewer sick days when they work in an environment where waste and litter are disposed of properly and surfaces are cleaned on a regular basis, which boosts productivity.

✓ **Productivity:**

Provisions for a clean environment can increase the productivity of employees. Cleanliness can help drive motivation and boost the morale of employees thereby creating a feeling of belonging within their organization.

✓ **Impression:**

A clean and tidy business space leaves a good impression on both its employees and its visitors.

✓ **Cost saving:**

By maintaining good levels of cleanliness in the workplace, companies can save on cleaning costs and refurbishments, which may become necessary if the premises are not properly maintained.

- **Types of cleaning methods**

Several categories of automotive materials call for different cleaning methods, including water-soluble deposits (dirt) organic soils, scale and rust. Cleaning methods include:

✓ **Wet cleaning or chemical cleaning:**

with petroleum solvents or water based chemical solutions like Alkaline (base) and Acid.

✓ **Abrasive clearing :**

Materials to be cleaned by abrasive cleaning methods must be free of oil and grease, which can interfere with the proper operation of an abrasive cleaning machine. Following preclearing, two types of abrasive blasting are used for various cleaning applications. Shot is round and grit is sharp and angular. Several blast materials are used by rebuilders for cleaning parts. Steel shot and glass beads are used for automotive part cleaning when removal of the surface of the material being cleaned is not desired. Beads and shot come in various sizes, depending on the application

✓ **Thermal cleaning:**

Many rebuilders use thermal cleaning:

A cleaning procedure in which a high-temperature pyrolytic oven cooks oil and grease, turning them to ash. The hard, dry deposit that remains on the part is removed by shot blasting or jet washing.

There are two types of thermal ovens: convection and open flame. A convection oven is a flameless, insulated oven that is heated by burners from the bottom. Parts are not exposed to flame and are warmed up gradually as the oven heats up. Gradually heating parts allows less chance of warpage.

An open flame oven is like a rotisserie. Parts are mounted in a cage that avoids hot spots by slowly rotating the parts directly over a flame.

- **Procedures for cleaning workplace, tools and equipment**

✓ **Shop Floors**

Mostly auto shop floor is filled with slick materials. This could lead to a serious hazard, as one fall in five causes serious injury. Do the following to avoid the above:

- Pick up floor mats.
- Sweep up dirt and debris.
- Spot clean spills.
- Quick mop.
- Replace mats.

✓ **Working Spaces**

To make it safe the following are to be done:

- Pick up debris.
- Put tools away.
- Replenish supplies.
- Wipe down surfaces.

✓ **Equipment**

Staff use both fixed and movable tools throughout the day. A quick, daily check can help to limit catastrophic failures that cost time and reputation by doing as follows:

- Wipe down permanent equipment (like compressor).
- Check for loose parts or missing pieces.
- Ensure everything is lubricated and running smoothly.

✓ **Linens**

Consumers understand that mechanics get dirty. But they may also expect to shake hands with and otherwise interact with auto professionals. Grime-coated towels and linens make it tough to keep hands clean.

- Swapping out soiled linens for fresh sets takes just minutes. And it could make a big difference in how clean and tidy the shop looks the next day.
- Waiting Areas & Restrooms

Staff can track dirt and debris into these spaces.

- Scouring surfaces and mopping floors keep bathrooms and waiting rooms clean and tidy.

Sanitize and clean restrooms

Both customers and employees need a clean bathroom, including plenty of soap, toilet paper and paper towels. It is advisable to have extra supplies on hand, so you don’t run out unexpectedly. Also, set up a daily reminder to sanitize and disinfect all surfaces.

In public restrooms, air fresheners are necessary because they eliminate offensive smells and maintain a fresh scent in the air.

Schedule deep cleanings

Although it is necessary to wipe the floor and other areas every day, not all automotive fluid buildup is eliminated. In addition to being unsightly, power steering fluids, antifreeze, and lubricants can make the shop floor dangerous for both customers and staff. Make a deep cleaning appointment and follow through on it.

Declutter the Shop

Any broken or outdated supplies, equipment, or parts in the shop should be disposed of. They not only add to an untidy workspace but also take up more space. Empty the shop area of any broken glass and remove any parts with sharp metal edges. Glass and metal recycling should be done with designated recycling bins. Someone could get cut or hurt if you don't properly clean up broken glass. Additionally, when the air conditioner or heater is turned on, glass can blow into people's eyes if the dash ducts aren't cleaned up.

Improve employee appearance

customers may be more willing to do business with clean, uniformed technicians. In addition, uniforms that show the shop’s name and employee name create a great first impression for the customers.

Promote Clean Hands

While repairing, technicians will inevitably have grease and oil on their hands after working on cars, proper handwashing stations are recommended and heavy-duty soaps and substantial paper towels.

- **Arrangement of workplace**

A clean organized facility is more pleasant for workers and could make jobs go quicker too. When workers can find what they need, they don't waste time looking.

✓ **Designate a storage for tools and equipment**

It is integral for technicians to have a designated space to put tools when they are finished using them. When a shop has a home for each instrument, technicians can quickly find the necessary tools and the shop looks organized. Likewise, when new order for automotive repair parts or supplies comes in, these should have a designated place for them to be stored.

✓ **Use approved storage for hazardous materials**

often overlooked area in auto repair shop is hazardous materials. This area should stay clean and safe when approved storage containers are used with securely closed lids and a proper fit.

✓ **Keep gas cylinders away from sources of heat, such as a furnace or room heater.**

Check and service furnaces and water heaters in the shop at least once every six months.

✓ **Store toxic materials properly**

Solvents, chemicals and other materials can contaminate clothing and wind up on the hands when you remove personal protective equipment or put away the refinishing tools.

Activity 2: Guided Practice

Task 16:

Visit the school auto workshop and follow the procedures to clean the workplace, tools and equipment.

1. Ask your trainer for clarifications
2. Produce a report on the procedures to clean the workplace, tools and equipment.

Activity 3: Application

Task 17:

Visit a nearby auto repair shop, clean and arrange the workplace.

Compile a report on the tasks undertaken by elaborating on the following elements:

1. The importance of the cleanliness of the workplace.
2. The cleaning methods used by the staff in the shop.
3. The procedures followed to clean the work area, tools and equipment.
4. The workplace arrangement
5. The weakness and strength observed of the shop in the cleaning the workplace

Formative Assessment

1. List five items that are personal protective equipment (PPE).
2. What are the types of fire extinguishers and their usage?
3. What items are included in a typical first aid box?
4. List five common automotive chemicals or products that may be considered hazardous materials.
5. Enumerate five safety measures that all technicians should follow when handling chemicals and automotive products.
6. Describe how to use fire extinguisher.
7. Talk about the hygienic practices that every repair shop should adhere to.
8. Describe the types of cleaning methods in repair shop.
9. Explain why cleanliness is important for workplaces.
10. Discuss on skin and body protection in repair shop.
11. What are the safety precautions to be applied in case of the hazardous situations below?
    a. Batteries include acids that are extremely caustic and possibly explosive.
    b. Fuels and cleaning solvents which are flammable
    c. Exhaust fumes which are poisonous
    d. During some repairs, technicians can be exposed to harmful dust particles and vapors
    e. High voltage on some types of vehicles which present shock and burn hazards

Points to Remember

- Automobile mechanics and technicians often suffer injuries due to their work environment, tools, lack of appropriate protection and machinery. Frequently these exposures can lead to poor health or even death if not appropriately addressed.
- Cuts are the leading causes of injury among automobile repair workers, with improper postures and repetitive work and tool design seen playing a role.
- Dressing safely for work is very important. Wear snug-fitting clothing, eye and ear protection, protective gloves, steel-toed shoes and caps to cover long hair.

- Safety while using any tool or equipment is essential and even more when using power tools. Before plugging in a power tool, make sure the power switch is off.
- Whenever you have to move an automobile in the shop, take caution. Playing about and being irresponsible can cause major injuries and damage to a car.
- When a car is running, you should always attach an exhaust line to the tailpipe to help prevent carbon dioxide (CO) from accumulating inside a closed garage.

Self-Reflection

1. Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.

There are no right or wrong answers for this evaluation. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

2. Think about yourself:

a) Do you think you have the knowledge, skills or attitudes to do the task?

b) How well?

3. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

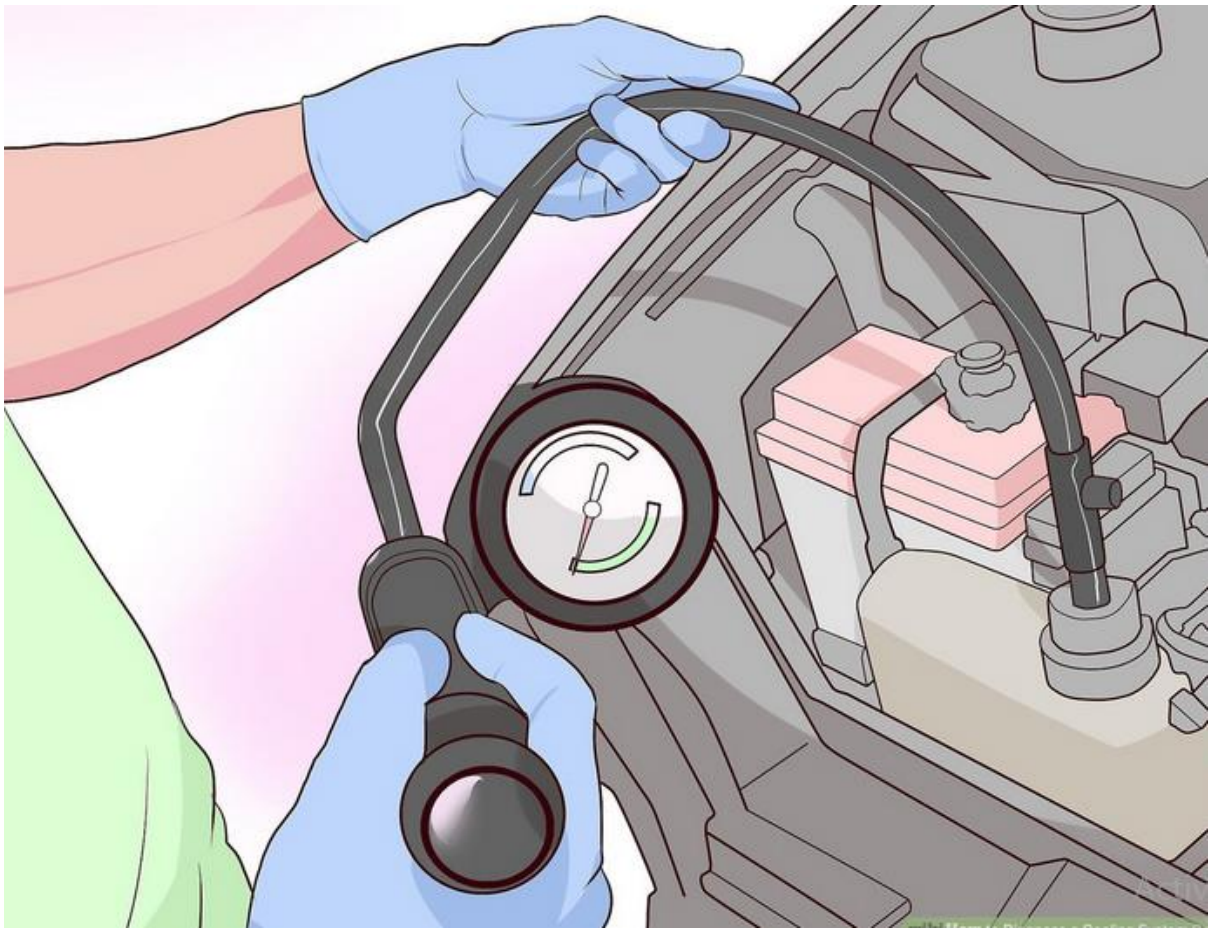
My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe safety at workplace					
Identify personal safety at workplace					

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Describe the work area safety at workplace					
Describe the tools and equipment safety					
Classify personal protective equipment (PPE)					
Use of personal protective equipment (PPE)					
Identify types of cleaning method at workplace					

Fill in the below table

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	**1.**	**1.**
2.	**2.**	**2.**
3.	**3.**	**3.**

UNIT 3: REPAIR ENGINE COOLING SYSTEM COMPONENTS



Unit summary:

This unit provides you with the knowledge, skills and attitudes to repair engine cooling systems. It covers the selection of tools, materials and equipment; detection and correction of engine cooling system components faults as well as the changing of engine coolant.

Self-Assessment: Unit 3

1. **Study the unit illustration above and answer the following questions.**
    a. What do you see in the illustration?
    b. What is happening in the illustration?
    c. What topics do you think will be covered under this unit based on the illustration?
2. **Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.**
    a. There are no right or incorrect answers for this evaluation. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
    b. Think about yourself: Do you think you have the knowledge, skills or attitudes to do the task? How well?
    c. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.
3. **At the end of this unit, you will assess yourself again.**

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Select tools, materials and equipment used to repair engine cooling system					
Explain the procedures used to detect and to correct engine cooling					

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
system components faults					
Detect engine cooling system components faults					
Correct engine cooling system components faults					
Explain the procedures used to test engine cooling system faults					
Test engine cooling system performance					
Change engine coolant					
Comply with safety precautions at the workplace					
Demonstrate team spirit while working with others					
Comply with national and international standards at the workplace					

Key Competencies:

Knowledge	Skills	Attitudes
1. Identify the tools, materials and equipment	1. Select tools, materials and equipment used to repair engine cooling system	1. Pay attention to details while using the tools, materials and equipment
2. Explain the procedures used to detect and to correct engine cooling system components faults	2. Use the tools, materials and equipment	2. Demonstrate team spirit while working with others
3. Explain the procedures used to test engine cooling system faults	3. Detect engine cooling system components faults	3. Be meticulous while detect engine cooling system components faults
4. Identify cooling system repairing methods	4. Correct engine cooling system components faults	4. Be careful while correct cooling system components faults
5. Identify the steps used to test engine cooling system performance	5. Test engine cooling system performance	5. Respect safety precautions at workplace while testing the cooling system
6. Identify the steps used to change engine coolant	6. Change engine coolant	6. Comply with safety rules related to the handling of tools and equipment

Discovery Activity

Task 18

Based on your experience in automobile answer the questions below:

1. What are the tools, materials and equipment which can help you to repair engine cooling systems?
2. Describe the engine cooling system's coolant level function.
3. Which kinds of antifreeze are used in engine cooling systems? And how do they differ from one another?
4. List the procedures for identifying problems with the engine cooling system.
5. List the procedures for filling, emptying, and refilling engine cooling system malfunctions.

Topic 3.1: Selection of Tools, Materials and Equipment

Activity 1: Problem Solving

Task 19

Analyze the figure below and answer the following questions:

1. What do you see in the picture below?
2. Identify various types of tools, materials and equipment in the picture below?
3. Describe the function of materials in the picture below.




Key Facts 3.1 a: Selection of tools, materials and equipment

- **Selecting materials, tools and equipment**

As with any engine component, there are some signs to look for that will alert you to a problem. Tools, materials and equipment must be selected according to the engine type cooling faults.

✓ **The engine overheats.**

An overheated engine should not be ignored. There are any number of things that can be causing the engine to overheat – like a bad water pump, broken hose or worn cooling pump driving belt. If the engine temperature warning light comes on or you notice the engine is overheated, safely proceed to the repair. Continuing to drive could lead to fatal engine damage.

✓ **Smell antifreeze when you drive.**

The smell of antifreeze when driving or right after you stop your vehicle is an indicator of a leak in the system. The smell is caused by the antifreeze dripping onto the hot engine. Like an engine that is overheated, this should be fixed right away.

✓ **You notice antifreeze under the front of your vehicle.**

If you notice a puddle of coolant under your vehicle, have your vehicle checked out right away. Any time there's a leak in the cooling system, it can't properly protect the engine from overheating.

✓ **The coolant level is always low.**

If you have to add coolant to the radiator on a regular basis, there's a leak in the system.

- **Tools**

Screwdrivers, Set of pliers, hummers, pressure tester tool kit and tool box spanners.

- **Materials**

  Engine cooling system components, Repair manual, Handout notes, Soap solution, Solvent, Broom, Mops, Clothes rugs, Metallic brush, Water container, Water, Antifreeze, Recipient, Funnel, radiator leak stop.

- **Equipment**

  Vehicle, Air compressor, Multimeter, PPE, hydrometer and infrared thermometer.

Activity 2: Guided Practice

Task 20

Visit your school automotive workshop and perform the following task, under the guidance of the trainer

1. Select the tools and equipment to be used for cooling system repair.
2. Differentiate tools from equipment selected.
3. Select the materials to be used for cooling system repair
4. Apply maintenance techniques to the selected tools and equipment.

Key Facts 3.1 b: Infrared thermometer and coolant pressure tester tool kits

- **Use of infrared thermometer**

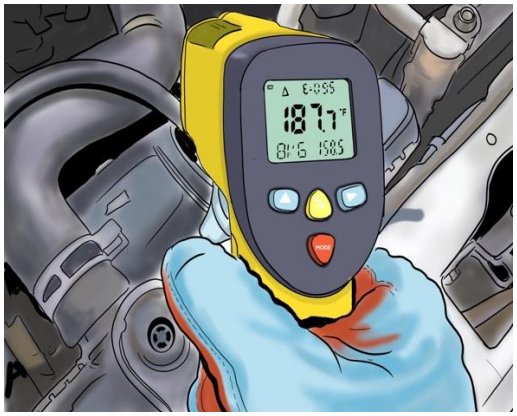


Figure 25: Infrared thermometer

How do you check the engine temperature by using an infrared thermometer?

a) **Prepare the Infrared Thermometer**: Make sure the infrared thermometer is clean and in good working condition. If it has a battery, ensure its charged or replace it if needed.
b) **Access the Engine**: Open the hood of your vehicle and locate the engine. Be cautious if the engine has been running, as some parts may be hot.
c) **Identify the Target Area**: Identify the part of the engine where you want to measure the temperature. Common areas to check include the radiator, engine block, or exhaust manifold.
d) **Point and Shoot**: Hold the infrared thermometer and aim it at the target area. Ensure there are no obstructions between the thermometer and the engine surface.
e) **Take the Reading**: Press the trigger on the thermometer to take a temperature reading. Some thermometers may require you to hold the trigger while aiming, while others may have a "hold" button to freeze the reading once it's taken.
f) **Interpret the Reading**: The infrared thermometer will display the temperature of the area you measured. Refer to your vehicle's specifications or consult a mechanic to determine if the temperature is within the normal operating range.
g) **Repeat as Necessary**: If you want to check multiple areas of the engine, repeat the process for each location.
h) **Handle with Care**: After you've finished using the infrared thermometer, turn it off and store it properly. Be cautious when handling hot engine components.
i) Note: the maximum distance you can reliably measure the temperature of the target is 48 inches/1220mm

- **Coolant pressure tester tool kits**

Pressure testing using a hand-operated pressure tester is a quick and easy cooling system test. The radiator cap is removed (engine cold!) and the tester is attached in the place of the radiator cap. By operating the plunger on the pump, the entire cooling system is pressurized.

- ✓ **CAUTION**: Do not pump up the pressure beyond that specified by the vehicle manufacturer. Most systems should not be pressurized beyond 14 PSI (100 kPa). If a greater pressure is used, it may cause the water pump, radiator, heater core or hoses to fail.
- ✓ **Specifications**

No	Description	Specifications	Material
1	Pressure pump	0-2.5 kg/cm² (35 psi)	Nylon 6-6
2	Pump hose	Max. pressure: 200 psi	Rubber
3	Black cap tester	For R123 and R124	Nylon 6-6
4	Blue cap tester	For R123 and R125	Nylon 6-6
5	Test cap	No. 3 to No. 5	Steel
6	Test cap	No. 6 to No. 23	Nylon 6-6
7	O-ring	Various sizes	NBR
8	Conical adapter	Universally applicable	Rubber
9	90° Connector	Suitable for confined spaces	Bronze
10	Coolant hose	L: 1200mm	PVC
11	Air bleeding hose	Ø8 × 12 × 600mm	PVC

A	Vacuum gauge -76 - 0 inHg
B	Shop air connector
C	Air switch
D	Air bleeding exit
E	Air control valve
F	Hook and chain
G	Coolant control valve
H	Coolant hose connector
I	Test cap connector

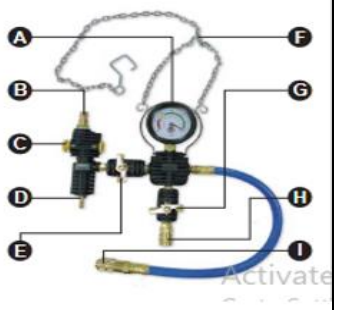


Figure 26: Coolant pressure tester tool kits

Key Facts 3.1 c: Maintenance of tools and equipment.

Tools and equipment suffer a lot of worn and break; it is important therefore to maintain them regularly to increase the service life as well as the performance of the equipment. Preventive maintenance helps to reduce unwanted expenses related to broken or faulty equipment as minor faulty generally leads to bigger issues if left unattended.

- **Tools and equipment maintenance techniques**

  ✓ **Cleaning:**

  Cleaning the tools regularly is essential to their proper functioning. After a day of work, your tools will be covered with some amount of dirt.

  ✓ **Lubrication:**

  Lubricating tools & equipment helps them to perform better and reduces worn and break of components.

  ✓ **Regular inspection:**

  Regularly inspect your tools and equipment for signs of damage and faulty functioning. Inspections should take place at the end of each job. Ensure that you maintain and repair them immediately if there is any damage. This will prevent any last-minute difficulties.

  ✓ **Careful storing:**

  Storing tools and equipment properly is the most important. Although they are designed for rough use, it is important to store them properly.

Before storing tools and equipment, use a clean rag to wipe them dry so that the metal surfaces do not get corroded. Inspect all parts of the tools for fragments, breaks and cracks. Ensure that there are no signs of corrosion in the metal parts.

Activity 3: Application

Task 21

Visit a nearby auto repair shop or school storing room, select from their store tools and equipment used to repair the cooling system.

1. Identify tools and equipment found at the shop.
2. Differentiate tools from equipment
3. Describe how the tools and equipment are maintained at the site.
4. Make a report on the types of tools and equipment found at the shop as well as the maintenance techniques used to keep them safe.

Topic 3.2: Detection and Correction of Engine Cooling System Components Faults

Activity 1: Problem Solving

Task 22

Analyze the illustration below and use it to answer questions that follow.

1. What is happening?
2. What are the components of the engine cooling system causing that problem?
3. How can it be avoided?

Key Facts 3.2a: Types of antifreezes

- **There are three types of antifreezes:**
  - ✓ Inorganic Acid Technology (IAT),
  - ✓ Organic Acid Technology (OAT) and
  - ✓ Hybrid Organic Acid Technology (HOAT).

- **Here's how to mix coolant:**
  - ✓ Check the coolant capacity listed in your vehicle's owner's manual
  - ✓ Measure out the correct ratio (listed below) of coolant into clean storage container
  - ✓ Measure out the correct corresponding ratio (listed below) of water into the partially filled storage container
  - ✓ Mix thoroughly
  - ✓ Store in a cool, dry place

- **Coolant-to-Water Ratio Guide**

  Different types of engine coolants require different coolant-to-water ratios. Which type of coolant you use depends on the type of vehicle you have and the type of environment you drive in. Each ratio is listed below, with the first number indicating the type of coolant and the second number representing water.
  - ✓ Antifreeze – 1:1 or 50/50
  - ✓ Ethylene-glycol – 7:3 or 70/30
  - ✓ Factory – 6:4 or 60/40

- **Cleaning the radiator exterior:**

  Overheating can result from exterior and interior radiator plugging. External plugging is caused by dirt and insects. This type of plugging can be seen if you look straight through the radiator while a light is held behind it. It is most likely to occur on off-road vehicles. The plugged exterior of the radiator core can usually be cleaned with water

pressured from a hose. The water is aimed at the engine side of the radiator. The water should flow freely through the core at all locations. If this does not clean the core, the radiator should be removed for cleaning at a radiator shop.

- **Precautions**

If the coolant temperature warning light comes on, follow these steps.

- ✓ STEP 1: Shut off the air conditioning and turn on the heater. The heater will help rid the engine of extra heat. Set the blower speed to high.
- ✓ STEP 2: If possible, shut the engine off and let it cool. (This may take over an hour.)
- ✓ STEP 3: Never remove the radiator cap when the engine is hot.
- ✓ STEP 4: Do not continue to drive with the coolant temperature warning light on or serious damage to your engine could result.
- ✓ STEP 5: If the engine does not feel or smell hot, it is possible that the problem is a faulty coolant temperature warning light sensor or gauge. Continue to drive, but to be safe, stop occasionally and check for any evidence of overheating or coolant loss.

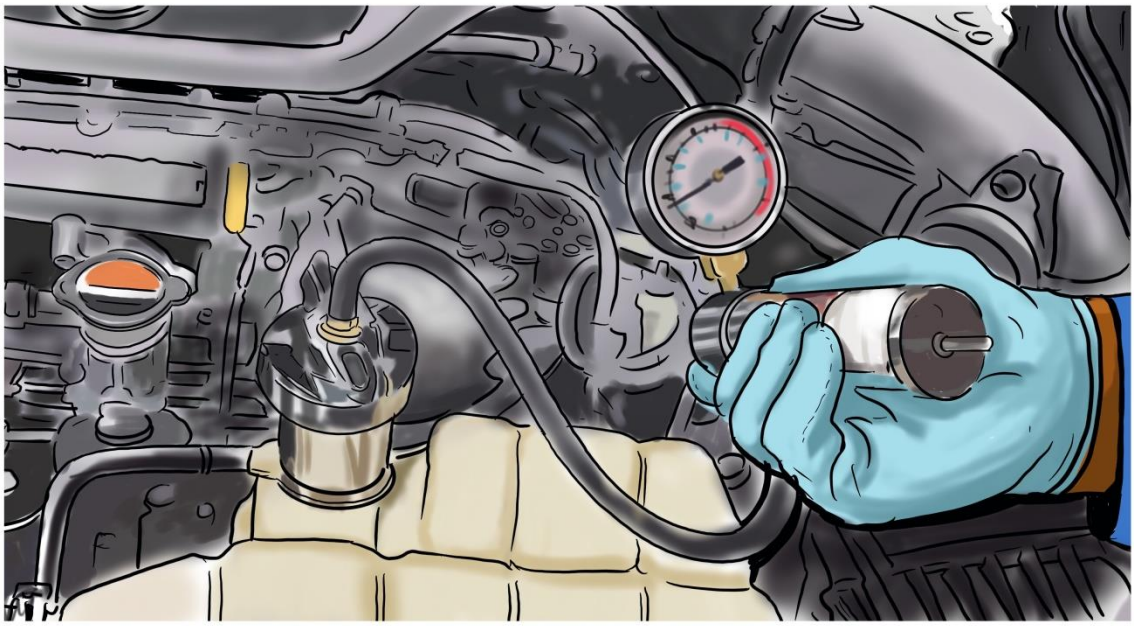
Activity 2: Guided Practice

Task 23

Visit the school workshop and inspect the cooling system of a vehicle that has high-frequency hissing or rushing noise.

Consult your trainer for advice as necessary.

1. Examine the image below; what is happening?
2. Test the system performance after correcting the components faults



Key Facts 3.2 b: Testing engine cooling system

1. **Testing engine cooling system**

There are several tests that cover a broad area.

2. **Leakage Test:** You apply pressure on the cooling system with the test kit. It simulates the running condition of the entire cooling system and places pressure on the gaskets, seals and hoses throughout the system to detect leaks.

3. **Temperature Test:** The test kit has a temperature probe, which you can use to measure if the operating temperature of the system is within the acceptable range. It will indicate whether the engine is running at the proper temperature or if it is too cold or too hot.

You can monitor the actual operation of the cooling system thermostat as it opens and closes as it regulates the liquid flow through the cooling system. The manufacturer and parts suppliers would have published data for your vehicle and its proper thermostat temperature. Do not use a 'cooler' or a 'hotter' thermostat than what the manufacturer recommends. The on board computer of the vehicle monitors the temperature of the engine very closely to ensure that the engine uses the most ideal air/fuel mixture.

A temperature test can be performed with an infrared temperature sensor, thermometer or temperature probe. The latter may be a feature of a digital multimeter (DMM). A temperature test allows for monitoring temperature change through the cooling system.

When a cold engine is started, the opening temperature of the thermostat can be observed as the engine warms. This can be compared to specifications to determine if the thermostat is bad. Once the engine has warmed up, the probe can be used to scan for cool spots in the radiator. These indicate an area where coolant is not flowing freely through the radiator. The cooling fan temperature switch can also be checked.

4. **Coolant Concentration Test:** There are different ways to perform this test. You can use alkaline test strips, a refractometer or a hydrometer, the last being the most common. This test indicates if the balance of water and coolant in your system is the most optimum. Although a water/coolant mixture in most cases is typically 50/50, some manufacturers also recommend 40 parts of water to 60 parts of coolant in the system. While a system with 100% coolant is not recommended as the coolant by itself will not dissipate the heat quickly enough, 100% water is also bad for the system as it will create corrosion problems along with poor heat dissipation.
5. **Pressure Cap Test:** Two basic cap tests that you can perform are the pressure and vacuum tests. The pressure test will indicate at what point the cap starts to yield under pressure and this should match with what is printed on the cap. There is a dedicated cap adapter, which you should use along with the cooling system pressure test kit.
6. **The vacuum test** is a relatively newer type of test that most technicians overlook. While older vehicles used an 'open system' that purged coolant as it expanded from heat, modern vehicles use a 'closed system'. Excess coolant, instead of being purged, is captured and drawn back into the system to be used again. A change in the environment laws has prompted the manufacturers to use the coolant recovery system.

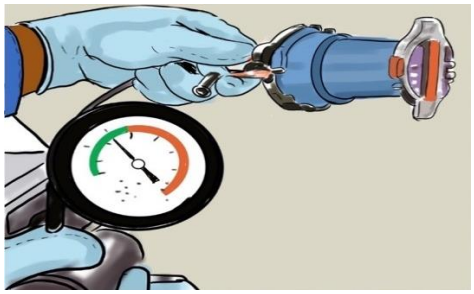
Therefore, modern vehicles need a vacuum test of the cooling system cap. This tests the ability of the coolant system in recovering coolant from an expansion tank or an overflow tank. As the system cools down, it generates a vacuum to recover coolant from the tank. This happens because the system is a closed one and the cooling liquid constracts. According to the rules of physics, liquids expand when heated and constract when cooled. Expansion and constraction of the coolant are a constant phenomenon within the cooling system of the modern automobile.

Pressure caps can pass one test but fail the other. For example, the pressure cap may work as expected for high pressures, but fail the vacuum test. Therefore, it is a good practice to check the functioning of the cap for both operations.

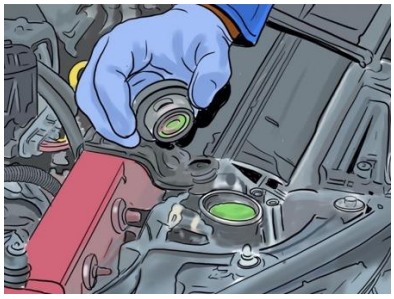
Here are a few steps of testing a radiator cap to know if it’s time for a replacement.

a) Start your car and leave it on for about 10 minutes before you open the hood. Check for coolant leaks or bubbles from the cap and the hoses.
b) If there aren't any visible signs of leaks, use gloves or a thick cloth to slowly unwind the radiator cap. Don't remove the cap or you risk burning yourself.
c) The loose coolant radiator cap should release small amounts of steam and bubbles to indicate that the radiator coolant is under the recommended pressure. Failure to release steam means that the radiator cap is faulty and has a pressure leak.
d) Alternatively, you can use the OEM (original equipment manufacturer) TOOLS 27065 Radiator and Cap Test Kit to test for pressure faults and leaks from your radiator cap.
e) To use this device, you need to turn off your car and wait for at least 30 minutes before you remove your radiator cap.
f) Connect the pressure gauge or tester to the cap adapter and screw it tight.
g) Fill the gauge with pressure by pumping the pump handle of the tester until it is filled.
h) Check the tester gauge reading against the recommended PSI readings on your car manual.
i) You will know when to replace a radiator cap depending on whether your gauge readings are within your car's recommended pressure indications in your user manual.

Using a Cooling System Pressure Tester



Remove radiator cup



Top off the coolant level

Connect the tester to the radiator's filler tube and apply pressure to the system by pumping the handle of the tester.

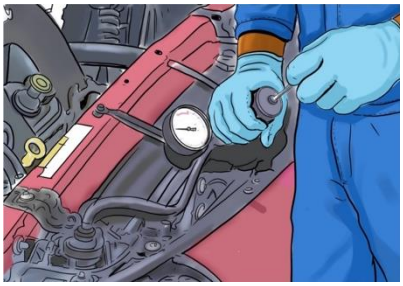


Figure 27:pumping the handle of the tester

Once the pressure is equal to the rating of the pressure cap, watch for a pressure decrease and look for leaks

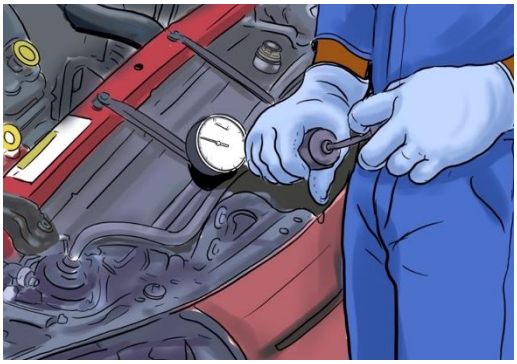


Figure 28:watch for a pressure decrease and look for leaks

Using the appropriate adapter, mount the pressure cap to the tester.

Figure 29:pressure cap adapter

Apply pressure to the cap that is equal to the cap's rating. If the cap does not hold that pressure, replace it. Then apply more pressure. If the cap is good, the excess pressure will vent through the cap

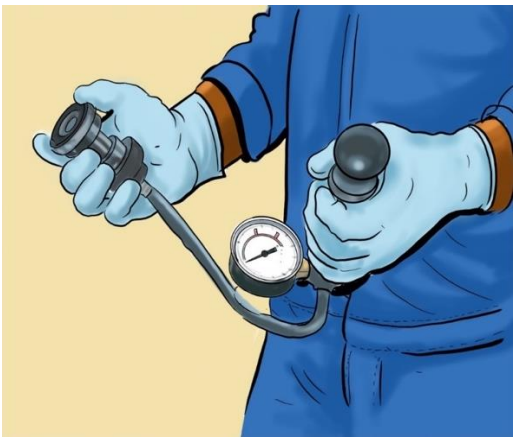


Figure 30:Apply pressure to the cap

Correct any leaks and top off the fluid level.

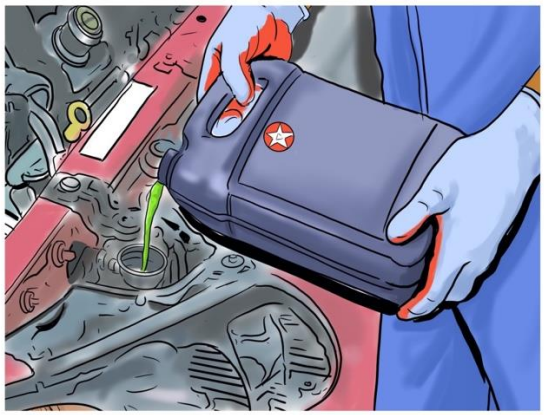


Figure 31: top off the fluid level

3. Combustion Leak Check

Internal leaks are suspected when there are no visible external leaks but the engine is losing coolant or could not hold pressure during the pressure test. These leaks are typically

caused by a cracked cylinder head or block or a bad head gasket that is allowing coolant to leak into the cylinders or combustion gases leak into the cooling system. Sometimes steam, white smoke or water in the exhaust or coolant in the oil or oil in the coolant, will give a hint that there is a bad head gasket.

A combustion leak tester is used to determine whether combustion gases are entering the cooling system. This tester is basically a glass tube with a rubber bulb. The tube is fit with a one-way valve at the bottom.

To check for combustion gas leaks, follow this procedure:

a) Start the engine and allow it to reach normal operating temperature.
b) Fill the tester's glass tube with the test fluid (normally a blue liquid).
c) Carefully remove the radiator cap
d) Make sure the coolant level in the radiator is below the lower sealing area of the filler neck.
e) Place the tester's tube into the filler neck.
f) Rapidly squeeze and release the rubber bulb. This will force air from the radiator up through the test fluid.
g) Observe the liquid. Combustion gases will change the color of the liquid to yellow. If the liquid remains blue, combustion gases are not present.
h) Dispose of the test fluid; never return used test fluid to its original container.

Activity 3: Application

Task 24

Visit different auto repair shops in the neighbourhood where the cooling system repair activities are carried out and perform the below:

1. State the steps used to mix water and antifreeze
2. State the functions of flushing engine radiator
3. State the steps used to fix engine cooling system

4. Make a report of what you have performed

Formative Assessment

1. What are the common problems of cooling system?
2. Describe the different types of antifreeze.
3. Which statement is true about thermostats?

   a. The temperature marked on the thermostat is the temperature at which the thermostat should be fully open.

   b. Thermostats often cause overheating.

   c. The temperature marked on the thermostat is the temperature at which the thermostat should start to open.

   d. Both a and b
4. Technician A says that the radiator should always be inspected for leaks and proper flow before installing a rebuilt engine. Technician B says that overheating during slow city driving can only be due to a defective electric cooling fan. Which technician is correct?

   a. Technician A only

   b. Technician B only

   c. Both Technicians A and B

   d. Neither Technician A nor B
5. The upper radiator collapses when the engine cools. What is the most likely cause?

   a. Defective upper radiator hose

   b. Missing spring from the upper radiator hose, which is used to keep it from collapsing

   c. Defective thermostat

   d. Defective pressure cap
6. What can be done to prevent air from getting trapped in the cooling system when the coolant is replaced?

   a. Pull the coolant into the radiator slowly.

   b. Use a coolant exchange machine that draws a vacuum on the system.

   c. Open the air bleeder valves while adding coolant.

   d. Either b or c
7. Heat transfer is improved from the coolant to the air when the

   a. Temperature difference is great

b. Temperature difference is small

c. Coolant is 95% antifreeze

d. Both a and c

8. A water pump is a positive displacement type of pump.

a. True b. False

9. Water pumps

a. Only work at idle and low speeds and are disengaged at higher speeds

b. Use engine oil as a lubricant and coolant

c. Are driven by the engine crankshaft or camshaft

d. Disengage during freezing weather to prevent radiator failure

10. Technician A says that the radiator should always be inspected for leaks and proper flow before installing a rebuilt engine.

Technician B says that overheating during slow city driving can only be due to a defective electric cooling fan. Which technician is correct?

a. Technician A only

b. Technician B only

c. Both Technicians A and B

d. Neither Technician A nor B

11. What are 10 common causes of engine overheating?

Points to Remember

- The fluid used as coolant today is a mixture of water and ethylene glycol-based antifreeze/ coolant.
- Closed-cooling systems are cooling systems with an expansion or recovery tank.
- The purpose of the water pump is to move the coolant efficiently through the system.
- The radiator transfers heat from the engine to the air passing through it.

- The thermostat attempts to control the engine's operating temperature by routing the coolant either to the radiator or through the bypass or sometimes a combination of both.
- Radiator pressure caps keep the coolant from splashing out of the radiator and keep the coolant under pressure. For every pound of pressure put on the coolant, the boiling point is raised about 3°F (1.6°C).
- Coolant flows from the engine to the radiator and from the radiator to the engine through radiator hoses.
- A temperature indicator is mounted in the dashboard to alert the driver of an overheating condition. A hot liquid passenger heater is part of the engine's cooling system.
- Radiators for vehicles with automatic transmissions have a sealed oil cooler located in the coolant outlet tank. The cooling fan delivers additional air to the radiator to maintain proper cooling at low speeds and idle.
- To save power and reduce the noise levels, most late-model vehicles have an electrically driven cooling fan.
- The basic procedure for testing a vehicle's cooling system includes inspecting the radiator filler neck, inspecting the overflow tube for dents and other obstructions, testing for external leaks and testing for internal leaks.
- Most radiator leak repairs require removing the radiator from the vehicle. The pressure cap should hold pressure in its range as indicated on the tester gauge dial for 1 minute.

Self-Reflection

Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.

There's no right or wrong response to this evaluation. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

1. Think about yourself:
    a) Do you think you have the knowledge, skills or attitudes to do the task?
    b) How well?
2. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Select tools, materials and equipment used to repair engine cooling system					
Explain the procedures used to detect and to correct engine cooling system components faults					
Detect engine cooling system components faults					
Correct engine cooling system components faults					
Explain the procedures used to test engine cooling system faults					
Test engine cooling system performance					
Change engine coolant					
Comply with safety precautions at the workplace					
Demonstrate team spirit while working with others					

My experience Knowledge, skills and attitudes	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Comply with national and international standards at the workplace					

Fill in the table below and share the results with the trainer for further guidance.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	1.	1.
2.	2.	2.

Summative assessment (Integrated situation)

Integrated/Summative assessment

Integrated situation

A driver from KATAZA Construction Company Ltd located in MUHANGA District, NYAMABUYE Sector was driving a dump truck for hauling the soil loaded by an excavator machine. During the journey to the dumping site at GACURABWENGE Sector in KAMONYI District, he encountered an engine overheating problem caused by a faulty cooling system. He contacted the head of GABIRO garage located at the NYAMABUYE Sector in MUHANGA District to send a mechanic for intervention. The head of the garage requested you as a mechanic to solve the aforementioned problem within 6 hours.

Tools	
Equipment	
Materials/ Consumables	

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