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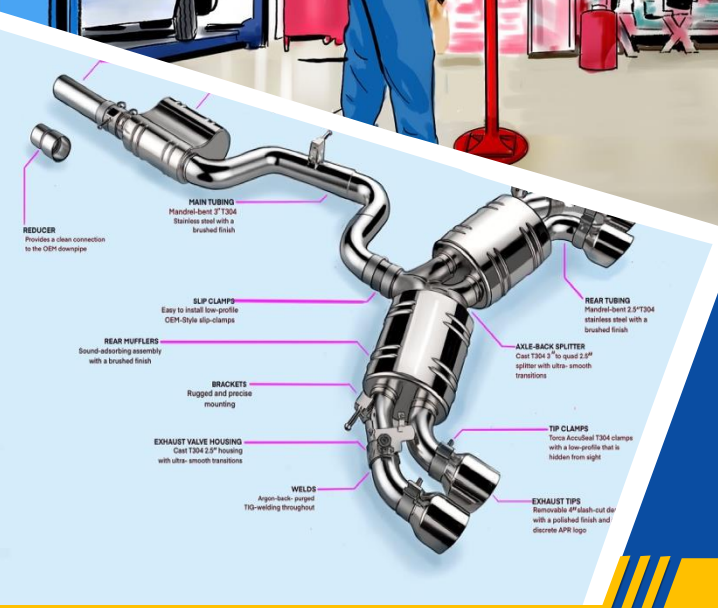
RQF LEVEL 3



AUTES301

AUTOMOBILE TECHNOLOGY

Engine Exhaust System Repairing

TRAINER'S MANUAL

December 2023

ENGINE EXHAUST SYSTEM REPAIRING

2023

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LIST OF ABBREVIATIONS AND ACRONYMS

CBET: Competency-Based Education and Training.

RQF: Rwanda Qualification Framework

RTB: Rwanda TVET Board

TVET: Technical and Vocational Education and Training

%: Percentages

cm: Centimeter

M: Meter

G: Gram

Kg: Kilogram

mm: Millimeter

PPE: Personal Protective Equipment

SCEB: Stabilized Compressed Earth Blocks

hp: Horsepower

RS: Rwandan Standard

RSB: Rwanda Standards Board

KPa: Kilopascal

N: Newton

mm^2: Millimeter Squared

MPa: Megapascal

TSB: Technical Service Bulletins.

PCM: Power-train Control Module

EGR: Exhaust Gas Recirculation.

DEF: Diesel Exhaust Fluid.

DTC: Diagnostic Trouble Code.

mV: Millivolt

MIL: Malfunction Indicator Lamp

^0F: Degree Fahrenheit

^{0}C:	Degree Celsius
Psi:	Pressure per Square Inch
RPM:	Revolution Per Minute
V6:	Engine with six cylinders in form of ‘‘V’’
V8:	Engine with eight cylinders in form of ‘‘V’’
CO:	Carbon Monoxide
CO_2:	Carbon Dioxide
Ho_2:	Water Vapor
NO_x:	Oxides of Nitrogen
H_2SO_4:	Sulfuric acid
HOS2:	Heater control/ Oxygen Sensor
A/F:	Air Fuel Ratio
HC:	Hydrocarbons
COVID-19:	Coronavirus Disease of 2019
OBD II:	On-Board Diagnostic II
MIG:	Metal Inert Gas
TIG:	Tungsten Inert Gas
PPM:	Parts Per Million.
G/MI:	Grams Per mile.

INTRODUCTION

This trainer manual encompasses all methodologies necessary to guide you to properly deliver the module titled: Engine Exhaust System Repairing. Students undertaking this module shall be exposed with practical activities that will develop and nurture their competencies. The writing process of this training manual embraced competency-based education and training (CBET) philosophy by providing practical opportunities reflecting real life situations.

The trainer manual is subdivided into learning outcomes; each learning outcome has got various topics. Trainer will start guiding a self-assessment exercise to help students rate themselves on their level of skills, knowledge and attitudes about the learning outcome or unit in their trainee manual.

The trainer manual will give trainer the information about the objectives, learning hours, didactic materials, proposed methodologies and crosscutting issues.

A discovery activity is followed to help students discover what they already know about the unit.

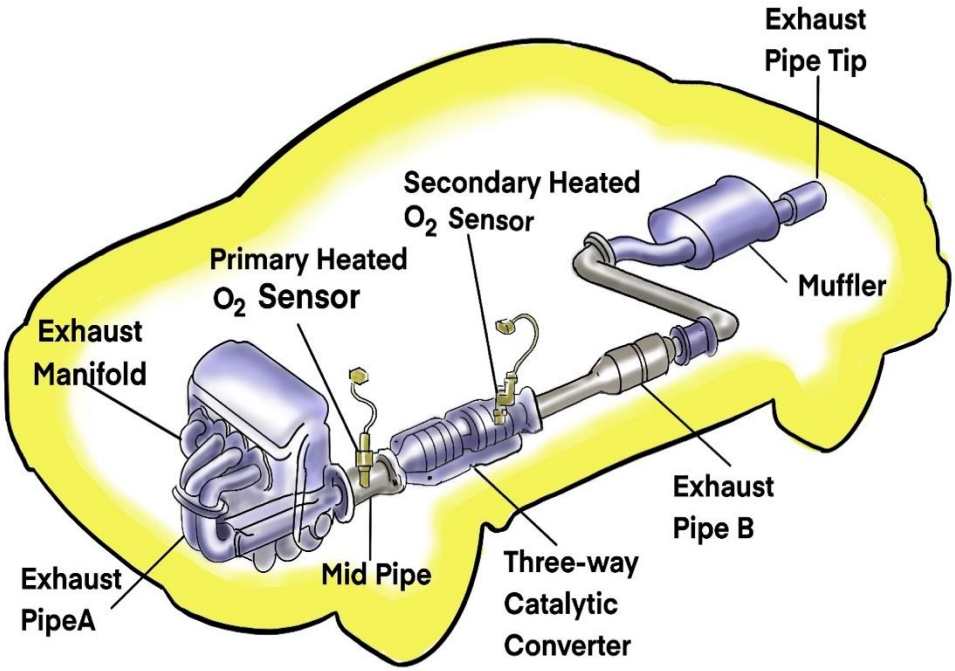
This manual will give trainer tips, methodologies and techniques about how to facilitate students to undertake different activities as proposed in their trainee manuals. The activities in this training manual are prepared such that they give opportunities to students to work individually and in groups.

After going through all activities, trainer shall help students to undertake progressive assessments known as formative and finally facilitate them to do their self-reflection to identify strengths, weaknesses and areas for improvements.

Trainer remind trainees to read the point to remember section which provides the overall key points and takeaways of the unit.

Learning outcomes	Learning Hours	Topics
Learning outcome 1: Describe exhaust systems	20	1.1 Identification of exhaust system according to exit pipes.
		1.2 Description of exhaust system components.
Learning outcome 2: Prepare workplace	10	2.1 Safety precautions at workplace
		2.2 Selection of PPE
		2.3 Cleaning and arrangement of the workplace
Learning outcome 3: Repair engine exhaust system	40	3.1 Selection of tools, materials and equipment
		3.2 Inspection of exhaust system components
		3.3 Correction of exhaust system damaged components.

LEARNING OUTCOMES 1: DESCRIBE ENGINE EXHAUST SYSTEM.



Learning outcome 1: Self-Assessment

1. Ask trainees to look at the unit Illustration in their Trainee Manuals and together discuss:
   a. What does the illustration show?
   b. What topics do you think will be covered under this unit based on the illustration?
2. After the discussion, inform students that this unit is intended to provide them with the knowledge, skills and attitudes to identify engine cooling systems. They will cover the identification of exhaust system exit pipe types, identification of exhaust system components, description of functions, constructions and operating principles of exhaust system components.
3. Ask trainees to fill out the self-assessment at the beginning of the unit in their Trainee Manuals. Explain that:
   a. The purpose of the self-assessment is to become familiar with the topics in the unit and for them to see what they know or do not know at the beginning.

b. There is no right or wrong ways to answer this assessment. It is for their own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

c. They should think about themselves: do they think they have the knowledge, skills or attitudes to do this? How well?

d. They read the statements across the top and put a tick in column that best represents their level of knowledge, skills or attitudes.

e. At the end of the unit, they will do a self-reflection, which includes re-taking the self-assessment and identifying their strengths, areas of improvement and actions to be taken.

Key Competencies:

Knowledge	Skills	Attitudes
1. Identify the type of exhaust system exit pipes	**1.** Describe the operating principle of exhaust system components	**1.** Pay attention to details while describing the engine exhaust system
2. Explain the function of exhaust system	**2.** Describe the function of exhaust system components	**2.** Demonstrate team spirit while working with others
3. Name the components of exhaust system	**3.** Describe the construction materials of exhaust system components	**3.** Comply with national and international standards at the workplace
4. Explain the construction materials of exhaust system components	**4.** Select exhaust system components	**4.** Time management

Discovery Activity

Task 1

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the picture and answer questions provided under task 1 in their trainee manuals and answer the questions that follow. *Make sure instructions are understood, all the students are actively participating and necessary materials/tools are given.*

2. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Encourage all students to give their views.

3. After the presentations/sharing session, inform students that this activity was not intended for them to give the right answers but to give them a picture of what they will cover in the unit.

4. Introduce Topic 1.1: Identification of exhaust system according to exit pipes.

Topic 1.1: Identification of exhaust system according to exit pipes.

Objectives: By the end of the topic, trainees will be able to: a. Identify engine exhaust systems types according to exit pipe b. Describe advantage and disadvantage of engine exhaust systems types according to exit pipe
Time Required: *3 hours*
Learning Methodology: *Group discussion, short questions, Open ended questions, Site visit, brainstorming, jig-saw*

- **Materials, Tools and equipment Needed:**
- **Materials:** Bolts and nuts, shop rags, WD40, cleaning brush, complete exhaust system
- **Tools:** Spanners, Screw drivers, Pry bar, Chipping hummer, Chisels, Scriber, Hammers,
- **Equipment:** Personal protective equipment (PPE), workshop with vehicle, personal computer, projector, car lift, jack and jack stand

Preparation:

- ❑ *Preparation of workshop with vehicles*
- ❑ *Availability of tools, materials and equipment to be used*
- ❑ *Contact garage manager for field visit.*

Cross Cutting Issues:

- ✓ Ensure gender balance while forming groups, allocating tasks and during presentations
- ✓ Ensure inclusivity while allocating tasks to students and provide facilities/environment that enable/allows participation of all
- ✓ Promote financial education by emphasizing the need/importance of taking care of tools and equipment
- ✓ Ensure environment and sustainability regulations are followed while dealing with engine exhaust systems.

Prerequisites:

- Classification of internal combustion engine
- Working principle of internal combustion engine
- Heat transfer

Activity 1: Problem-Solving

Task 2

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustrations and answer the questions provided under task 2 in their trainee manuals. *Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used*

2. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

3. After the sharing session, refer students to **Key facts 1.1. a &1.1. b,** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 2: Guided Practice

Task 3

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to visit the school workshop and answer the questions provided under task 3 in their trainee manuals. *Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.*

2. During the task, students should be given degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as W*hy? What? How?* to enable them come to informed responses.

3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, financial education, environment and sustainability

among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

5. After the sharing session, refer students to **Key Facts 1.1.a&b,** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 3: Application

Task 4

1. Using an appropriate methodology such as individual work, pairs, or small groups trainees visit the nearest garage and make a report of the identification of the vehicle and motorcycle engines exhaust systems that they will need to analyze and focus on the following:
    a. Identify the exhaust system types according to exit pipe of the vehicle
    b. Describe the difference between exhaust system types according to exit pipe of the above vehicle

Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used

2. This activity requires students to work independently with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the report.

Topic 1.2: Description of engine exhaust system components

Objectives:

By the end of the topic, trainees will be able to:

a. Identify engine exhaust system components
b. Differentiate engine exhaust system components
c. Describe the function of engine exhaust system components
d. Describe the construction materials of engine exhaust system components

Time Required: *7 hours*

Learning Methodology: *Group discussion, short questions, Open ended questions, Site visit, brainstorming, jig-saw.*

Materials, Tools and equipment Needed:

- **Materials:** Bolts and nuts, shop rags, WD40, cleaning brush, complete exhaust system
- **Tools:** Spanners, Screw drivers, pry bar, Chipping hummer, Chisels, Scriber, Hammers,
- **Equipment:** Personal protective equipment (PPE), workshop with vehicle, personal computer, projector, car lift, jack and jack stand.

Preparation:

- ❑ *Preparation of workshop with vehicles*
- ❑ *Availability of tools materials and equipment to be used*
- ❑ *Contact garage manager for field visit.*

Cross Cutting Issues:

- ✓ Ensure gender balance while forming groups, allocating tasks and during presentations
- ✓ Ensure inclusivity while allocating tasks to students and provide facilities/environment that enable/allows participation of all
- ✓ Promote financial education by emphasizing the need/importance of taking care of tools and equipment
- ✓ Ensure environment and sustainability regulations are followed while dealing

with exhaust gases.

Prerequisites:

- Bench work
- Knowledge of materials
- Classification of internal combustion engine
- Working principle of internal combustion engine

Activity 1: Problem-Solving

Task 5

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustration about the engine exhaust system components and answer the questions provided under task 5 in their trainee manuals. *Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.*

2. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

3. After the sharing session, refer students to **Key facts 1.2a & 1.2b,** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 2: Guided Practice

Task 6

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the

scenario about describing the engine exhaust systems components and answer the questions provided under task 6 in their trainee manuals. *Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.*

2. During the task, students should be given degree of independence to apply the knowledge and skills acquired in activity 1&2. Your role is to guide them by using probing questions such as W*hy? What? How?* to enable them come to informed responses.

3. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, financial education among others. Also attitudes and behavior changes should be handled during this activity.

4. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

5. After the sharing session, refer students to **Key facts 1.2a & 1.2b,** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 3: Application

Task 7

1. Using an appropriate methodology such as individual work, pairs, or small groups trainees read the scenario under task 7 in their trainee manual and make a report of components of the exhaust systems for the vehicles found at the garage including:
    a. Engine exhaust components,
    b. Functions of engine exhaust system components,
    c. Construction materials of enging exhaust system?

    Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.

2. This activity requires students to work independently with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the report.

Formative Assessment

1. What are the types the exhaust system due to exit pipe?

   Answer: Single exit exhaust system, and high-performance exhaust system which include: dual exit exhaust, dual side exhaust, opposite dual exhaust.

2. Differentiate is the type the exhaust system due to exit pipe.

   Answer: Single exit exhaust system is a type of car exhaust system that utilizes a single pipe to direct the flow of exhaust gases out of a vehicle. But high-performance exhaust system is an exhaust system with improved pipework, silencers, and use the dual exit pipe to reduce noise emitted, improve fuel consumption and improve engine performance and increase horsepower.

3. Explain the function of exhaust system.

Answer:

- ✓ It carries burned exhaust gases away from the passenger compartment of the car.
- ✓ It quiets the engine.
- ✓ One or more catalytic converters control exhaust emissions.

4. Explain the function of the following exhaust system components

   a) Exhaust manifold

   Answer: The exhaust manifold collects the burnt gases as they are expelled from the cylinders and directs them to the exhaust pipe.

   b) Exhaust pipe

   Answer: It routes and expel the exhaust gases from the combustion chamber of each cylinder out to the atmosphere.

   c) Exhaust gasket

Answer: it helps sealing the gap between the engine block and the exhaust pipe and prevent the leaking problem and ensuring the exhaust gas will flow through the catalytic converter.

d) Catalytic converter

Answer: As an emission control device, it is responsible for converting undesirable exhaust gases into harmless gases. As part of the exhaust system, it helps reduce the noise level of the exhaust.

e) Muffler

Answer: is to break up, cancel out, or silence the pressure pulsations that occur each time an exhaust valve opens.

f) Resonator

Answer: This unit is designed to further reduce or change the sound level of the exhaust.

g) Tailpipe

Answer: It releases the exhaust fumes into the atmosphere beyond the back end of the car.

h) Heat shields

Answer: Heat shields are used to protect other parts from the heat of the exhaust system and the catalytic converter.

i) Clamps, Brackets and Hangers

Answer: Clamps, brackets, and hangers are used to properly join and support the various parts of the exhaust system.

j) Exhaust gas oxygen sensors

Answer: It is an oxygen concentration sensor which measures the residual oxygen content of the exhaust gases and then transmits a signal to the engine management system in the form of an electric voltage.

5. Describe the construction materials of the following exhaust system components

a) Exhaust manifold

Answer: Exhaust manifolds for most vehicles are made of cast or nodular iron.

b) Exhaust pipe

Answer: The exhaust pipe is metal pipe, made of aluminized steel, stainless steel, or zinc-plated heavy gauge steel.

c) Exhaust gasket

Answer: Exhaust gaskets are generally designed in the form of composite graphite - cemjo, crush ring, spiral wound gasket, wire mesh gasket and steel embossed gaskets.

d) Catalytic converter

Answer: The converter beads or ceramic block are coated with a thin coating of cerium, platinum, palladium, rhodium, or any combination of these and are held in a stainless-steel container.

e) Muffler

Answer: a series of baffles, chambers, tubes, and holes.

f) Resonator

Answer: Aluminized Steel, Mild Steel 304, and 409 Stainless Steel.

g) Tailpipe

Answer: The exhaust tailpipe is metal pipe, made of aluminized steel, stainless steel, or zinc-plated heavy gauge steel.

h) Heat shields

Answer: They are usually made of pressed or perforated sheet metal.

6. Describe the operating principle of the following exhaust system components

a) Exhaust manifold

Answer: In-line engines have one exhaust manifold. V-type engines have an exhaust manifold on each side of the engine. An exhaust manifold will have three, four, or six passages, depending on the type of engine. These passages blend into a single passage at the other end, which connects to an exhaust pipe. From that point, the flow of exhaust gases continues to the catalytic converter, muffler, and tailpipe, and then exits at the rear of the car.

b) Catalytic converter

Answer: Modern vehicles are equipped with three-way catalytic converters, which means the converter reduces the three major exhaust emissions, hydrocarbons

(HC), carbon monoxide (CO), and oxides of nitrogen (NOx). The converter oxidizes HC and CO into water vapor and carbon dioxide (CO2) and reduces NOx to oxygen and nitrogen.

Many vehicles are equipped with a mini-catalytic converter that either is built into the exhaust manifold or is located next to it. These converters are used to clean the exhaust during engine warm-up and are commonly called warm-up converters. Some older catalytic converters have an air hose connected from the air system to the oxidizing catalyst. This air helps the converter work by making extra oxygen available. The air from the air system is not always forced into the converter; rather, it is controlled by the vehicle's PCM. Fresh air added to the exhaust at the wrong time could overheat the converter and produce NOx, something the converter is trying to destroy.

c) Muffler

Answer: Two types of mufflers are commonly used on passenger vehicles. Reverse-flow mufflers change the direction of the exhaust gas flow through the inside of the unit. This is the most common type of automotive muffler. Straight-through mufflers permit exhaust gases to pass through a single tube. The tube has perforations that tend to break up pressure pulsations. They are not as quiet as the reverse-flow type.

Points to Remember

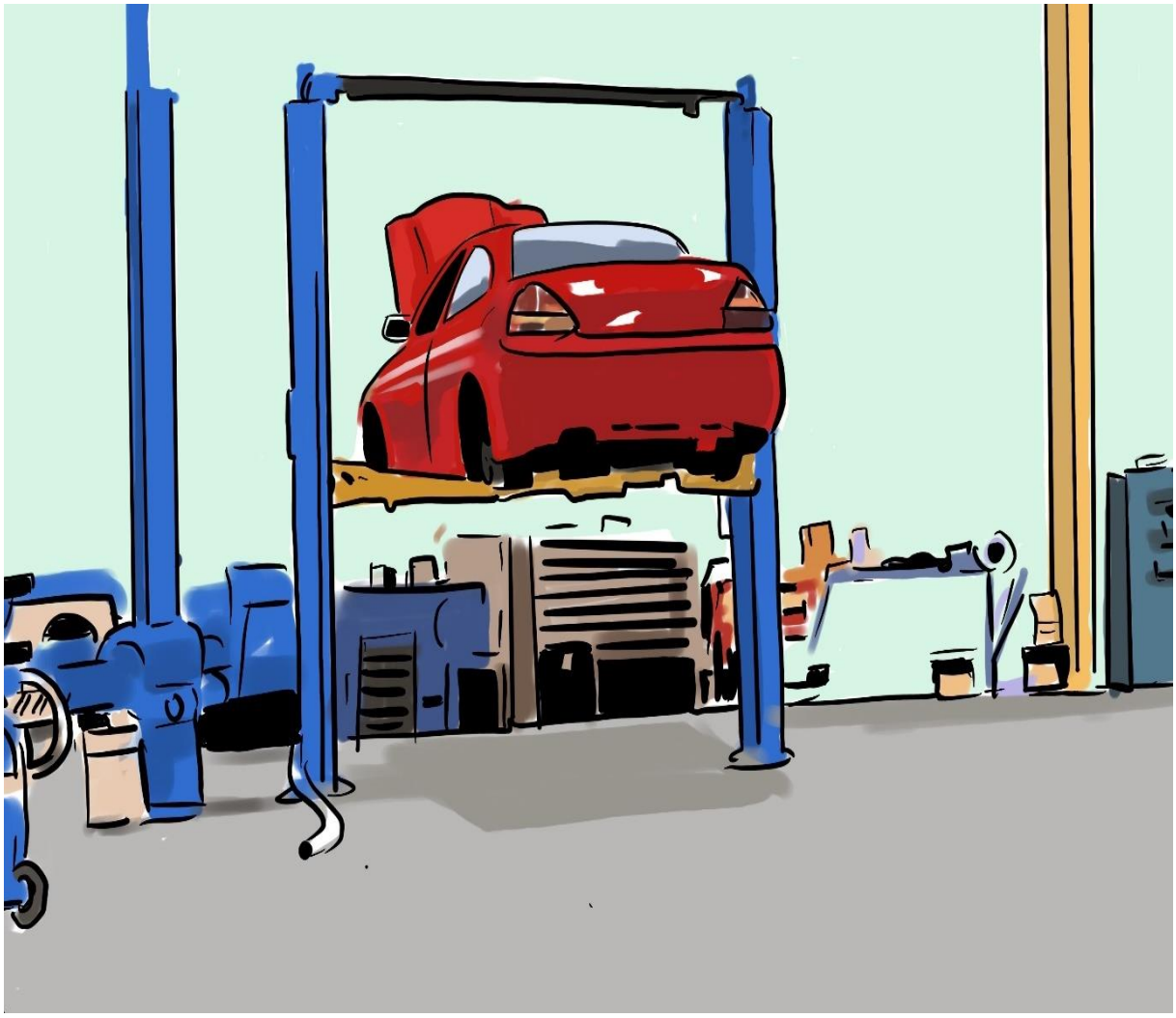
- Single exhaust systems commonly feature a Y-pipe design, which gathers the exhaust gases from the manifold and channels them into a singular pipe.
- A single exhaust is lighter in weight and has a lower cost compared to other exhaust systems.
- High-performance exhaust systems are comparatively more expensive which is found doing a highly efficient job of filtering out the gasses.
- High performance dual exhaust system comes in different ways including dual exit pipe, opposite dual exhaust system and dual Side Exhaust
- A vehicle's exhaust system carries away gases from the passenger compartment, cleans

the exhaust emissions, and muffles the sound of the engine. Its components include the exhaust manifold, exhaust pipe, catalytic converter, muffler, resonator, tailpipe, heat shields, clamps, brackets, and hangers.

- The exhaust manifold is a bank of pipes that collects the burned gases as they are expelled from the cylinders and directs them to the exhaust pipe. Exhaust manifolds for most vehicles are made of cast or nodular iron.
- The catalytic converter reduces HC, CO, and NOx emissions.
- The muffler consists of a series of baffles, chambers, tubes, and holes to break up, cancel out, and silence pressure pulsations.
- In four-stroke engines, restrictions in the exhaust can cause backpressure, especially at higher speeds. Excessive backpressure reduces performance and fuel economy.
- The oxygen sensor is an instrument for managing the exhaust emissions of petrol, diesel and gas engines.
- Heat shields are used to protect other parts from the heat of the exhaust system and the catalytic converter.
- Clamps, brackets, and hangers are used to properly join and support the various parts of the exhaust system.
- A resonator is designed to further reduce or change the sound level of the exhaust.
- The tailpipe is the last pipe in the exhaust system. It releases the exhaust fumes into the atmosphere beyond the back end of the car.

Self-Reflection

1. Ask learners to re-take the self-assessment at the beginning of the unit. They should then fill in the table in the Trainee's Manual to identify their areas of strength, areas for improvement and actions to take to improve.
2. Discuss trainees' results with them. Identify any areas that are giving many trainees difficulties and plan to give additional support as needed (ex. use class time before you begin the next learning outcome to go through commonly identified difficult concepts).



Learning outcome 2: Self-Assessment

1. Ask trainees to look at the unit Illustration in their Trainee Manuals and together discuss:
    a. What does the illustration show?
    b. What topics do you think will be covered under this unit based on the illustration?
2. After the discussion, inform students that this unit is intended to provide them with the knowledge, skills and attitudes to prepare workplace. They will cover the identification

of Safety precautions at workplace, Selection of personal protective equipment (PPE), Cleaning and arrangement of the workplace.

3. Ask trainees to fill out the self-assessment at the beginning of the unit in their Trainee Manuals. Explain that:
   a) The purpose of the self-assessment is to become familiar with the topics in the unit and for them to see what they know or do not know at the beginning.
   b) There is no right or wrong ways to answer this assessment. It is for their own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
   c) They should think about themselves: do they think they have the knowledge, skills or attitudes to do this? How well?
   d) They read the statements across the top and put a check in column that best represents their level of knowledge, skills or attitudes.
   e) At the end of the unit, they will do a self-reflection, which includes re-taking the self-assessment and identifying their strengths, areas of improvement and actions to be taken.

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)

Discovery Activity

Task 8

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustration about application of Safety precautions at workplace and answer questions provided under task 8 in their trainee manuals and answer the questions that follow.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are given.
3. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Encourage all students to give their views.
4. After the presentations/sharing session, inform students that this activity was not intended for them to give the right answers but to give them a picture of what they will cover in the unit.
5. Introduce Topic 2.1: Application of Safety precautions at workplace.

Topic 2.1: Application of Safety precautions at workplace.

Objectives: By the end of the topic, trainees will be able to: a. Describe the personal safety b. Describe work area safety c. Describe tools and equipment safety d. Follow safety precautions at workplace
Time Required: *1 hours*
Learning Methodology: *Group discussion, short questions, Open ended questions, Site visit, brainstorming, jig-saw.*

Materials, Tools and Equipment Needed:

- **Materials:** Soap solution, Solvent, Clothes rugs, white board, spray bottle, soft brushes, scrubber sponge, Broom, Mops.
- **Tools:** Electric blower, cleaning drill brush, cleaners' corner & edge brush
- **Equipment** PPE's (Boots, masks, helmets, gloves, overcoats), dust pan and Air compressor.

Preparation:

- ❑ *Preparation of workshop with vehicles*
- ❑ *Availability of tools, materials and equipment to be used*
- ❑ *Contact garage manager for field visit.*

Cross Cutting Issues:

- ✓ Ensure gender balance while forming groups, allocating tasks and during presentations
- ✓ Ensure inclusivity while allocating tasks to students and provide facilities/environment that enable/allows participation of all
- ✓ Promote financial education by emphasizing the need/importance of taking care of tools and equipment
- ✓ Ensure environment and sustainability regulations are followed while dealing with engine exhaust systems.

Prerequisites:

- N/A

Activity 1: Problem-Solving

Task 9

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustrations about safety precautions at workplace and answer the questions provided under task 9 in their trainee manuals.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used

3. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.

4. After the sharing session, refer students to **Key facts 2.1 a & b** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 2: Guided Practice

Task 10

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to visit the school workshop then properly prepare the workshop by applying the safety precautions for the workplace using the equipment required for safety precautions at workplace and answer the questions provided under task 10 in their trainee manuals.

2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used

3. During the task, students should be given degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using questions such as Why? What? How? to enable them come to informed responses.

4. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, financial education, environment and sustainability among others. Also attitudes and behavior changes should be handled during this activity.

5. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.

6. After the sharing session, refer students to **Key Facts 2.1.a & b** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 3: Application

Task 11

1. Using an appropriate methodology such as individual work, pairs, or small groups trainees visit the nearest garage, then participate in the application of safety precautions at the workplace.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
3. This activity requires students to work independently with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the report.

Topic 2.2: Selection of personal protective equipment (PPE)

Objectives: By the end of the topic, trainees will be able to: a. Select personal protective equipment b. Describe how to use personal protective equipment c. Describe the advantages of PPE
Time Required: *2 hours*
Learning Methodology: *Group discussion, short questions, Open ended questions, Site visit, brainstorming, jig-saw.*

Materials, tools and equipment Needed: Projector, Chalk, pen, workshop with vehicle and teaching manual and PPE's (Boots, masks, helmets, gloves, overall or overcoats)

- **Materials:** Soap solution, Solvent, Clothes rugs, white board, spray bottle, soft brushes, scrubber sponge, Broom, Mops.
- **Tools:** Electric blower, cleaning drill brush, cleaners' corner & edge brush
- **Equipment** PPE's (Boots, masks, helmets, gloves, overcoats), dust pan and Air compressor.

Preparation:

- ❑ *Preparation of workshop with vehicles*
- ❑ *Availability of tools materials and equipment to be used*
- ❑ *Contact garage manager for field visit.*

Cross Cutting Issues:

- ✓ Ensure gender balance while forming groups, allocating tasks and during presentations
- ✓ Ensure inclusivity while allocating tasks to students and provide facilities/environment that enable/allows participation of all
- ✓ Promote financial education by emphasizing the need/importance of taking care of tools and equipment
- ✓ Ensure environment and sustainability regulations are followed while dealing with exhaust gases.

Prerequisites:

- N/A

Activity 1: Problem-Solving

Task 12

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the

illustration about the selection and use of PPE then answer the questions provided under task 12 in their trainee manuals.

2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used

3. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

4. After the sharing session, refer students to **Key facts 2.2,** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 2: Guided Practice

Task 13

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the scenario about the workshop hazards and answer the questions provided under task 13 in their trainee manuals.

2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used

3. During the task, students should be given degree of independence to apply the knowledge and skills acquired in activity. Your role is to guide them by using probing questions such as W*hy? What? How?* to enable them come to informed responses.

4. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, financial education among others. Also attitudes and behavior changes should be handled during this activity.

5. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

6. After the sharing session, refer students to **Key Facts 2.2** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 3: Application

Task 14

1. Using an appropriate methodology such as individual work, pairs, or small groups trainees read the scenario under task 14 in their trainee manual and prepare needed PPEs for the interns and demonstrate how to use them properly to repair exhaust system.

2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used

3. This activity requires students to work independently with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the report.

Topic 2.3: Cleaning and arrangement of the workplace

Objectives:

By the end of the topic, trainees will be able to:

a. Explain cleaning procedures for the workplace.
b. Explain procedures to arrange the workplace.
c. Clean the workplace
d. Arrange the workplace

Time Required: *2 hours*

Learning Methodology: *Group discussion, short questions, Open ended questions, Site visit, Brainstorming, Jig-saw.*

Materials, tools and Equipment Needed:

Materials: Soap solution, Solvent, Clothes rugs, white board, spray bottle, soft brushes, scrubber sponge, Broom, Mops.

Tools: Electric blower, cleaning drill brush, cleaners' corner & edge brush.

Equipment PPE's (Boots, masks, helmets, gloves, overcoats), dust pan and Air compressor.

Preparation:

- ❑ *Preparation of workshop with vehicles*
- ❑ *Availability of tools materials and equipment to be used*
- ❑ *Contact garage manager for field visit.*

Cross Cutting Issues:

- ✓ Ensure gender balance while forming groups, allocating tasks and during presentations
- ✓ Ensure inclusivity while allocating tasks to students and provide facilities/environment that enable/allows participation of all
- ✓ Promote financial education by emphasizing the need/importance of taking care of tools and equipment
- ✓ Ensure environment and sustainability regulations are followed while dealing with exhaust gases.

Prerequisites:

- N/A

Activity 1: Problem-Solving

Task 15

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustration about cleaning and arrangement of the workplace and answer the questions provided under task 15 in their trainee manuals.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used
3. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
4. After the sharing session, refer students to **Key facts 2.3** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 2: Guided Practice

Task 16

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to clean the workplace, tools and equipment and answer the questions provided under task 16 in their trainee manuals.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used
3. During the task, students should be given degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as Why? What? How? to enable them come to informed responses.

4. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, financial education among others. Also attitudes and behavior changes should be handled during this activity.
5. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
6. After the sharing session, refer students to **Key Facts 2.3** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 3: Application

Task 17

1. Using an appropriate methodology such as individual work, pairs, or small groups trainees read the scenario under task 17 in their trainee manual and clean and arrangement of workplace
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used
3. This activity requires students to work independently with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the report.

Formative Assessment

a. List five items that are personal protective equipment (PPE).

   Answer: Gloves, safety glasses, overall, safety shoes, ear protection, respiratory protection and head protection

b. What are the types of fire extinguishers and their usage?

   Answer:

c. What items are included in a typical first aid box?

Answer: types of fire extinguisher including: Water, Foam, CO2, Dry Powder and Wet Chemical.

d. List five common automotive chemicals or products that may be considered hazardous materials.

Answer:

- Used oil, including used oil filters and sorbents.
- Rags, towels, or paper towels that have come into contact with chemicals.
- Cleaners.
- Lead-acid batteries.
- Lead wheel weights.
- Automotive chemicals like antifreeze and refrigerants.
- Fluorescent lamps.
- Asbestos
- Fumes
- Solvents

e. List five precautions to which every technician should adhere when working with automotive products and chemicals.

Answer:

- ✓ Never smoke while working on a vehicle or while working with any machine in the shop. It is good practice to never smoke in the shop, because of the flammable chemicals and fluids that could be nearby.
- ✓ Playing around or horseplay is not appropriate for professional technicians. Such things as air nozzle fights, creeper races, or practical jokes can hurt people and have no place in the professional workplace.
- ✓ To prevent serious burns, keep your skin away from hot metal parts such as the radiator, exhaust manifold, tailpipe, catalytic converter, and muffler.
- ✓ When working with a hydraulic press, make sure that the pressure is applied in a safe manner. It is generally wise to stand to the side when operating the press. Always wear safety glasses.
- ✓ 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.

f. Describe how to use fire extinguisher

Answer:

a. P - PULL THE PIN at the top of the extinguisher. The pin releases a locking mechanism and will allow you to discharge the extinguisher.
b. A - AIM at the base of the fire and not at the flames. ...
c. S - SQUEEZE the lever.
d. S - SWEEP from side to side.

g. Discus the good housekeeping precautions that should be followed in every repair

Answer:

- Keep all aisleways and walking-working surfaces clear of material and debris.
- Keep all cords out of aisleways and walking-working surfaces. If this cannot be avoided, use floor cord covers or sturdy tape to secure cords so they do not pose a tripping hazard.
- Keep all work areas and machinery clear and free of materials and debris. Never remove metal chips or shavings with bare hands.
- Never block fire exits, fire extinguishers, first-aid kits, eyewashes/safety showers, electrical panels, electrical disconnects, emergency stop devices, or any other critical safety devices.
- Put away any tools or materials in their proper spot when finished with them.

h. Describe the types of cleaning methods in repair shop

Answer:

✓ Abrasive cleaning: 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

✓ Wet cleaning or chemical cleaning: with petroleum solvents or water based chemical solutions like Alkaline (base), and Acid.

- ✓ 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.

i. Explain why cleanliness is important for workplaces

Answer:

- ✓ Well-being: Providing a clean work environment helps in maintaining the well-being of employees.
- ✓ Productivity: Provisions for a clean environment can increase the productivity of employees.
- ✓ 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.

j. Discuss on skin and body protection in repair shop

Answer:

- Head:
- ✓ Ensure that there are no dents or deformities on the shell and connections are tightened inside.
- ✓ Do not store in direct sunlight as extreme heat can cause damage.
- ✓ Choose appropriate cleaning agents as it can weaken the shells of hard hats and may eliminate electrical resistance.
- ✓ Always replace a hard hat if it was used for any kind of impact, even if the damage is unnoticeable.
- Body protection
- ✓ Ensure that they are clean and free from cuts and burns.
- ✓ Always get a good fit to ensure full body protection.
- ✓ Ensure bodysuit is heat-resistant clothing when working with high-temperature hazards.
- Hand protection:
- ✓ Ensure hand protection fits perfectly with no spaces and is free from cuts, burns and chemical residue.

- ✓ Always replace them if any sign of contamination was observed.
- ✓ Use rubber gloves when working with heat and electricity to reduce the risk of burn or electrical shock.

- Foot Protection:

- ✓ Ensure boots have slip-resistant soles that can protect against compression and impact.
- ✓ Ensure the sole plate is in good condition to prevent punctures.

- Fall Protection:

- ✓ Ensure that the straps are free from tears, deformities and burn marks.
- ✓ Check the buckles if connected securely and tightly.
- ✓ Dispose of the equipment if used after a falling incident.

k. What are the safety precautions to be applied in case of the hazardous situations below?

i. Batteries contain highly corrosive and potentially explosive acids……

Answer: Wear protective equipment when handling batteries including gloves, eyewear and hardhat.

ii. Fuels and cleaning solvents are flammable……

Answer: It is good practice to never smoke in the shop, because of the flammable chemicals and fluids that could be nearby.

iii. Exhaust fumes are poisonous……

Answer: 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.

iv. During some repairs, technicians can be exposed to harmful dust particles and vapors……

Answer: harmful dust particles must be removed in workplace and disposed in dust bin, also wear respiratory protection when you are working where there are vapors.

v. High voltage on some types of vehicles present shock and burn hazards……

Answer:

a. Always wear high voltage insulating gloves when working on high voltage
b. Always ensure all tools are cleared away before you start any work near the source of power like the motors or generators because they pose an increased risk.
c. Children should be kept out of repair areas, especially when you're working.
d. Always make sure you maintain good housekeeping practices by keeping floors clean.

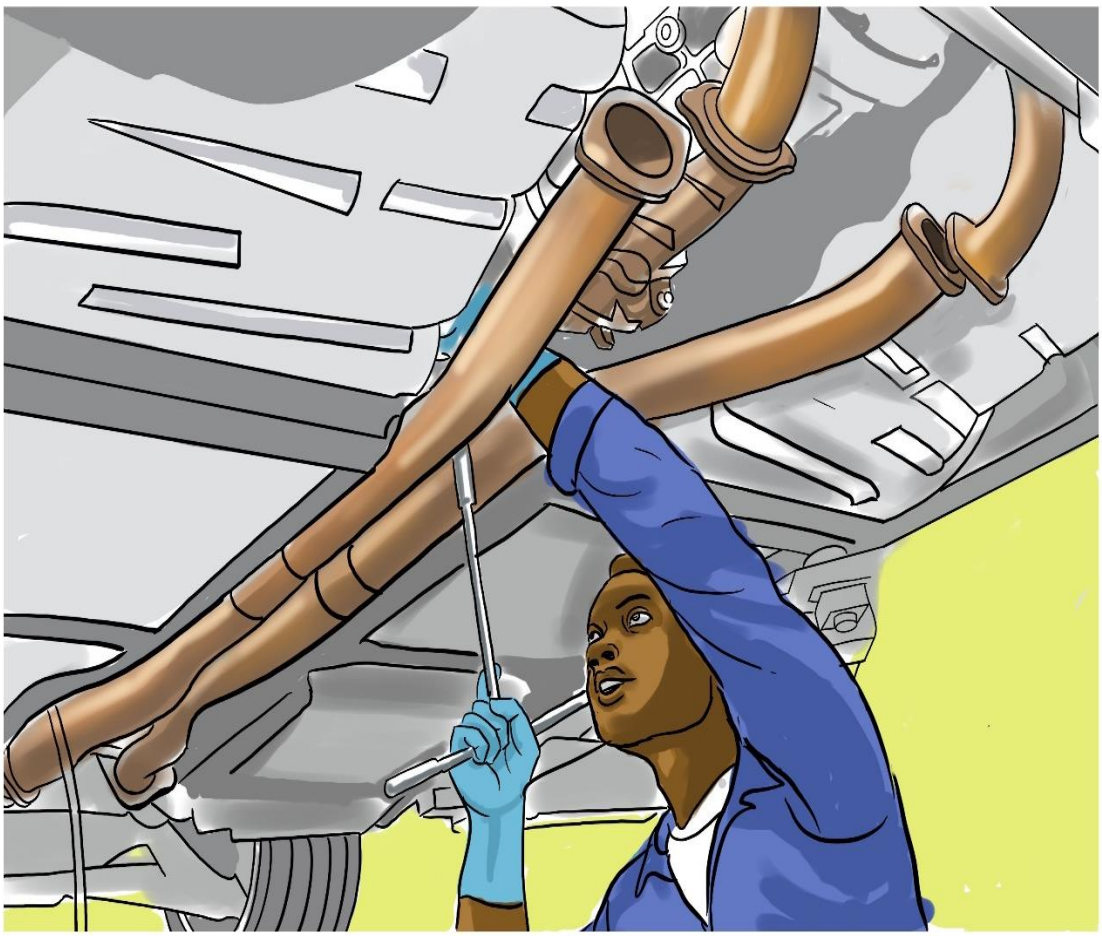
Points to Remember

- 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.
- Use care whenever it is necessary to move a vehicle in the shop. Carelessness and playing around can lead to a damaged vehicle and serious injury.
- Always connect an exhaust hose to the tailpipe of any running vehicle to help prevent the buildup of carbon dioxide (CO) inside a closed garage space.

Self-Reflection

1. Ask learners to re-take the self-assessment at the beginning of the unit. They should then fill in the table in the Trainee's Manual to identify their areas of strength, areas for improvement and actions to take to improve.

2. Discuss trainees' results with them. Identify any areas that are giving many trainees difficulties and plan to give additional support as needed (ex. use class time before you begin the next learning outcome to go through commonly identified difficult concepts).



Learning outcome 3: Self-Assessment

1. Ask trainees to look at the unit Illustration in their Trainee Manuals and together discuss:
    a. What does the illustration show?
    b. What topics do you think will be covered under this unit based on the illustration?
2. After the discussion, inform students that this unit is intended to provide them with the knowledge, skills and attitudes to repair engine exhaust system. It will cover the

selection of tools, materials and equipment, inspection of exhaust system components and correction of exhaust system damaged components

3. Ask trainees to fill out the self-assessment at the beginning of the unit in their Trainee Manuals. Explain that:
    a. The purpose of the self-assessment is to become familiar with the topics in the unit and for them to see what they know or do not know at the beginning.
    b. There are no right or wrong ways to answer this assessment. It is for their own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
    c. They should think about themselves: Do they think they have the knowledge, skills or attitudes to do this? How well?
    d. They read the statements across the top and put a tick in column that represents their level of knowledge, skills or attitudes.
    e. At the end of the unit, they will do a self-reflection, which includes re-taking the self-assessment and identifying their strengths, areas of improvement and actions to be taken.

Key Competencies:

Knowledge	Skills	Attitudes
1. Identify the tools, materials and equipment	1. Select the tools, materials and equipment	1. Pay attention to details while using the tools, materials and equipment
2. Identify exhaust system components faults	2. Use the tools, materials and equipment	2. Demonstrate team spirit while working with others
3. Identify exhaust system testing methods	3. Correct exhaust system faults	3. Be meticulous while repair exhaust system
4. Identify exhaust system repairing methods	4. Test exhaust system	4. Be careful while testing exhaust system

Knowledge	Skills	Attitudes
		5. Respect safety precautions at workplace while repairing the exhaust system
		6. Comply with safety rules related to the handling of tools and equipment

Discovery Activity

Task 18

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustration about repair of exhaust system and answer questions provided under task 18 in their trainee manuals and answer the questions that follow.

2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are given.

3. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Encourage all students to give their views.

4. After the presentations/sharing session, inform students that this activity was not intended for them to give the right answers but to give them a picture of what they will cover in the unit.

5. Introduce Topic 3.1: Selection of tools, materials and equipment.

Topic 3.1: Selection of tools, materials and equipment.

Objectives: By the end of the topic, trainees will be able to:

a. Identify the tools, materials and equipment
b. Select the tools, materials and equipment
c. Follow safety measures while using tools, materials and equipment

Time Required: *5 hours*

Learning Methodology: *Group discussion, Trainer guided, short questions, Open ended questions, Site visit, brainstorming, jig-saw.*

Materials, Tools and equipment Needed:

- **Materials:** Exhaust gaskets, Bolts and nuts, Rags, Welding electrodes, Wire brushes, grinding disc, Cutting disc, Penetrating oil, Exhaust gaskets, Sealant, Sandpapers, Grinding discs, Cutting discs, Welding electrodes, Catalytic converter cleaner, Anti- seize, Epoxy adhesives, Exhaust tape, Exhaust clamp, Aluminum patch.
- **Tools:** Spanners, Screw drivers, Tire lever, Chipping hummer, Tongue, Chisels, Scriber, Ruler, Hammer, scan tool, Exhaust Pipe and Tail Pipe Expander, Exhaust Pipe and Tubing Cutter, Exhaust Pipe Cutter, Hanger Removal Pliers, Oxygen Sensor Socket, Sensor Wrench, Socket Set
- **Equipment:** PPE's (Boots, masks, helmets, gloves, overcoats), dust pan Multimeter, Exhaust gas analyzer, Welding machine, Gas welding equipment, Cutting machine, Grinding machine, Drilling machine, Air tools, Battery-operated drill motors, Drill press, Bench vises, Exhaust pipe stands, An angle grinder, Digital multimeter, Digital pyrometer, Jack and jack stands.

Preparation:

- ❑ *Preparation of workshop with vehicles*
- ❑ *Availability of tools, materials and equipment to be used*
- ❑ *Contact garage manager for field visit.*

Cross Cutting Issues:

- ✓ Ensure gender balance while forming groups, allocating tasks and during presentations
- ✓ Ensure inclusivity while allocating tasks to students and provide facilities/environment that enable/allows participation of all
- ✓ Promote financial education by emphasizing the need/importance of taking care of tools and equipment
- ✓ Ensure environment and sustainability regulations are followed while dealing with engine exhaust systems.

Prerequisites:

- Physics,
- Bench work,
- Welding

Activity 1: Problem-Solving

Task 19

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustrations and answer the questions provided under task 19 in their trainee manuals.

2. *Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.*

3. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

4. After the sharing session, refer students to **Key facts 3.1. a, b & c,** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 2: Guided Practice

Task 20

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to visit the school workshop then properly select tools, materials and equipment required for exhaust system repair and answer the questions provided under task 20 in their trainee manuals.

2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.

3. During the task, students should be given degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using probing questions such as W*hy? What? How?* to enable them come to informed responses.

4. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, financial education, environment and sustainability among others. Also attitudes and behavior changes should be handled during this activity.

5. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

6. After the sharing session, refer students to **Key facts 3.1. a, b, c & d** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 3: Application

Task 21

1. Using an appropriate methodology such as individual work, pairs, or small groups trainees visit the nearest garage, then participate in the selection and basic maintenance of tools, materials and equipment.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used.
3. This activity requires students to work independently with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the report.

Topic 3.2: Inspection of exhaust system components faults

Objectives: By the end of the topic, trainees will be able to: a. Identify exhaust system components faults b. Inspect exhaust system components faults c. Respect safety precautions at workplace while inspecting the exhaust system d. Comply with safety rules related to the handling of tools and equipment
Time Required: *5 hours*
Learning Methodology: *Group discussion, Trainer guided, short questions, Open ended questions, Site visit, Brainstorming, Jig-saw*
Materials, Tools and Equipment Needed: • **Materials:** Exhaust gaskets, Bolts and nuts, Rags, Welding electrodes, Wire brushes, grinding disc, Cutting disc, Penetrating oil, Exhaust gaskets, Sealant, Sandpapers, Grinding discs, Cutting discs, Catalytic converter

cleaner, Anti- seize, Epoxy adhesives, Exhaust tape, Exhaust clamp, Aluminum patch.

- **Tools:** Spanners, Screw drivers, Tire lever, chipping hammer, Tongue, Chisels, Scriber, Ruler, Hammer, scan tool, Exhaust Pipe and Tail Pipe Expander, Exhaust Pipe and Tubing Cutter, Exhaust Pipe Cutter, Hanger Removal Pliers, Oxygen Sensor Socket, Sensor Wrench, Socket Set
- **Equipment:** PPE's (Boots, masks, helmets, gloves, overcoats), dust pan Multimeter, Exhaust gas analyzer, Welding machine, Gas welding equipment, Cutting machine, Grinding machine, Drilling machine, Air tools, Battery-operated drill motors, Drill press, Bench vises, Exhaust pipe stands, angle grinder, Digital multimeter, Digital pyrometer, Jack and jack stands.

Preparation:

- ❑ *Preparation of workshop with vehicles*
- ❑ *Availability of tools materials and equipment to be used*
- ❑ *Contact garage manager for field visit.*

Cross Cutting Issues:

- ✓ Ensure gender balance while forming groups, allocating tasks and during presentations
- ✓ Ensure inclusivity while allocating tasks to students and provide facilities/environment that enable/allows participation of all
- ✓ Promote financial education by emphasizing the need/importance of taking care of tools and equipment
- ✓ Ensure environment and sustainability regulations are followed while dealing with exhaust gases.

Prerequisites:

- Physics,
- Bench work,

Activity 1: Problem-Solving

Task 22

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustration about inspection of engine exhaust system and answer the questions provided under task 22 in their trainee manuals.

2. Make sure instructions are understood, all the students are actively participating and necessary materials, tools are provided and being used
3. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

4. After the sharing session, refer students to **Key facts 3.2** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 2: Guided Practice

Task 23

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to visit the school workshop and inspect the exhaust system of a vehicle that has high-frequency hissing or rushing noise and answer the questions provided under task 23 in their trainee manuals.

2. Make sure instructions are understood, all the students are actively participating and necessary materials, tools are provided and being used

3. During the task, students should be given degree of independence to apply the knowledge and skills acquired in activity 1. Your role is to guide them by using

probing questions such as W*hy? What? How?* to enable them come to informed responses.

4. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, financial education among others. Also attitudes and behavior changes should be handled during this activity.

5. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. *Encourage all students to give their views.*

6. After the sharing session, refer students to **Key Facts 3.2** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 3: Application

Task 24

1. Using an appropriate methodology such as individual work, pairs, or small groups trainees to carry out the automobile repair shop visit in the neighborhood under task 24 in their trainee manual and perform the inspection of the exhaust system.

2. Make sure instructions are understood, all the students are actively participating and necessary materials, tools are provided and being used

3. This activity requires students to work independently with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the report.

Topic 3.3: Correction of exhaust system damaged components

Objectives:

By the end of the topic, trainees will be able to:

a. Identify exhaust system testing methods
b. Identify exhaust system repairing methods
c. Correct exhaust system faults
d. Replace damaged components
e. Test exhaust system

Time Required: *15 hours*

Learning Methodology: *Group discussion, Trainer guided, short questions, Open ended questions, Site visit, Brainstorming, Jig-saw.*

Materials, Tools and equipment Needed:

- **Materials:** Exhaust gaskets, Bolts and nuts, Rags, Welding electrodes, Wire brushes, grinding disc, Cutting disc, Penetrating oil, Exhaust gaskets, Sealant, Sandpapers, Grinding discs, Cutting discs, Catalytic converter cleaner, Anti- seize, Epoxy adhesives, Exhaust tape, Exhaust clamp, Aluminum patch.
- **Tools:** Spanners, Screw drivers, Tire lever, chipping hammer, Tongue, Chisels, Scriber, Ruler, Hammer, scan tool, Exhaust Pipe and Tail Pipe Expander, Exhaust Pipe and Tubing Cutter, Exhaust Pipe Cutter, Hanger Removal Pliers, Oxygen Sensor Socket, Sensor Wrench, Socket Set
- **Equipment:** PPE's (Boots, masks, helmets, gloves, overcoats), dust pan, Exhaust gas analyzer, Welding machine, Gas welding equipment, Cutting machine, Grinding machine, Drilling machine, Air tools, Battery-operated drill motors, Drill press, Bench vises, Exhaust pipe stands, An angle grinder, Digital multimeter, Digital pyrometer, Jack and jack stands.

Preparation:

- ❑ *Preparation of workshop with vehicles*
- ❑ *Availability of tools materials and equipment to be used*

❑ *Contact garage manager for field visit.*
Cross Cutting Issues: ✓ Ensure gender balance while forming groups, allocating tasks and during presentations ✓ Ensure inclusivity while allocating tasks to students and provide facilities/environment that enable/allows participation of all ✓ Promote financial education by emphasizing the need/importance of taking care of tools and equipment as well as spare parts replacement. ✓ Ensure environment and sustainability regulations are followed while dealing with exhaust gases.
Prerequisites:  ▸ Physics, ▸ Bench work, ▸ Welding

Activity 1: Problem-Solving

Task 25

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to analyze the illustration about correction of exhaust system damaged components and answer the questions provided under task 25 in their trainee manuals.
2. *Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used*
3. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
4. After the sharing session, refer students to **Key facts 3.3 a, b & c** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 2: Guided Practice

Task 26

1. Using an appropriate methodology such as individual work, pair-share, small group discussions, guided discussions or large group discussion, guide trainees to read the scenario about repair the exhaust system of a vehicle which has a catalytic converter partialy blocked and answer the questions provided under task 26 in their trainee manuals.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used
3. During the task, students should be given degree of independence to apply the knowledge and skills acquired in activity 9. Your role is to guide them by using probing questions such as Why? What? How? to enable them come to informed responses.
4. During the task, use this opportunity to discuss or address any cross-cutting issues that may arise such as gender, inclusivity, financial education among others. Also attitudes and behavior changes should be handled during this activity.
5. Using an appropriate methodology such as question and answer in a large group, pair presentations, or small group presentations, students share their answers to the class. Write their responses for reference. Encourage all students to give their views.
6. After the sharing session, refer students to **Key Facts 3.3. a, b, c &d** and discuss them together while harmonizing their responses provided in the sharing session and answer any questions they have.

Activity 3: Application

Task 27

1. Using an appropriate methodology such as individual work, pairs, or small groups trainees read the scenario about to replace the defective muffler with a rusted pipe with a new one and answer the questions provided under task 27 in their trainee manual.
2. Make sure instructions are understood, all the students are actively participating and necessary materials/tools are provided and being used
3. This activity requires students to work independently with limited support from the trainer. During the task, students should be given a high degree of independence to apply the knowledge, skills and attitudes acquired to real life situations. Your role is to set clear instructions, methodology and timeframe for submitting the report.

Formative Assessment

a. List five tools that are used to repair exhaust system.

- **Answer:** Air Hammers, Chisels, Separators, Splitters, Cutters; Support Stands; screw drivers Tail Pipe Expanders, Exhaust Pipe & Tubing Cutters, Exhaust Hanger Pliers, Oxygen Sensor Sockets & Socket Kits, and spanners etc.

b. List five materials that are used to repair exhaust system.

- **Answer:** Hand gloves, Sandpaper, Metal wire brush, Soapy water, Putty, Muffler bandage, Exhaust band clamp, catalytic converter cleaner, Penetrating oil, Exhaust gaskets, Sealant, Sandpaper, glass paper, grinding discs, cutting discs, Welding electrodes, Anti- seize, Epoxy, Exhaust tape, exhaust clamp, aluminum patch etc.

c. List five equipment that are used to repair exhaust system.

- **Answer:** Air compressor, Car lift, Jack and jack stands, Exhaust pipe stands, An angle grinder, digital multimeter, Digital pyrometer, Scan tool, Exhaust gas analyzer, Arc Welding equipment, Oxyacetylene Welding equipment, Bench vises, Drill press, Air tools, Battery-operated drill motors etc.

d. Explain the procedures of dismounting exhaust system.

Answer:

Step 1: prepare the workplace

Step 2: Let the exhaust system cool if you've used your vehicle recently.

Step 3: Raise your vehicle so you can work underneath it using a jack or car lift.

Step 4: Place jack stands near each tire to keep the vehicle from moving around.

Step 5: Disconnect the oxygen sensors from underneath your vehicle.

Step 6: Spray the nuts along the exhaust pipe with penetrating fluid.

Step 7: Unscrew the nuts with a ratchet.

Step 8: Unhook the pipes from the rubber exhaust hangers.

Step 9: Pull the exhaust system down from your vehicle.

e. Explain the procedures of remounting exhaust system.

Answer:

Step 1: prepare the workplace

Step 2: position the vehicle

Step 3: Get a new exhaust system that matches the make and model of your vehicle.

Step 4: Clean the rust off of the bolt threads with a wire cleaning brush.

Step 5: Apply anti-seize fluid on all of the bolt threads.

Step 6: Lift the new exhaust system into place using your jack.

Step 7: Place a gasket over the downpipe with one of the bolts.

Step 8: Attach the front of the exhaust system loosely to the downpipe with the bolts.

Step 9: Connect sections of your system with exhaust clamps, if needed.

Step 10: Plug the oxygen sensors back into the ports on your vehicle.

Step 11: Slide the metal pins on the system into the rubber exhaust hangers.

Step 12: Tighten the bolts at the front of the exhaust until they form a tight seal.

Step 13: Spray the connections with soapy water to see if there are any leaks.

f. Explain how to inspect a restricted exhaust system.

Answer: The catalytic converter can often become partially or fully blocked, particularly after it has been overheated by extended periods of misfire or rich running. When this happens, the engine will lose power. It will accelerate slowly and have a hard time reaching higher speeds. In severe cases, the engine may stall or fail to start. If you suspect a restricted exhaust, give a light tap to the converter and to the muffler. Rattling in either component indicates internal damage that may be causing a restriction. There are several ways to test for a restricted exhaust. Also check for blockages in the exhaust system by performing an engine vacuum or backpressure test.

g. Describe how to inspect a leaking exhaust system.

Answer:

Leaks can be visible or audible. Look under the vehicle for leaks that you can see. Pay attention to the following areas:

- Welds – look for breaks, cracks or corrosion.
- Pipe connections – check for improper alignment or burned gaskets.
- Clamp connections – ensure there are no leaks.
- Flex pipe – a common area for failure, make sure there are no leaks.

To check for audible leaks, take the vehicle for a test drive and listen for any unusual sounds coming from the exhaust system. While you are still testing the car, have the opportunity to check for the smell of exhaust gases in the cabin of the vehicle.

h. Explain the how to clean exhaust system catalytic converter.

Answer:

A. Unclogging catalytic converter without Removing

Step 1: Drive until your gas tank is ¼-full

Step 2: Pour catalytic converter cleaner into your gas tank

Step 3: Drive the vehicle for about 15 minutes

Step 4: Fill up your gas tank as you normally would

B. Taking the Converter off for Cleaning

Step 1: Jack up your vehicle on jack stands

Step 2: Remove the oxygen sensor from your exhaust line

Step 3: Loosen the bolts to remove your catalytic converter

Step 4: Spray inside the converter with a pressure washer on low

Step 5: Soak your catalytic converter overnight in soapy water

Step 6: Rinse your catalytic converter and let it dry completely

Step 7: Reattach your catalytic converter and oxygen sensor to your vehicle

i. Describe how to weld an exhaust leak

Answer:

1. Prepare the area
2. Decide which welder you are going to use
3. Choose the right wire
4. Set up your welder
5. Clean the metal
6. Put on your safety gear
7. Tack welds the pipe
8. Begin welding
9. Finish welding and let it cool
10. Inspect your work and test it out.

Points to Remember

- The catalytic converter is a metal box near the front of the exhaust pipe that filters out harmful gases, such as nitrogen oxide and carbon monoxide. Your exhaust system may have more than 1 catalytic converter.
- The oxygen sensors are electronic ports that plug into the exhaust system before and after the catalytic converters to check if your engine is burning oxygen efficiently. The wires for the oxygen sensors will go directly into your vehicle's body.
- The resonator is a slightly wider section of your exhaust pipe that helps reduce the amount of noise when you run your engine at certain RPMs. Not every exhaust system will have a resonator.
- The muffler is the large metal box near the rear of your vehicle that helps reduce the amount of noise your exhaust makes.
- The tailpipe is the small section of tubing that connects to the back of the muffler and allows the fumes to escape into the air.
- Here are the most common causes of an exhaust noise:
- A crack in the exhaust pipe or muffler – This can happen if the car hits something underneath or just from rust or regular wear and tear. You may need to crawl under the car to see this.
- A leak in the exhaust system – To detect if this is the case, lay next to your car while it is running in park and check for any fluid dripping along your exhaust system.
- A rusty muffler or exhaust pipe – Exterior rust will not cause the system to make a noise at first. But rust will work its way through the muffler or pipe over time causing cracks and holes.
- If the engine has been running, exhaust system components may be extremely hot! Wear protective gloves when working on these components, and keep flammable objects away from hot areas.
- Exhaust gas contains poisonous carbon monoxide (CO) gas. This gas can cause illness and death by asphyxiation. Exhaust system leaks are dangerous for customers and technicians.
- Any exhaust system inspection should include listening for hissing or rumbling that

would result from a leak in the system. An on-lift inspection should pinpoint any of the following types of damage:

- ✓ Holes, road damage, separated connections, and bulging muffler seams
- ✓ Kinks and dents
- ✓ Discoloration, rust, soft corroded metal, and so forth
- ✓ Torn, broken, or missing hangers and clamps
- ✓ Loose tailpipes or other components
- ✓ Bluish or brownish catalytic converter shell, which indicates overheating

Self-Reflection

1. Ask learners to re-take the self-assessment at the beginning of the unit. They should then fill in the table in the Trainee's Manual to identify their areas of strength, areas for improvement and actions to take to improve.

2. Discuss trainees' results with them. Identify any areas that are giving many trainees difficulties and plan to give additional support as needed (ex. use class time before you begin the next learning outcome to go through commonly identified difficult concepts).

Summative assessment (Integrated situation)

Integrated situation

Integrated/Summative assessment

Mr.KALISA brought his vehicle FORD 2023 Escape in garage for repair the exhaust system which loosing power, laud noise and vibration . After inspection garage foreman found that the catalytic converter and muffler are leaking and the pipe is rusted. He assign you as a mechanic for exhaust system repair to replace that exhaust system with new one in 2 hours.

Tools	Spanners, Screw drivers, Tire lever, chipping hammer, Tongue, Chisels, Scriber, Ruler, Hammer, scan tool, Exhaust Pipe and Tail Pipe Expander, Exhaust Pipe and Tubing Cutter, Exhaust Pipe Cutter, Hanger Removal Pliers, Oxygen Sensor Socket, Sensor Wrench, Socket Set
Equipment	Personal protective equipment (PPE), Multimeter, Exhaust gas analyzer, Welding machine, Gas welding equipment, Cutting machine, Grinding machine, Drilling machine, Air tools, Battery-operated drill motors, Drill press, Bench vises, Exhaust pipe stands, An angle grinder, Digital multimeter, Digital pyrometer, Jack and jack stands.
Materials/ Consumables	Exhaust gaskets, Bolts and nuts, Rags, Welding electrodes, Wire brushes, grinding disc, Cutting disc, Penetrating oil, Exhaust gaskets, Sealant, Sandpapers, Grinding discs, Cutting discs, Welding electrodes, Catalytic converter cleaner, Anti- seize, Epoxy adhesives, Exhaust tape, Exhaust clamp, Aluminum patch.

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator	Observation		Marks allocation
			Yes	No	
1 **Learning outcome 1: Describe engine exhaust system (30%)**	1.1 Exhaust system is appropriately identified according to the exhaust exit pipe.	Exhaust system is appropriately identified			10
	1.2 Exhaust system components are appropriately identifiedaccording to the repair manual guide	Exhaust system components are appropriately identified			10
	1.3 Exhaust system components are properly described based on the manufacturer's instructions	Exhaust system components areproperly described			10
2 **Learning outcome 2: Prepare workplace (20%)**	2.1 PPE are properly selected and worn asper safety measures	PPE are properly selected and worn			5
	2.2 Safety precautions of working area are appropriately applied before the work	Safety precautions of working areaare appropriately applied			5
	2.3 Workplace is properly cleaned and arranged according to the standard	Workplace is properly cleaned and arranged			10
3 **Learning outcome 3: Repair engine exhaust system (50%)**	3.1. Tools, materials, and equipment is properly selected based on their function	Tools, materials, and equipmentare properly selected			5
	3.2. Exhaust system components are properly inspected according to the repair manual	Exhaust system components areproperly inspected			5

	3.3. Exhaust system is properly dismounted from the vehicle according to the repair manual	Exhaust system is properly dismounted from the vehicle			5
	3.4. Exhaust system components are methodical disassembled according to the repair manual	Exhaust system components are methodically disassembled			5
	3.5. Exhaust system damaged componentsare properly corrected based on repairing procedures	Exhaust system damaged components are properly corrected			10
	3.6. Exhaust system components are methodically reassembled according tothe repair manual	Exhaust system components are methodically re-assembled			10
	3.7. Exhaust system is properly re-mounted tothe vehicle according to the repair manual	Exhaust system is properly re-mounted to the vehicle			5
	3.8. Exhaust system is properly tested according to the system functionality	Exhaust system is properly tested			5
Total marks		**100**			
Percentage Weightage		**100%**			
Minimum Passing line % (Aggregate): 70%					

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