Ethiopian TVET-System

Electro Mechanical Equipment Operation and Maintenance

Level –II

Based on March, 2017G.C. Occupational Standard

Module Title:
Inspecting and Servicing Engines

TTLM Code: **EIS EME2TTLM1220 v1**

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This module includes the following Learning Guides

LG 57: Prepare to Inspect and Service Engine

LG Code: EIS EME2 M12 L0 01-LG-57

LG 58: Inspect Engine

LG Code: EIS EME2 M12 L0 02-LG-58

LG 59: Engine Service

LG Code: EIS EME2 M12 L0 03-LG-59

LG 60: Complete work processes

LG Code: EIS EME2 M12 L0 04-LG-60

Instruction Sheet	Learning Guide #46: Prepare to Inspect and Service Engine

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Determining job requirements
- Sourcing and interpreting servicing information
- Identifying hazards associated with the work and managing risks
- Selecting and checking tools, equipment and materials

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Determine job requirements
- Source and interpret servicing information
- Identify hazards associated with the work and managing risks
- Select and check tools, equipment and materials

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.

5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).

6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1

7. Submit your accomplished Self-check. This will form part of your training portfolio.

8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.

9. Accomplish the “Self-check 2” in page __.

10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).

11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.

12. Accomplish the “Self-check 3” in page __.

13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).

14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet-1	Determining job requirements

Engine Inspection and service technicians and mechanics (also known as *engine technicians*) inspect, service, repair, or overhaul engines, or maintain and repair any type of engine.

Job requirements of Engine technician

Engine Inspection and service technicians and mechanics typically do the following:

- Consult with customers, read work orders, and determine work required
- Plan work procedures, using technical charts and manuals
- Inspect brake systems, steering mechanisms, transmissions, engines, and other parts of vehicles
- Follow checklists to ensure that all critical parts are examined
- Read and interpret diagnostic test results to identify mechanical problems
- Repair or replace malfunctioning components, parts, and other mechanical or electrical equipment
- Perform basic care and maintenance, including changing oil, checking fluid levels, and rotating tires
- Test-drive vehicles to ensure that they run smoothly

Because of their efficiency and durability, engines have become the standard in powering generators and other heavy pumps and mobile equipment.

Engine technicians make major and minor engine repairs, and work on a generator's electrical and engine exhaust systems to comply with pollution regulations.

Engine maintenance and repair is becoming more complex as engines and other components use more electronic systems to control their operation. For example, fuel injection and engine timing systems rely on microprocessors to maximize fuel efficiency and minimize harmful emissions. In most shops, workers often use hand-held or laptop computers to diagnose problems and adjust engine functions.

Engine technicians also use a variety of power and machine tools, such as pneumatic wrenches, lathes, grinding machines, and welding equipment. Hand tools, including pliers, sockets and ratchets, and screwdrivers, are commonly used.

Employers typically provide expensive power tools and computerized equipment, but workers generally acquire their own hand tools over time.

Injuries and Illnesses

Engine service technicians and mechanics often lift heavy parts and tools, handle greasy or dirty equipment, and work in uncomfortable positions. Sprains and cuts are common among these workers. Engine technicians need to follow some safety precautions when in the workplace. clarity and confidence that comes from understanding your strengths, talents, and preferences, and knowing which path is truly right for you.

Work Schedules

Most Engine technicians work full time. Overtime is common, as many repair shops extend their service hours during evenings and weekends.

In addition, some truck and bus repair shops provide 24-hour maintenance and repair services.

Although most Engine technicians learn on the job after a high school education, employers are increasingly preferring applicants who have completed postsecondary training programs in engine repair. In addition, obtaining industry certification may be helpful because certification demonstrates an engine technician's competence and experience.

Engine service technicians and mechanics should also possess the following specific qualities:

***Customer-service skills*.** Engine mechanics frequently talk to their customers about automotive problems and work that they have planned, started, or completed. They must be courteous, good listeners and ready to answer customers' questions.

***Dexterity*.** Mechanics need a steady hand and good hand-eye coordination for many tasks, such as disassembling engine parts, connecting or attaching components, or using hand tools.

***Mechanical skills*.** Engine mechanics must be familiar with parts and components of engines, transmissions, braking mechanisms, and other complex systems. They must also be able to disassemble, work on, and reassemble parts and machinery.

***Troubleshooting skills*.** Engine mechanics must be able to identify mechanical and electronic problems, make repairs, and offer a proper maintenance strategy. They must be familiar with electronic control systems and the appropriate tools needed to fix and maintain them.

Self-Check 1	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. What are the jobs required to carry out engine inspection and services? (describe at least five of them)(5pts)
2. What are the specific qualities an engine technicians and mechanics should have? Discuss briefly with your group. (4pts)

Note: Satisfactory rating –5 points **Unsatisfactory - below 5 points**

Answer Sheet

Name: _____ Date: _____

Score = 9pts

Rating: _____

Short Answer Questions

1. _____

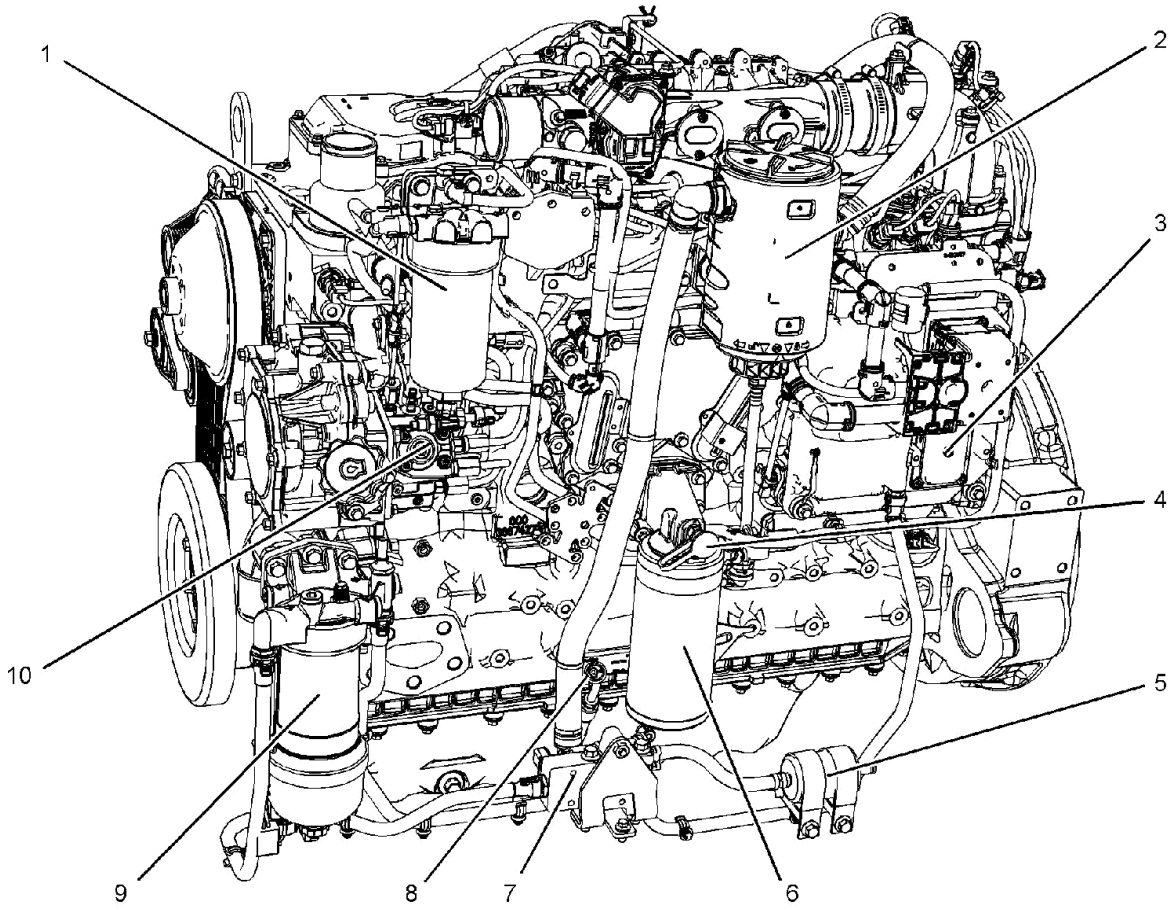
   _____

2. _____

Information Sheet-2	Sourcing and Interpreting Servicing Information

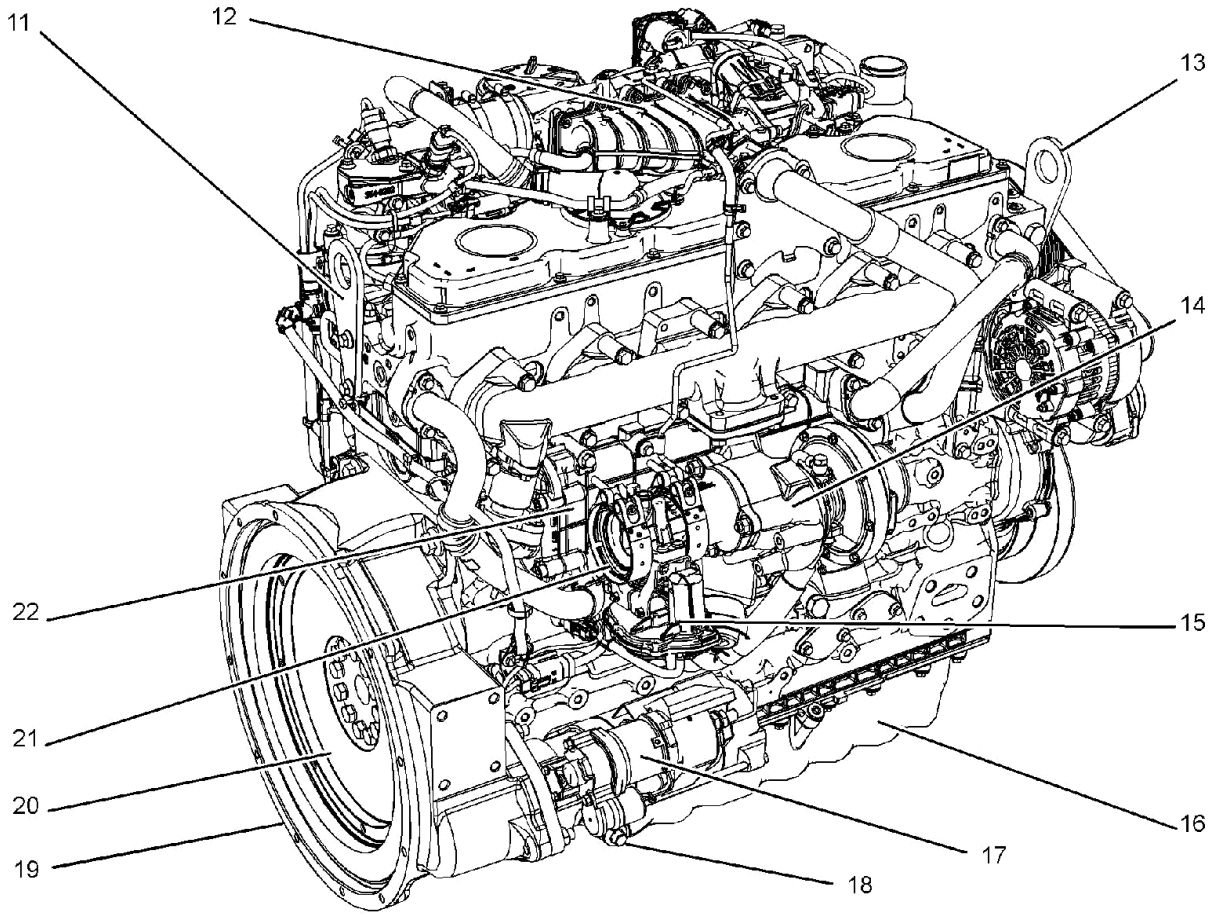
The following model views show typical features of the engine. Due to individual applications, your engine may appear different from the illustrations (see figure below as a sample).

Engine views



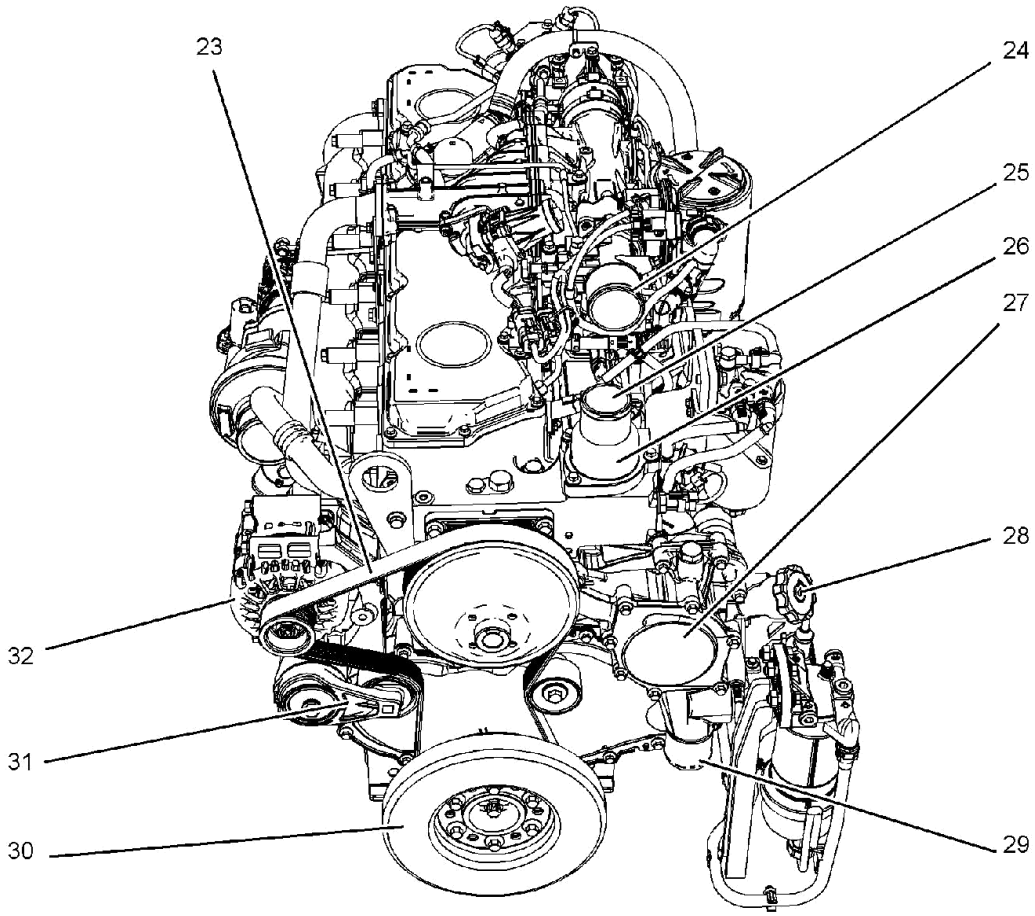
(1) Secondary fuel filter
(2) Crankcase breather
(3) Electronic control module (ECM)
(4) Oil sampling valve
(5) Fuel strainer
(6) Oil filter
(7) Fuel priming pump
(8) Oil gauge (Dipstick)
(9) Primary fuel filter
(10) High-pressure fuel pump

The location of the in-line strainer (5) and the priming pump (7) will depend on the application.



(11) Rear lifting eye
(12) NOx reduction system (NRS)
(13) Front lifting eye
(14) Turbocharger
(15) Back pressure valve
(16) Engine oil pan (Sump)
(17) Starting motor
(18) Engine oil drain plug
(19) Flywheel housing
(20) Flywheel
(21) Exhaust outlet
(22) Exhaust gas cooler

Model Views continued…..



(23) Belt

(24) Connection for air inlet

(25) Outlet connection for the coolant

(26) Water temperature regulator housing(Thermostat housing)

(27) Water pump

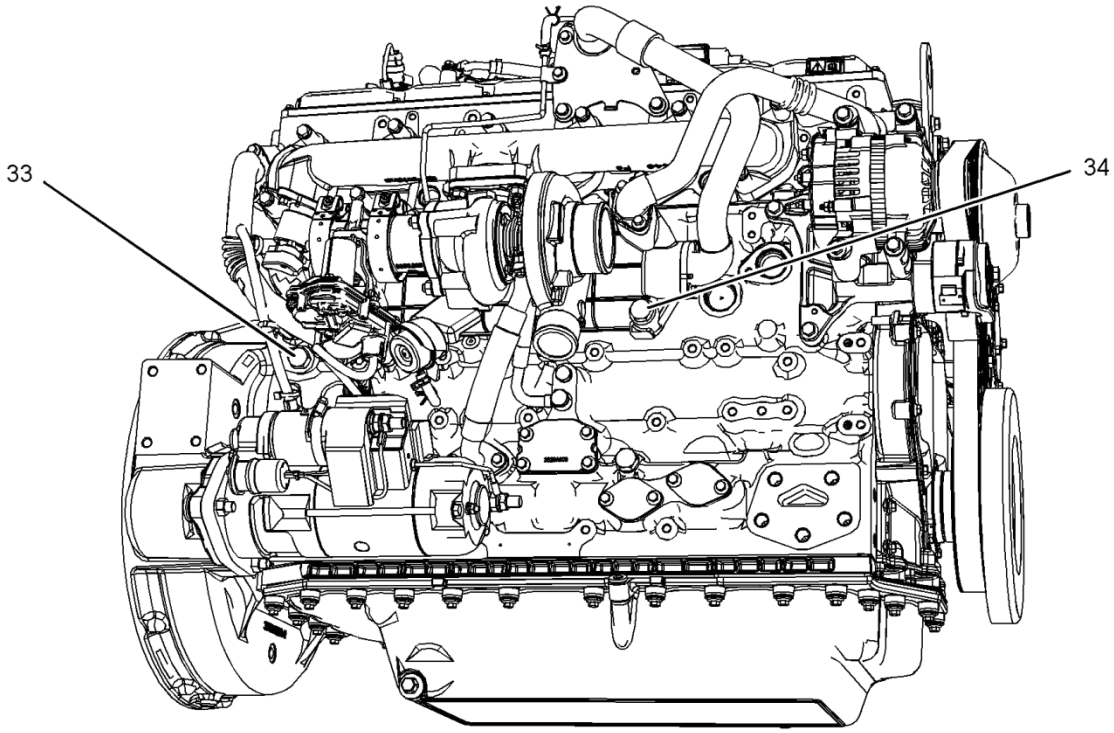
(28) Oil filler

(29) Inlet connection for the Coolant

(30) Vibration damper

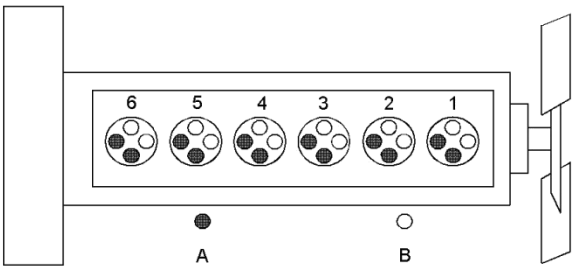
(31) Belt tensioner

(32) Alternator



(33) Coolant drain plug for cylinder block

(34) Coolant drain plug for exhaust gas cooler



Engine Description

The Industrial Engine has the following characteristics.

- In-line Six cylinder
- Four stroke cycle
- Turbocharged charge cooled

Engine Specifications

Note: The front end of the engine is opposite the flywheel end of the engine. The left and the right sides of the engine are determined from the flywheel end. The number 1 cylinder is the front cylinder.

Cylinder and valve location

(A) Exhaust valves

(B) Inlet valves

Table 1.1 Engine Specifications (Sample)

Operating Range (rpm)	900 to 2800[1]
Number of Cylinders	6 In-Line
Bore	105 mm (4.13 inch)
Stroke	127 mm (5 inch)
Power	129.4 kW (173.52 hp)
Aspiration	Turbocharged charge cooled
Compression Ratio	16.5:1
Displacement	6.6 L (402.7 cubic inch)
Firing Order	1-5-3-6-2-4
Rotation (flywheel end)	Counterclockwise

[1] The operating rpm is dependent on the engine rating, the application, and the configuration of the throttle.

Engine Diagnostics

The engine has built-in diagnostics in order to ensure that the engine systems are functioning correctly. The operator will be alerted to the condition by a “Stop or Warning” lamp. Under certain conditions, the engine horsepower and the vehicle speed may be limited.

The electronic service tool may be used to display the diagnostic codes. There are three types of diagnostic codes: active, logged, and event.

Most of the diagnostic codes are logged and stored in the ECM. For additional information, refer to the Operation and Maintenance Manual, “Engine Diagnostics” topic (Operation Section).

The ECM provides an electronic governor that controls the injector output in order to maintain the desired engine rpm.

Electronic Engine Features

The engine operating conditions are monitored. The Electronic Control Module (ECM) controls the response of the engine to these conditions and to the demands of the operator. These conditions and operator demands determine the precise control of fuel injection by the ECM. The electronic engine control system provides the following features:

- Engine monitoring
- Engine speed governing
- Control of the injection pressure
- Cold start strategy
- Automatic air/fuel ratio control
- Torque rise shaping
- Injection timing control
- System diagnostics
- Low temperature regeneration

For more information on electronic engine features, refer to the Operation and Maintenance Manual, “Features and Controls” topic (Operation Section).

Engine Cooling and Lubrication

The cooling system and lubrication system consists of the following components:

- Gear-driven centrifugal water pump
- Water temperature regulator which regulates the engine coolant temperature
- Gear-driven rotor type oil pump
- Oil cooler

The engine lubricating oil is supplied by a rotor type oil pump. The engine lubricating oil is cooled and the engine lubricating oil is filtered. The bypass valve can provide unrestricted flow of lubrication oil to the engine if the oil filter element should become plugged.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to proper operation and maintenance recommendations.

Engine performance and efficiency also depend on the use of recommended fuels, lubrication oils, and coolants. *Refer to this Operation and Maintenance Manual, “Maintenance Interval Schedule” for more information on maintenance items.*

Engine Service Life

Engine efficiency and maximum utilization of engine performance depend on the adherence to proper operation and maintenance recommendations. In addition, use recommended fuels, coolants, and lubricants. Use the Operation and Maintenance Manual as a guide for required engine maintenance.

Expected engine life is generally predicted by the average power that is demanded. The average power that is demanded is based on fuel consumption of the engine over a period of time. Reduced hours of operation at full throttle and/or operating at reduced throttle settings result in a lower average power demand. Reduced hours of operation will increase the length of operating time before an engine overhaul is required. *For more information, refer to the Operation and Maintenance Manual, "Overhaul Considerations" topic (Maintenance Section).*

Reference Numbers

Information for the following items may be needed to order parts. Locate the information for your engine. Record the information in the appropriate space. Make a copy of this list for a record. Keep the information for future reference.

Record for Reference

Engine Model _____

Engine Serial number _____	
Engine Low Idle rpm _____	
Engine Full Load rpm _____	
Primary Fuel Filter _____	
Water Separator Element _____	
Secondary Fuel Filter Element _____	
Lubrication Oil Filter Element _____	
Auxiliary Oil Filter Element _____	
Total Lubrication System Capacity _____	
Total Cooling System Capacity _____	
Air Cleaner Element _____	
Drive Belt _____	

Self-Check 4	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. What are sourcing and how to interpret servicing information of engine? (2pts)
2. What is the technical information of an engine? Interpret them.(3pts)
3. Write down what may you commonly view in engine illustrations?(4pts)

Note: Satisfactory rating –5 points Unsatisfactory - below 5 points

Answer Sheet

Name: _____ Date: _____

Score = 9pts

Rating: _____

Short Answer Questions

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

Information Sheet-3	Identifying hazards associated with the work and managing risks

General Hazard Information

Attach a “Do Not Operate” warning tag or a similar warning tag to the start switch or to the controls before the engine is serviced or before the engine is repaired. Attach the warning tags to the engine and to each operator control station. When it is appropriate, disconnect the starting controls.

Do not allow unauthorized personnel on the engine, or around the engine when the engine is being serviced.

- Tampering with the engine installation or tampering with the OEM supplied wiring can be dangerous. Personal injury, death and/or engine damage could result.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- The engine is stopped. Ensure that the engine can not be started.
- The protective locks or the controls are in the applied position.
- Engage the secondary brakes or parking brakes.
- Block the vehicle or restrain the vehicle before maintenance or repairs are performed.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Disconnect the connector for the unit injector that is located on the valve cover base. This will help prevent personal injury from the high voltage to the unit injectors. Do not come in contact with the unit injector terminals while the engine is operating.
- Do not attempt any repairs or any adjustments to the engine while the engine is operating.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- For initial start-up of a new engine or for starting an engine that has been serviced, make provisions to stop the engine if an overspeed occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

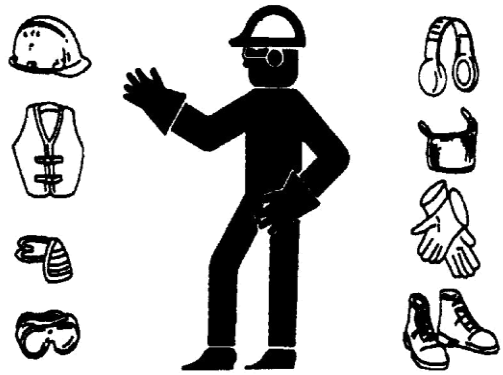
- Start the engine from the operator's station (cab). Never short across the starting motor terminals or the batteries. This could bypass the engine neutral start system and/or the electrical system could be damaged.

Engine exhaust contains products of combustion which may be harmful to your health. Always start the engine and operate the engine in a well ventilated area. If the engine is in an enclosed area, vent the engine exhaust to the outside.

Cautiously remove the following parts. To help prevent spraying or splashing of pressurized fluids, hold a rag over the part that is being removed.

- Filler caps
- Grease fittings
- Pressure taps
- Breathers
- Drain plugs

Use caution when cover plates are removed. Gradually loosen, but do not remove the last two bolts or nuts that are located at opposite ends of the cover plate or the device. Before removing the last two bolts or nuts, pry the cover loose in order to relieve any spring pressure or other pressure.



- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

Unless other instructions are provided, perform the maintenance under the following conditions:

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent

sparks.

- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

Identifying hazards associated with the work and managing risks

Pressurized Air and Water

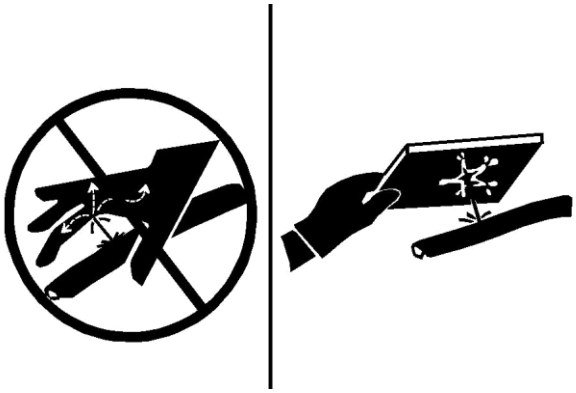
Pressurized air and/or water can cause debris and/or hot water to be blown out. This could result in personal injury.

When pressurized air and/or pressurized water is used for cleaning, wear protective clothing, protective shoes, and eye protection. Eye protection includes goggles or a protective face shield.

The maximum air pressure for cleaning purposes must be below 205 kPa (30 psi). The maximum water pressure for cleaning purposes must be below 275 kPa (40 psi).

Fluid Penetration

Pressure can be trapped in the hydraulic circuit long after the engine has been stopped. The pressure can cause hydraulic fluid or items such as pipe plugs to escape rapidly if the pressure is not relieved correctly. Do not remove any hydraulic components or parts until pressure has been relieved or personal injury may occur. Do not disassemble any hydraulic components or parts until pressure has been relieved or personal injury may occur. *Refer to the OEM information for any procedures that are required to relieve the hydraulic pressure.*



Always use a board or cardboard when you check for a leak. Leaking fluid that is under pressure can penetrate body tissue. Fluid penetration can cause serious injury and possible death. A pin hole leak can cause severe injury. If fluid is injected into your skin, you must get treatment immediately. Seek treatment from a doctor that is familiar with this type of injury.

Containing Fluid Spillage

NOTICE

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Asbestos Information

Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

Use caution. Avoid inhaling dust that might be generated when you handle components that contain asbestos fibers. Inhaling this dust can be hazardous to your health. The components that may contain asbestos fibers are some gaskets. The asbestos that is used in these components is usually bound in a resin or sealed in some way. Normal handling is not hazardous unless airborne dust that contains asbestos is generated.

If dust that may contain asbestos is present, there are several guidelines that should be followed:

- Never use compressed air for cleaning.
- Avoid brushing materials that contain asbestos.
- Avoid grinding materials that contain asbestos.
- Use a wet method in order to clean up asbestos materials.
- A vacuum cleaner that is equipped with a high efficiency particulate air filter (HEPA) can also be used.
- Use exhaust ventilation on permanent machining jobs.
- Wear an approved respirator if there is no other way to control the dust.
- Comply with applicable rules and regulations for the work place. In the United States, use Occupational Safety and Health Administration (OSHA) requirements. These OSHA requirements can be found in “29 CFR 1910.1001”.
- Obey environmental regulations for the disposal of asbestos.
- Stay away from areas that might have asbestos particles in the air.

Dispose of Waste Properly

Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations.

Always use leak proof containers when you drain fluids. Do not pour waste onto the ground, down a drain, or into any source of water.

Burn Prevention

Do not touch any part of an operating engine system. The engine, the exhaust system

surface temperatures can reach temperatures of approximately 600° C (1112 ° F) under normal operating conditions.

Allow the engine system to cool before any maintenance is performed. Relieve all pressure in the following systems, hydraulic system, lubrication system, fuel system, and the coolant system before the related items are disconnected.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fu-el spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed on the engine fuel lines.

Allow the pressure to be purged in the air system, in the hydraulic system, in the lubrication system, or in the cooling system before any lines, fittings, or related items are disconnected.

Induction System

⚠ WARNING

Sulfuric Acid Burn Hazard may cause serious personal injury or death.

The exhaust gas cooler may contain a small amount of sulfuric acid. The use of fuel with sulfur levels greater than 15 ppm may increase the amount of sulfuric acid formed. The sulfuric acid may spill from the cooler during service of the engine. The sulfuric acid will burn the eyes, skin and clothing on contact. Always wear the appropriate personal protective equipment (PPE) that is noted on a material safety data sheet (MSDS) for sulfuric acid. Always follow the directions for first aid that are noted on a material safety data sheet (MSDS) for sulfuric acid.

Coolant

When the engine is at operating temperature, the engine coolant is hot. The coolant is also under pressure. The radiator and all lines to the heaters or to the engine contain hot coolant.

Any contact with hot coolant or with steam can cause severe burns. Allow cooling system components to cool before the cooling system is drained.

Check that the coolant level after the engine has stopped and the engine has been allowed to cool.

Ensure that the filler cap is cool before removing the filler cap. The filler cap must be cool enough to touch with a bare hand. Remove the filler cap slowly in order to relieve pressure.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Also, do not allow hot components to contact the skin.

Batteries

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or the eyes. Always wear protective glasses for servicing batteries. Wash hands after touching the batteries and connectors. Use of gloves is recommended.

Fire Prevention and Explosion Prevention

Store fuels and lubricants in correctly marked containers away from unauthorized persons. Store oily rags and any flammable materials in protective containers. Do not smoke in areas that are used for storing flammable materials.

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in case of a line, a tube, or a seal failure. Exhaust shields must be installed correctly.

Do not weld on lines or tanks that contain flammable fluids. Do not flame cut lines or tanks that contain flammable fluid. Clean any such lines or tanks thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. All electrical wires must be correctly routed and securely attached. Check all electrical wires daily. Repair any wires that are loose or frayed before you operate the engine. Clean all electrical connections and tighten all electrical connections.

Eliminate all wiring that is unattached or unnecessary. Do not use any wires or cables that are smaller than the recommended gauge. Do not bypass any fuses and/or circuit breakers.

All fuels, most lubricants, and some coolant mixtures are flammable.

Flammable fluids that are leaking or spilled onto hot surfaces or onto electrical components can cause a fire. Fire may cause personal injury and property damage.

After the emergency stop button is operated ensure that you allow 15 minutes, before the

engine covers are removed.

Determine whether the engine will be operated in an environment that allows combustible gases to be drawn into the air inlet system. These gases could cause the engine to overspeed. Personal injury, property damage, or engine damage could result.

If the application involves the presence of combustible gases, consult your Perkins dealer and/or your Perkins distributor for additional information about suitable protection devices.

Remove all flammable combustible materials or conductive materials such as fuel, oil, and debris from the engine. Do not allow any flammable combustible materials or conductive materials to accumulate on the engine.

Arcing or sparking could cause a fire. Secure connections, recommended wiring, and correctly maintained battery cables will help to prevent arcing or sparking.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fu-el spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

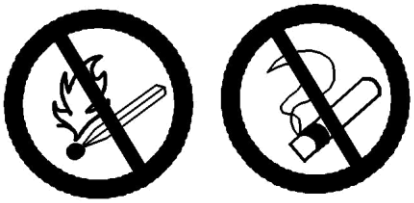
After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines.

Ensure that the engine is stopped. Inspect all lines and hoses for wear or for deterioration. The hoses must be correctly routed. The lines and hoses must have adequate support and secure clamps.

Oil filters and fuel filters must be correctly installed. The filter housings must be tightened to the correct torque. *Refer to the Disassembly and Assembly manual for more information.*

Use caution when you are refueling an engine. Do not smoke while you are refueling an engine. Do not refuel an engine near open flames or sparks. Always stop the engine before refueling.

Gases from a battery can explode. Keep any open flames or sparks away from the top of a battery. Do not smoke in battery charging areas.



Never check the battery charge by placing a metal object across the terminal posts. Use a voltmeter or a hydrometer.

Incorrect jumper cable connections can cause an explosion that can result in injury. Refer to the Operation Section of this manual for specific instructions.

Do not charge a frozen battery. This may cause an explosion.

The batteries must be kept clean. The covers (if equipped) must be kept on the cells. Use the recommended cables, connections, and battery box covers when the engine is operated.

Fire Extinguisher

Make sure that a fire extinguisher is available. Be familiar with the operation of the fire extinguisher. Inspect the fire extinguisher and service the fire extinguisher regularly. Obey the recommendations on the instruction plate.

Lines, Tubes and Hoses

Do not bend high pressure lines. Do not strike high pressure lines. Do not install any lines that are damaged.

Leaks can cause fires. Consult your Perkins dealer or your Perkins distributor for replacement parts.

Replace the parts if any of the following conditions are present:

1. High pressure fuel line or lines are removed.
2. End fittings are damaged or leaking.
3. Outer coverings are chafed or cut.
4. Wires are exposed.
5. Outer coverings are ballooning.
6. Flexible part of the hoses are kinked.
7. Outer covers have embedded armoring.
8. End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly. During engine

operation, this will help to prevent vibration, rubbing against other parts, and excessive heat.

Crushing Prevention and Cutting Prevention: crushing and cutting prevention includes:

- Supporting the component correctly when work beneath the component is performed.
- Unless other maintenance instructions are provided, never attempting adjustments while the engine is running.
- Staying clear of all rotating parts and of all moving parts. Leaving the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.
- Keeping objects away from moving fan blades. The fan blades will throw objects or cut objects.
- When objects are struck, wearing protective glasses in order to avoid injury to the eyes.
- Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensuring that no one will be injured by flying debris.

Mounting and Dismounting:- when mounting and dismounting engines:

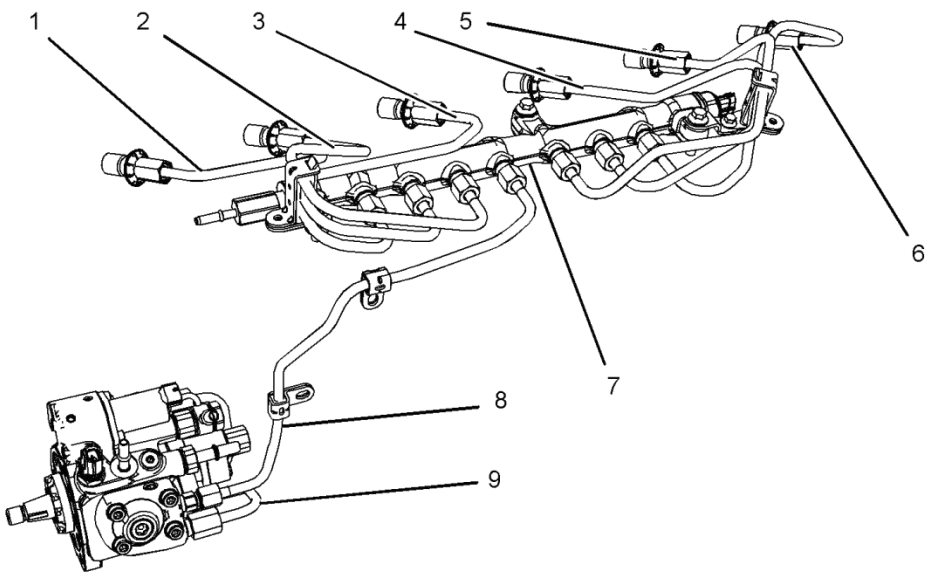
- Do not climb on the engine or the engine after treatment. The engine and after treatment have not been designed with mounting or dismounting locations.

Refer to the OEM for the location of foot and hand holds for your specific application.

High Pressure Fuel Lines

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fu-el spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.



(1) High pressure line

(2) High pressure line

(3) High pressure line

(4) High pressure line

(5) High pressure line

(6) High pressure line

The high pressure fuel lines (see figure above) are the fuel lines that are between the high pressure fuel pump and the high pressure fuel manifold and the fuel lines that are between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

This is because of the following items:

- The high pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high pressure fuel lines are higher than other types of fuel system.
- The high pressure fuel lines are formed to shape and then strengthened by a special process.

Accordingly, when working on high pressure fuel lines:

- Do not step on the high pressure fuel lines. Do not deflect the high pressure fuel lines. Do not bend or strike the high pressure fuel lines. Deformation or damage of the high pressure fuel lines may cause a point of weakness and potential failure.
- Do not check the high pressure fuel lines with the engine or the starting motor

in operation. After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines.

- Do not loosen the high pressure fuel lines in order to remove air from the fuel system. This procedure is not required.
  - High pressure fuel manifold (rail)
  - High pressure line
  - Fuel transfer line that is high pressure
- Visually inspect the high pressure fuel lines before the engine is started. This inspection should be each day.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. *Therefore, the following information is a sample for proper inspection procedure.*

- Inspecting the high pressure fuel lines for damage, deformation, a nick, a cut, a crease, or a dent.
- Not operating the engine with a fuel leak. So, if there is a leak do not tighten the connection in order to stop the leak. The connection must only be tightened to the recommended torque. Refer to Disassembly and Assembly, "Fuel injection lines - Remove and Fuel injection lines - Install" for more information.
- If the high pressure fuel lines are torqued correctly and the high pressure fuel lines are leaking the high pressure fuel lines must be replaced.
- Ensuring that all clips on the high pressure fuel lines are in place. Operating the engine with clips that are damaged, missing or loose is dangerous.
- Attaching any other item to the high pressure fuel lines may damage.
- Loosened high pressure fuel lines must be replaced. Also removed high pressure fuel lines must be replaced..
- Before the initial start-up of an engine that is new, serviced or repaired, making provision to shut the engine off, in order to stop an overspeed. This may be accomplished by shutting off the air and/or fuel supply to the engine.

Overspeed shutdown should occur automatically for engines that are controlled electronically. If automatic shutdown does not occur, press the emergency stop button in order to cut the fuel and/or air to the engine.

Inspecting the engine for potential hazards are:

- Before starting the engine, ensuring that no one is on, underneath, or close to the engine. Ensuring that the area is free of personnel.
- If equipped, ensuring that the lighting system for the engine is suitable for the conditions. Ensuring that all lights work correctly, if equipped.

All protective guards and all protective covers must be installed if the engine must be started in order to perform service procedures. To help prevent an accident that is caused by parts in rotation, work around the parts carefully.

Note: Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided in order to help prevent personal injury. The circuits are also provided in order to help prevent engine damage. *See the Service Manual for repairs and for adjustments.*

Engine Starting

Starting the engine from the operators compartment or from the engine start switch is safe.

⚠ WARNING

Always start the engine according to the procedure that is described in the Operation and Maintenance Manual, "Engine Starting" topic in the Operation Section. Knowing that the correct procedure will help to prevent major damage to the engine components. Knowing that the procedure will also help to prevent personal injury.

To ensure that the jacket water heater (if equipped) and/or the lube oil heater (if equipped) is working correctly, checking the water temperature gauge is appropriate. Also, checking the oil temperature gauge during the heater operation is required.

Engine exhaust contains products of combustion which can be harmful to your health. So, always start the engine and operate the engine in a well ventilated area. If the engine is started in an enclosed area, vent the engine exhaust to the outside.

Note: The engine is equipped with a device for cold starting. If the engine will be operated in very cold conditions, then an extra cold starting aid may be required. Normally, the engine will be equipped with the correct type of starting aid for your region of operation.

These engines are equipped with a glow plug starting aid in each individual cylinder that heats the intake air in order to improve starting. Some Perkins engines may have a cold starting system that is controlled by the ECM that allows a controlled flow of ether into the engine. The ECM will disconnect the glow plugs before the ether is introduced. This system would be installed at the factory.

Engine Stopping

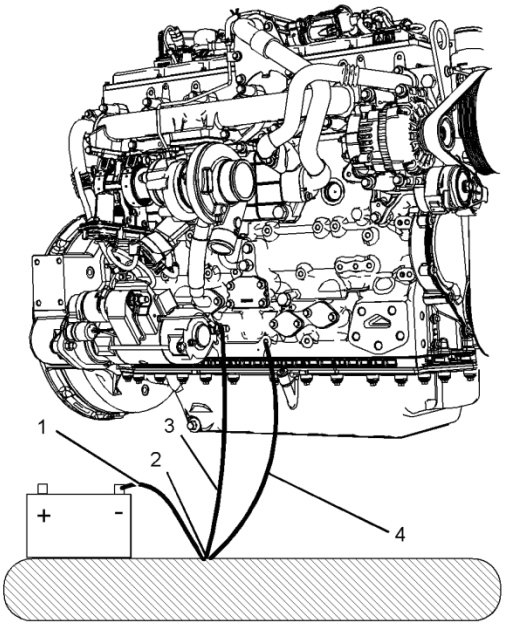
When stopping an engine, using aerosol types of starting aids such as ether could result in an explosion and personal injury.

If a warning tag is attached to the engine start switch, or to the controls, starting the engine or moving the controls may cause personal injury. So, consult with the person that attached the warning tag before the engine is started. Therefore:

- Stop the engine according to the procedure in the Operation and Maintenance Manual, “Engine Stopping (Operation Section)” in order to avoid overheating of the engine and accelerated wear of the engine components.
- Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. Do not use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.
- Stop the engine if an overspeed condition occurs during the initial start-up of a new engine or an engine that has been overhauled.
- To stop an electronically controlled engine, cut the power to the engine and/or shutting off the air supply to the engine.

Grounding Practices
Electrical System

In practicing grounding electrical system of an engine:



- Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.
- To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative “−” cable should be connected last from the external power source to the primary position for grounding.
- Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical connections before the engine is started. Repair all frayed electrical wires before the engine is started. See the Operation and Maintenance Manual for specific starting instructions.

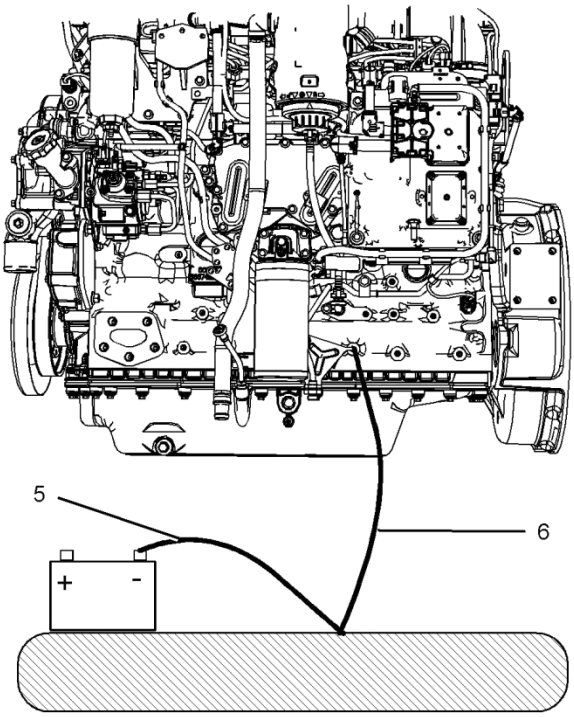
1. Ground to the battery
2. Primary position for grounding
3. Ground to the starting motor
4. Ground to the engine block

Engine Electronics

The power supply connections and the ground connections for the engine electronics should always be from the isolator to the battery.

⚠ WARNING

Tampering with the electronic system installation or the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.



Electrical Shock Hazard. The electronic unit injectors use DC voltage. The ECM sends this voltage to the electronic unit injectors. Do not come in contact with the harness connector for the electronic unit injectors while the engine is operating. Failure to follow this instruction could result in personal injury or death.

1. Ground to the battery
2. Ground to the cylinder block

Correcting grounding for the engine electrical system is necessary for optimum engine performance and reliability. Incorrect grounding will result in uncontrolled electrical circuit paths and in unreliable electrical circuit paths.

Uncontrolled electrical circuit paths can result in damage to the crankshaft bearing journal surfaces and to aluminum components.

Engines that are installed without engine-to-frame ground straps can be damaged by electrical discharge.

To ensure that the engine and the engine electrical systems function correctly, an engine-to-frame ground strap with a direct path to the battery must be used. This path may be provided by way of a direct engine ground to the frame.

The connections for the grounds should be tight and free of corrosion. The engine alternator must be grounded to the negative "-" battery terminal. The grounding wire must be adequate to handle the full charging current of the alternator.

This engine has a comprehensive, programmable Engine Monitoring System. The

Electronic Control Module (ECM) has the ability to monitor the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control:

- Warning
- Derate
- Shutdown

The following monitored engine operating conditions have the ability to limit engine speed and/or the engine power:

- Engine Coolant Temperature
- Engine Oil Pressure
- Engine Speed
- Intake Manifold Air Temperature
- Engine Intake Throttle Valve Fault
- Wastegate Regulator
- Supply Voltage to Sensors
- Fuel Pressure in Manifold (Rail)
- NOx Reduction System
- Engine Aftertreatment System

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

Self-Check 3	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. What are the hazardous types that are possibly available while we conduct engine inspection and services? Describe at least six. How do we manage them? (5pts)
2. Discuss with your group how to practice on grounding electrical system of an engine. (3pts)
3. What are the hazardous that may cause personal injury and damage of an engine itself or both? (5pts)

Answer Sheet

Name: _____ Date: _____

Score = 13pts

Rating: _____

Short Answer Questions

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

Information Sheet - 4	Selecting and checking tools, equipment and materials

Identify and make ready tools, equipment and materials.

The most common instruments used for engine inspections and Services are: -

1. **Test lump (bulb):** - to adjust ignition timing statically.
2. **Tachometer:** - to indicates the engine speed in revolutions per minute (rpm).
3. **Cylinder compression tester**: - to measure the compression pressure.
4. **Cylinder leakage tester**: - to find places of compression pressure leakage.
5. **Dwell angle tester**: - to measure and correct the dwell angle.
6. **Ignition timing light**: - to adjust ignition timing dynamically.
7. **Oscilloscope: -** to examine the condition of the primary and secondary ignition circuits.
8. **Exhaust-gas analyzer:** - to measure the concentration of exhaust gases (CO, HC).
9. **Vacuum gauge:** - to check manifold vacuum.
10. **Engine analyzer:** - to measure various engine parameters on a single unit.

Self-Check 4	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. What are the tools and equipment and materials used to carry out engine inspection and services? Describe how to check them? (at least five of them) (5pts)

Note: Satisfactory rating –3 points **Unsatisfactory - below 3 points**

Answer Sheet

Name: _____ Date: _____

Score = 5pts
Rating: _____

Short Answer Questions

Q1._____

_____

_____

_____

LAP Test	Preparing to Inspect and Service Engine

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: complete the following job and report to your instructor

Job 1: Carry out complete preparation used to carry out engine inspection and services

Instruction Sheet	Learning Guide #47: Inspect Engine

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Carrying out inspection
- Comparing inspection results
- Reporting inspection findings

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Carry out inspection
- Compare inspection results
- Report inspection findings

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1

7. Submit your accomplished Self-check. This will form part of your training portfolio.
8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet-1	Carrying out Inspection

Introduction

In the Engine Inspection part, the scope of engine inspections includes visual observations during engine servicing or maintenance as well as inspections based on progressive time intervals after the engine is put into service.

All engine inspections are mandatory and must be completed no later than 10 hours after the specified time interval for the inspection.

NOTICE: More frequent inspections could be necessary for engines operated in particulate-laden or extremely humid, cold, damp environments.

Visual Inspection for Engines are:
Completing the Visual Inspection, with the engine installed in the aircraft, before the initial 10-hour inspection and each routine 25, 50, 100, 400, 500, and 1000-hour inspection and every time before you service, maintain, clean, or disassemble the engine.

Before any engine inspection or service procedure, making sure the ignition switch is set to off and that all power to the engine is disconnected is required. Ensuring all objects/personnel are clear of the propeller's rotational arc. If power is on, a loose or broken wire can cause the engine to start and the propeller to turn which can lead to death or serious injury or a propeller strike.

Checking and making ready the Injection System Components.

Setting and Installing Injection Pump to Engine

1. Removing the injection pump

Figure 1.1 Disconnecting vacuum hoses from injection pump

a. Labeling the vacuum hoses and disconnect them from the injection pump. (See figure at the left)

Figure 1.2 Loosen the Fuel Filter

b. Loosening the fuel filter union bolts and removing the one connected to the injection pump.

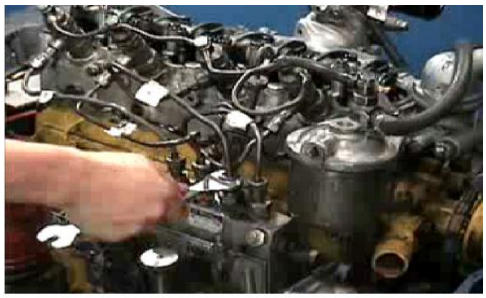


Figure 1.3 Remove the delivery pipes

c. Removing the delivery pipes connected to the injection pump delivery valves and injection nozzles.

Figure 1.4 Loosen the bolts on injection pump

d. Loosening the bolts on the injection pump cover. These bolts also hold the injection pump.

e. Holding and supporting the injection pump while removing the bolts.

Figure 1.5 Removing the bolts

2. Setting the injection timing

a. Removing the timing mark cover.

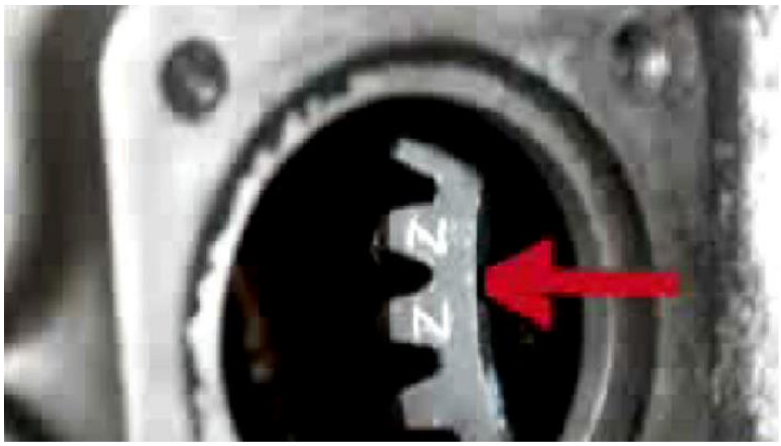


Figure 1.6 Removing timing gear cover

Figure 1.7 Finding timing gear position

Figure 1.8 Pull out the injection pump

b. Finding the marks on the idler gear and the injection pump gear. (See figure 1.7)

c. Pulling out the injection pump from the cover. (See figure 1.8)

Figure 1.9 Installing bolts

d. Installing the bolts holding the injection pump and tighten.

e. Inspecting the position of the injection pump gear timing mark. It must be between the idler gear timing marks.(see figure 1.10)

f. Returning the timing mark cover.(see figure 1.11)

Figure 1.10 Inspecting the position of the injection pump gear timing mark

Figure 1.11 returning the timing gear cover

A large percentage of fuel injection pumps have timing devices incorporated in them.

Varying the time when fuel injection begins will improve Engine engine performance and fuel economy, for the same reason that varying spark timing will improve the performance of a gasoline engine.

1. The timing device usually consists of an aluminum casting with mounting flanges at both ends. A bore in the housing guides and supports the spider assembly.

1. A timing opening, with a cover, is located in the top of the housing and is used to observe the position of the timing pointer in relation to the timing mark on the timing device hub during injection pump timing procedures.
2. The timing device hub, with external left-hand helical splines for engaging the internal helical splines of the sliding gear, has a tapered bore and keyway. The hub is secured to the camshaft extension by a woodruff key, nut, and setscrew. The hub is usually counter bored to receive the timing device springs. The springs oppose the flyweight forces of the weight and spider assembly.
3. The weight and spider assembly has external right-hand helical splines which mesh with the internal helical splines of the sliding gear. The splined end is machined to receive the end play spacer. Three flyweights are pinned to a flange adjacent to the splines. The weight and spider thrust plate, located between the flange and the timing device housing, carries the back thrust of the flyweights and prevents housing wear.

4. The sliding gear has internal left-hand helical splines at one end and internal right hand helical splines at the other, and meshes with the external splines of both the weight and spider assembly and the timing device hub. Correct assembly of the spline train is ensured by a wide land on both the hub and weight and the spider assembly. The sliding gear has a missing tooth on each set of internal splines to receive the wide lands.

Three arms extend from the outer surface of the sliding gear to provide seats for the three timing device springs. The force on these springs is controlled by a sliding gear spacer.

1. **Setting valve tappet clearance:** There must be a certain clearance between the top of the valve stem and the operating mechanism to allow the valve to seat correctly under all working conditions. Since relative expansion of the various components takes place when the engine is hot, there should be sufficient clearance to ensure that the valve is properly seating irrespective of the temperature. If there is insufficient clearance the valve will not fully close during the compression and power strokes of the piston, which will reduce the operating efficiency of the engine. However, excessive clearance reduces valve life and hence the period during which it is fully open; there will also be an increase in engine noise.

If at any time the valve operating mechanism is dismantled or disturbed in any way, the valve clearance should be checked and readjusted if necessary. The actual clearance may vary from engine to engine; in some designs the exhaust valve clearance will be greater than the inlet valve clearance. These clearances are sometimes checked when the engine is hot and sometimes when cold. Therefore, it is most important that the manufacturer's specifications and procedures are closely followed.

Methods of Adjustment: The valve clearance must be set when the cam follower is on the back of the cam; this ensures that the valve is fully closed. This position may be determined by rotating the crankshaft through one full revolution from the fully open position of the valve. There are various methods of operating overhead valves and the method of adjustment of the valve clearance depends upon the arrangement employed. If the conventional push-rod and rocker arm assembly is used, adjustment is usually by set screw and lockout. Measurement of the valve clearance is generally made with a feeler gauge of the recommended size, inserted between the top of the valve stem and the rocker arm. If the feeler gauge will not go between the valve stem and the rocker arm, the lockout should be released and the set screw slackened. Alternatively, if excessive clearance exists, the set screw should be tightened. The clearance is correct when it is just possible to enter the feeler gauge blade of the correct thickness between the valve stem and the rocker arm.

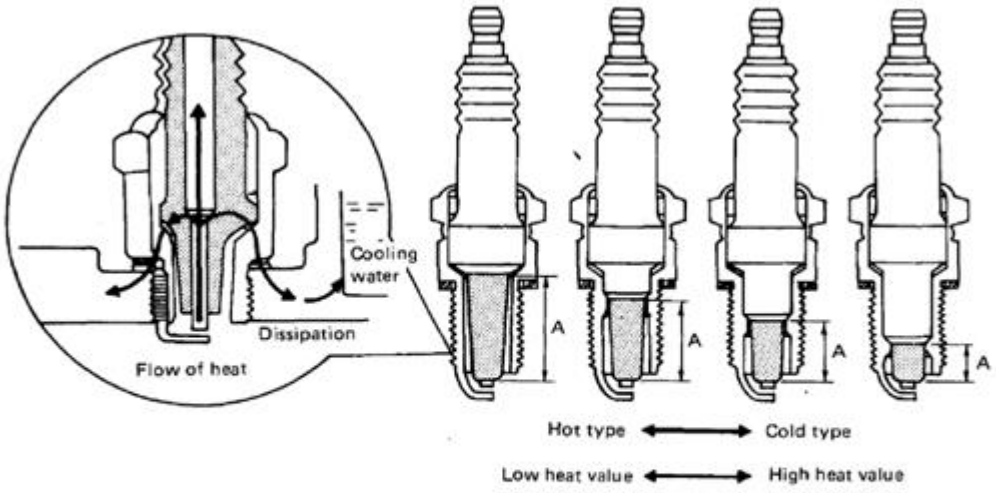
Inspection of spark plugs

Self cleaning action

Carbon and contamination can be cleaned by high temperature of the plug itself. This is called self-cleaning action. This self cleaning action is generally between 400^0c to 800^0c.

Heat value

1. The temperature to which the spark plug can rise is referred to as heat range. The heat value is numerical representation of this heat range.
2. The heat value and the flow of heat in spark plug are shown below



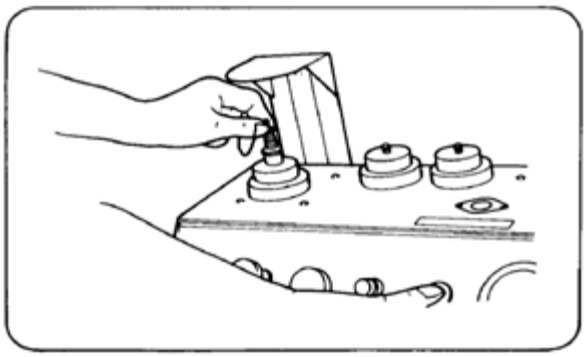
a. Cold type: The length (A) of the insulator is short, and heat dissipation is good.
b. Hot type: The length (A) of the insulator is long, and high temperatures are generated.

Inspecting spark plug

1. Checking the insulator for burning:
   - the plug is normal if it is dry and light brown in color
   - clean or replace the plug if:
     1. it is strained with black carbon, or
     2. it burnt white, or the electrode is worn

2. Checking the insulator and gasket:
   Replace the plug if the insulator is damaged
   Replace the plug if the gasket is damaged or worn

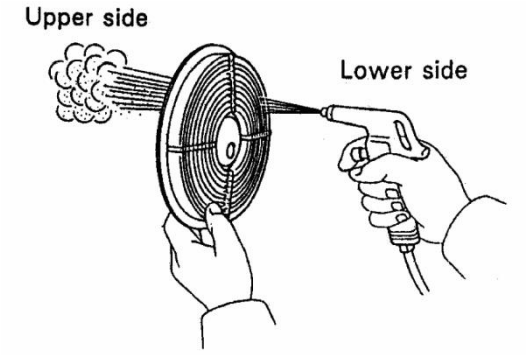
3. Cleaning the plug:
   - Use the plug cleaner
   - Clean the plug with sand and then with air (see figure below)



1. Intake System Inspection methods may include:

1. Removing the air cleaner element.

2. Cleaning the element by blowing compressed air from inside if it is dry-paper type (see figure below). Otherwise refer to the repair manual.



3. If the element is torn or excessively dirty, replacing it with a new one.

4. Checking the carburetor mountings and gaskets for leakage.

5. Checking the intake manifold mountings and gaskets for leakage.

2. Methods of checking the engine compression test.

Power loss:- Before a successful tune-up can be performed, it must be determined if the engine is in a satisfactory mechanical condition. An engine that has burned or leaking valves, worn piston rings, sticking valve lifters, leaking cylinder head gaskets or other mechanical malfunctions, will not perform efficiently even after being tuned-up. These conditions must be corrected before an engine can be tuned to perform satisfactorily or before emissions can be effectively limited.

Since the power developed by the engine on its power stroke is largely dependent on the efficiency of the compression stroke, and because of the testing convenience afforded, the compression stroke is used for testing engine condition.

During the compression stroke the air-fuel mixture is compressed in the tightly sealed combustion chamber. Should any openings be created by burned valves, leaking gaskets, or worn piston rings, the reduced amount of the air-fuel mixture would proportionately reduce the power output of the engine. Leaking at any point in the combustion chamber will affect efficient engine operation. Leaking intake valves will allow a portion of the air-fuel mixture to be pushed back into the intake manifold during the compression stroke. During the power stroke, the expanding gases will leak past the burned valves and less fuel will be available on the head of the piston. Also burned gases will be forced into the intake manifold to mix with the air-fuel mixture. A diluted air-fuel mixture will then be available for the next intake stroke and consequently the engine will develop less power. If the exhaust valve is burned, the expanding gases will leak through it and less power will be available from the cylinder.

Any leakage past the piston rings will also affect the power of the engine. During the compression stroke, part of the air-fuel mixture will be forced into the crankcase and cause oil contamination. The power stroke will also force burned gases into the crankcase. These gases will overheat some of the oil, turning it into carbon and the oil will become contaminated.

A leaking head gasket will permit water to be drawn into the cylinder during the intake stroke. During the compression and power strokes, gases will be forced from the combustion chamber into the cooling system and cause the engine to overheat. Also, a less dense air-fuel mixture will be available for the power stroke.

It is obvious that conditions of compression stroke leakage are proportionately reflected in engine power loss and must be corrected before an engine can be properly tuned.

Checking Injection Nozzle

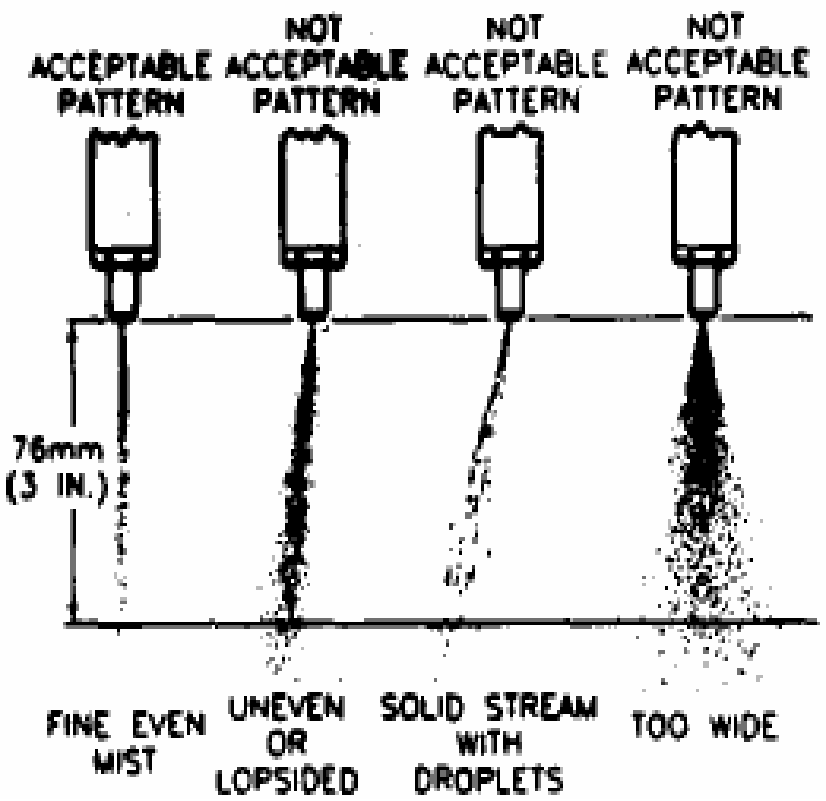
Note: Never remove an injection nozzle from the engine except for service or replacement.
The following indicate injection-nozzle trouble:

- One or more cylinder knocking.
- Smoky black exhaust.
- Loss of power.
- Engine overheating.
- Excessive fuel consumption.

When you check an injection nozzle, you shall perform or consider the following activities. These are:

1. One way to check injection nozzles is to run the engine at fast idle.
2. Loosen the connector at each nozzle in turn, one at a time.
3. Wrap a cloth around the connection before you loosen it to keep fuel from spurting out. If loosening the connector causes engine speed to drop, the nozzle is probably working normally. If the engine speed remains the same, the nozzle is not working properly. Clogged holes are preventing fuel delivery or causing an improper spray pattern some manufacturers recommend a spray test of the detached injection nozzle. This requires a nozzle tester, which is a special hydraulic pump and pressure gauge.
4. Attach the nozzle and apply pressure. The fuel should spray in an acceptable pattern when the specified pressure is reached.
5. Releasing the pressure should stop the spray abruptly without any drip from the nozzle.

The pressure is high enough to force fuel oil through the skin. You can be seriously injured because the oil could cause an infection. If the engine misses at all speeds and produces a puff of exhaust smoke each time it misfires, an injection nozzle is probably sticking open. The nozzle can be disassembled and cleaned. Some manufacturers recommend replacing a faulty nozzle. **Caution:** Direct the spray from the nozzle into a suitable container. Do not allow the spray to hit your skin.



Caution: If you disassemble a nozzle, do not damage the tip or enlarge the holes. This can cause leakage and other troubles.

Testing/adjusting dwell angle and ignition setting, engine idle speed and Ignition System

The purpose of the ignition system is to provide the high intensity electrical spark that is used to ignite the air-fuel mixture in the combustion chamber of the engine. The spark must be supplied at the right time and it must possess sufficient energy to ignite the mixture under various engine-operating conditions. The energy is obtained from the alternator and battery, and the ignition coil increases the voltage. The sparks that cause combustion are produced across the electrodes of the spark plugs, which provide into the combustion chamber. The spark must be of high intensity. Voltages in high-energy ignition systems can be as high as 40000 volts or more.

Alternator - Inspect

Perkins recommends a scheduled inspection of the alternator. Inspect the alternator for loose connections and correct battery charging. Check the ammeter (if equipped) during engine operation in order to ensure correct battery performance and/or correct performance of the electrical system. Make repairs, as required.

Aftercooler Core - Inspect

Note: Adjust the frequency of cleaning according to the effects of the operating environment.

Inspect the aftercooler for these items: damaged fins, corrosion, dirt, grease, insects, leaves, oil, and other debris. Clean the aftercooler, if necessary.

For air-to-air aftercoolers, use the same methods that are used for cleaning radiators.

Check the alternator and the battery charger for correct operation. If the batteries are correctly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the

cranking power. If the battery is too cold, the battery will not crank the engine. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

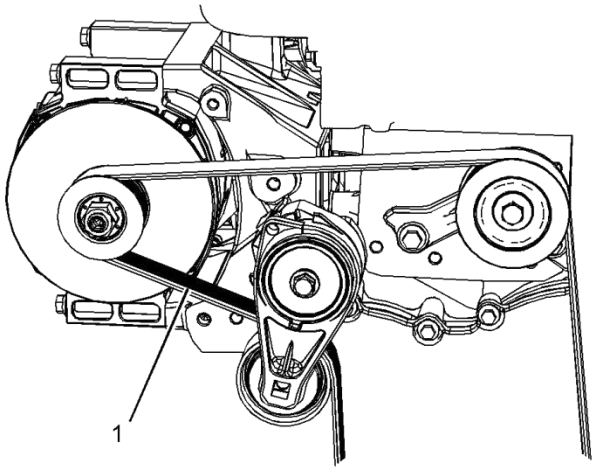
After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

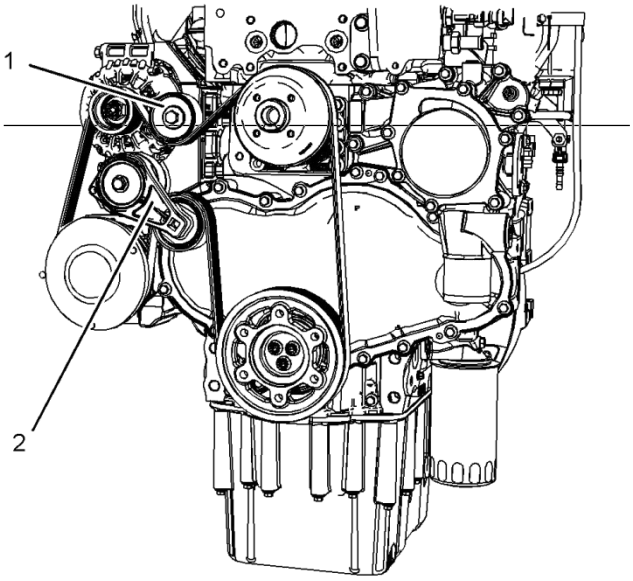
Inspect the fins for damage. Bent fins may be opened with a “comb”.

Note: If parts of the aftercooler system are repaired or replaced, a leak test is highly recommended.

Inspect these items for good condition: Welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

Belt Tensioner - Inspecting
Belt - Inspecting



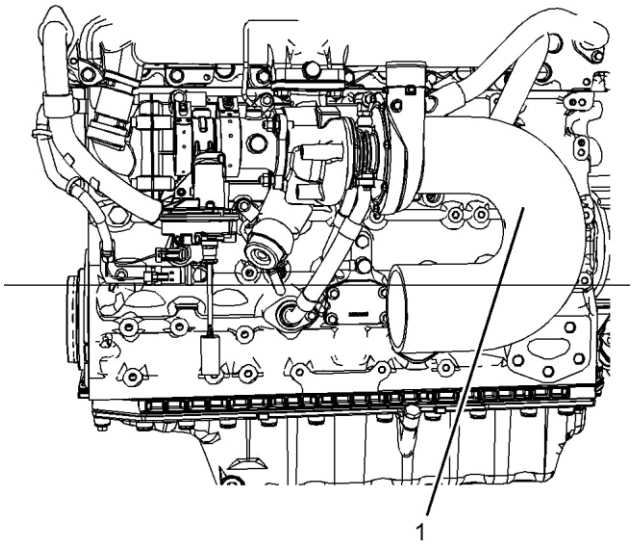


NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

To maximize the engine performance, inspect the belt
(1) for wear and for cracking. Replace the belt if the belt is worn or damaged.
Remove the belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install”.
Ensure that the belt tensioner is securely installed. Visually inspect the belt tensioner (2) for damage. Check that the pulley on the tensioner rotates freely and that the bearing is not loose. Some engines have an idler pulley (1). Ensure that the idler pulley is securely installed. Visually inspect the idler pulley for damage. Ensure that the idler pulley can rotate freely and that the bearing is not loose. If necessary, replace damaged components.

Starting Motor - Inspection
If the starting motor fails, the engine may not start in an emergency situation.
So, check the starting motor for correct operation. Check the electrical connections and clean the electrical connections. Refer to the Systems Operation, Testing and Adjusting Manual, “Electric Starting System - Test” for more information on the checking procedure and for specifications or consult your supervisor/ assistance.



Turbocharger - Inspection

Turbocharger bearing failures can cause large quantities of oil to enter the air intake and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of oil into a turbocharger under extended low idle operation should not cause problems as long as a turbocharger bearing failure has not occurred.

If a turbocharger failure is suspected do not operate the engine. A failure of the turbocharger can be signaled by significant loss of engine performance and erratic RPM at no load. Also, large quantities of engine oil could pass into the engine air intake. This oil would have been seen as smoke from the engine exhaust. Applications that have a DPF installed will filter the engine exhaust.

A visual inspection of the turbocharger or turbochargers can minimize unscheduled downtime.

A visual inspection of the turbocharger or turbochargers can also reduce the chance for potential damage to other engine parts. Therefore:

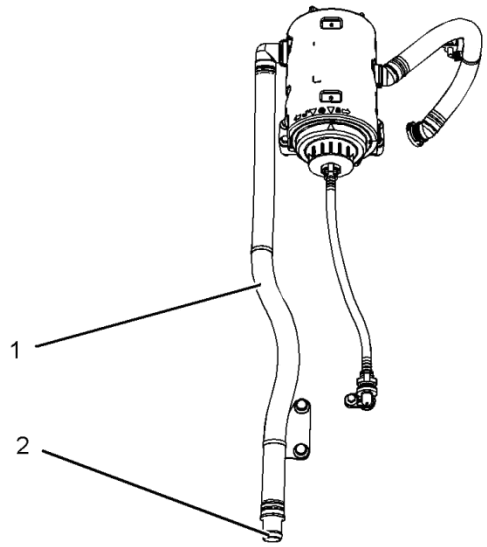
1. Do not inspect the engine with the engine in operation.
2. Ensure that the turbocharger is clean and free from dirt before removing components for inspection.
3. Remove the pipe from the turbocharger exhaust outlet and remove the air intake pipe (1). Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.
4. Check for abnormal heat discoloration of the turbocharger. Check for any loose bolts or any missing bolts. Check for damage to the oil supply line and the oil drain line. Check for cracks in the housing of the turbocharger. Ensure that the compressor wheel can rotate freely. Check for signs of damage to the compressor wheel, or contact of the compressor wheel to the body of the compressor housing.
5. Check for the presence of oil. If oil is leaking from the back side of the compressor wheel, there is a possibility of a failed turbocharger oil seal.

   The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the intake air (clogged air filters), which causes the turbocharger to slobber. For more information, refer to Systems Operation, Testing, and Adjusting, “Turbocharger -

Inspect".

Walk-Around Inspection

Inspecting the Tube of the Crankcase Breather



Inspecting the breather tube (1) for damage: Ensure that the outlet (2) is clean and free from any obstructions. Ice can cause obstructions in adverse weather conditions.(see figure on the right)

Inspecting the Engine for Leaks and for Loose Connections

A walk-around inspection should only take a few minutes. When the time is taken to perform these checks, costly repairs and accidents can be avoided.

For maximum engine service life, make a thorough inspection of the engine compartment before starting the engine. Look for items such as oil leaks or coolant leaks, loose bolts, worn belts, loose connections, and trash buildup. Make repairs, as needed:

- The guards must be in the correct place. Repair damaged guards or replace missing guards.
- Wipe all caps and plugs before the engine is serviced in order to reduce the chance of system contamination.

NOTICE

For any type of leak (coolant, lube, or fuel) clean up the fluid. If leaking is observed, find the source and correct the leak. If leaking is suspected, check the fluid levels more often than recommended until the leak is found or fixed, or until the suspicion of a leak is proved to be unwarranted.

Accumulated grease and/or oil on an engine is a fire hazard. Remove the accumulated grease and oil.

Ensure that the cooling system hoses are correctly clamped and that the cooling system hoses are tight. Check for leaks. Check the condition of all pipes.

- Inspect the water pump for coolant leaks.

Note: The water pump seal is lubricated by the coolant in the cooling system. It is normal for a small amount of leakage to occur as the engine cools down and the parts contract.

Excessive coolant leakage may indicate the need to replace the water pump. Therefore,

remove the water pump and conduction inspection as follows: (Refer to Disassembly and Assembly , “Water Pump - Remove and Install”)

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters, and the rocker cover.
- Inspect the piping for the air intake system and the elbows for cracks and for loose clamps. Ensure that hoses and tubes are not contacting other hoses, tubes, wiring harnesses, etc.
- Ensure that the areas around the rotating parts are clear.
- Inspect the alternator belts and any accessory drive belts for cracks, breaks, or other damage.
- Inspect the wiring harness for damage.

Belts for multiple groove pulleys must be replaced as matched sets. If only one belt is replaced, the belt will carry more load than the belts that are not replaced. The older belts are stretched. The additional load on the new belt could cause the belt to break.

Replace any high-pressure fuel line that has leaked. Refer to Disassembly and Assembly Manual, “Fuel Injection Lines - Install”.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, “General hazard Information”.

Visually inspect the high-pressure fuel lines for damage or signs of fuel leakage. Replace any damaged high-pressure fuel lines or high-pressure fuel lines that have leaked. Therefore:

- Ensure that all clips on the high-pressure fuel lines are in place and that the clips are not loose.
- Inspect the rest of the fuel system for leaks. Look for loose fuel line clamps.
- Drain the water and the sediment from the fuel tank on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires. Check for any loose tie-wraps or missing tie-wraps.
- Inspect the ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauge that cannot be calibrated.
- A piston seizure

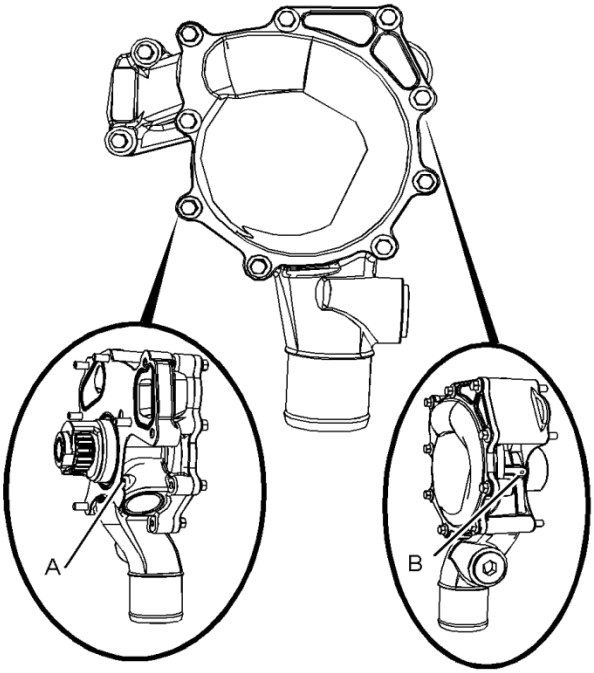
Other potential damage to the engine are:

(A) Weep hole

(B) Vent hole

Visually inspect the water pump for leaks.

Note: If engine coolant enters the engine lubricating system the lubricating oil and the engine oil filter must be replaced. This will remove any contamination that is caused by the coolant and this will prevent any irregular oil samples (see the figure below).



Water Pump – Inspection

The water pump is not a serviceable item. In order to install a new water pump, refer to the Disassembly and Assembly Manual, “Water Pump - Remove and Install”.

Self-Check 1	Written Test

Directions Answer all the following **choose questions** and write your answer on the space provided

1. An engine cranks but will not start. No spark is available at the end of a spark plug wire with a spark tester connected and the engine cranked. Technician A says that a defective crankshaft position (CKP) sensor could be the cause. Technician B says that a defective ignition module could be the cause. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

2. Two technicians are discussing a waste spark-type of ignition system. Technician A says that a defective coil can cause a crank, but no-start condition. Technician B says that a defective coil could affect the spark output to two spark plugs. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

3. Battery voltage during cranking is below specifications. Technician A says that a defect in the engine may be the cause. Technician B says that the starter motor may be defective. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

4. Technician A says that a leaking intake manifold gasket can cause a vacuum leak. Technician B says that a clogged air filter can cause a low power concern. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

5. A starter motor cranks the engine too slowly to start. Technician A says that the cause could be a weak or defective battery. Technician B says that the cause could be loose or corroded battery cable connections. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

6. Technician A says that a clogged port fuel injector can cause a misfire. Technician B says that a leaking injector lower O-ring can cause a vacuum leak. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

7. Which computer sensor may have to be replaced if the engine had been found to have a defective head gasket or cracked head?

a. Throttle position sensor
b. Oxygen sensor
c. Manifold absolute pressure sensor
d. Engine coolant temperature sensor

8. A supercharged engine lacks power. What is *not* a possible cause?

a. Clogged air filter
b. Restricted intercooler

c. Clogged condenser
d. Restricted exhaust

9. Technician A says that a defective one-way exhaust check valve could cause the air pump to fail. Technician B says that the air should stop flowing to the exhaust manifold when the engine is warm and operating in closed loop. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

10. Two technicians are discussing positive crankcase ventilation (PCV) valves. Technician A says that if the valve rattles, it is good. Technician B says the PCV valve may still require replacement even if it rattles. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

11. A spark plug has dry, black fluffy deposits. Technician A says this is caused by the engine burning oil. Technician B says that the engine may be operating with a rich air-fuel mixture. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

12. A turbocharged engine is burning oil. Technician A says that a defective turbocharger could be the cause. Technician B says that a clogged PCV system could be the cause. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

13. Technician A says that low fuel pressure can cause the engine to produce low power. Technician B says that all fuel pumps should be able to pump at least 2 pints (1 liter) per minute. Which technician is correct?

a. A only
b. B only
c. Both A and B

14. An engine misfire is being diagnosed. One spark plug wire measured “OL” on a digital ohmmeter set to the auto range scale. Technician A says that the spark plug wire should be replaced. Technician B says that the spark plug wire is okay. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

15. Technician A says that oil should be squirted into all of the cylinders before taking a compression test. Technician B says that if the compression greatly increases when some oil is squirted into the cylinders, it indicates defective or worn piston rings. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

16. Two technicians are discussing oil leaks. Technician A says that an oil leak can be found using a fluorescent dye in the oil with a black light to check for leaks. Technician B says that a white spray powder can be used to locate oil leaks. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

17. Technician A says that a worn (stretched)

timing chain and worn gears will cause the valve timing to be retarded. Technician B says that if the timing chain slack is over ½ inch (13 mm), the timing chain and gears should be replaced. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

18. Leaking antifreeze can be what color?

a. Green
b. Orange
c. Red
d. Any of the above

19. An increase in oil viscosity can be due to _____.

a. wear metals in the oil
b. fuel dilution of the oil
c. a clogged air filter
d. any of the above

20. Oil is discovered inside the air cleaner assembly. Technician A says that the cause could be excessive blow by past the piston rings. Technician B says that the cause could be a clogged PCV valve, hose, or passage. Which technician is correct?

a. Technician A
b. Technician B
c. Both A and B
d. Neither A nor B

21. Two technicians are discussing the cause of low oil pressure. Technician A says that a worn oil pump could be the cause. Technician B says that worn main or rod bearings could be the cause. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

22. A noisy valve train is being diagnosed. Technician A says that the rocker arm may be adjusted too tightly. Technician B says that the rocker arm may be adjusted too loosely or may be worn. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

23. A head gasket failure is being diagnosed. Technician A says that an exhaust analyzer can be used to check for HC when the -tester probe is held above the radiator coolant. Technician B says that a combustion tester liquid changes color in the presence of -combustion gases. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

24. Technician A says that black exhaust smoke is an indication of too-rich air-fuel mixture. Technician B says that white smoke (steam) is an indication of coolant being burned in the engine. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

25. Technician A says that cranking vacuum should be the same as idle vacuum. Technician B says that sticking valve is indicated by a floating valve gauge needle reading. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

26. Two technicians are discussing a cylinder

power balance test. Technician A says the more the engine RPM drops, the weaker the cylinder. Technician B says that all cylinder RPM drops should be within 50 RPM of each other. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

27. A cylinder leakage (leak-down) test indicates 30% leakage, and air is heard coming out of the air inlet. Technician A says that this is a normal reading for a slightly worn engine. Technician B says that one or more intake valves are defective. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

28. During a cylinder leakage (leak-down) test, air is noticed coming out of the oil fill opening. Technician A says that the oil filter may be clogged. Technician B says that the piston rings may be worn or defective. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

29. The low oil pressure warning light usually comes on _____.

a. whenever an oil change is required
b. whenever oil pressure drops dangerously low (3 to 7 psi)
c. whenever the oil filter bypass valve opens
d. whenever the oil filter anti-drain-back valve opens

30. Two technicians are discussing a compression test. Technician A says that the engine should be cranked over with the pressure gauge installed for "3 puffs." Technician B says that the maximum difference between the highest-reading cylinder and the lowest-reading cylinder should be 20%. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

31. A compression test gave the following results:

cylinder #1 = 155, cylinder #2 = 140, cylinder #3 = 110, cylinder #4 = 105. Technician A says that a defective (burned) valve is the most likely cause. Technician B says that a leaking head gasket could be the cause. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

32. An engine noise is being diagnosed. Technician A says that a double knock is likely to be due to a worn rod bearing. Technician B says that a knock only when the engine is cold is usually due to a worn piston pin. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

33. An engine equipped with a turbocharger is burning oil (blue exhaust smoke all the time). Technician A says that a defective waste gate could be the cause. Technician B says that a plugged PCV system could be the cause. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

34. An engine cranks rapidly but does not start. Technician A says that a defective coil on a

waste-spark-type ignition could be the cause. Technician B says that a broken timing belt could be the cause. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

35. An engine uses an excessive amount of oil. Technician A says that clogged oil drain-back holes in the cylinder head could be the cause. Technician B says that worn piston rings could be the cause. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

36. An engine is misfiring. A power balance test indicates that when the spark to cylinder #4 is grounded, there is no change in the engine speed. Technician A says that a burned valve is a possible cause. Technician B says that a defective cylinder #4 injector or spark plug wire could be the cause. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

37. Technician A says that white exhaust can be caused by a defective cylinder head gasket allowing coolant to enter the combustion chamber. Technician B says a leaking fuel injector can be the cause of white exhaust smoke. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

38. Cranking vacuum should be _____.

a. 2.5 inches Hg or higher
b. over 25 inches Hg
c. 17 to 21 inches Hg
d. 6 to 16 inches Hg

39. Technician A says that during a power balance test, the cylinder that causes the biggest RPM drop is the weak cylinder. Technician B says that if one spark plug wire is grounded out and the engine speed does not drop, a weak or dead cylinder is indicated. Which technician is correct?

a. A only
b. B only
c. Both A and B
d. Neither A nor B

40. A good reading for a cylinder leakage test would be _____.

a. within 20% among cylinders
b. all cylinders below 20% leakage
c. all cylinders above 20% leakage
d. all cylinders above 70% leakage and within 7% of each other

Note: Satisfactory rating –10 points **Unsatisfactory - below 10 points**

Answer Sheet

Name: _____ Date: _____

Score = 19pts

Rating: _____

Answer Questions

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
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28. _____
29. _____
30. _____
31. _____
32. _____
33. _____
34. _____
35. _____
36. _____
37. _____
38. _____
39. _____
40. _____

Information Sheet #-2	Comparing inspection results

Comparing inspection results

Comparing nominal compression pressure values as recommended by the engine manufacturer can be done through adding the actual pressure values as measured and determining the differences in compression pressure between each cylinder.

Therefore, compression pressure value can be compared through taking the Nominal compression pressure P (bar), and Pressure difference between each cylinder P (bar), from the repair manual.

Table 2 Sample table used for testing and comparing values of compression pressure

Cylinder No.	1	2	3	4
Normal pressure, in bar				
Actual pressure, in bar				
Pressure difference, in bar				

If low compression or high differences in pressure between cylinders are measured, inject a small quantity of engine oil through the spark plug hole into the cylinder.

Adding oil helps to seal the piston rings temporarily so that the defective cylinder shows one of the two possible results. These are:-

a) Adding oil increases the compression pressure.

Possible causes:-

- Worn cylinder wall or piston.
- Broken or stuck piston rings.

b) Adding oil does not increases the compression pressure

Possible causes:-

- →Burned cylinder head gasket.
- →Worn or burned valves and valve seats.
- →Damaged or cracked cylinder head.

→Incorrect valve clearance adjustment.

Self-Check 2	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. Explain on how to compare engine inspection results?(3pts)
2. Discuss benefits of adding oil in compression pressure values difference problems. (2pts)

Note: Satisfactory rating –3 points Unsatisfactory - below 3 points

Answer Sheet

Score = 5pts

Rating: _____

Name: _____ Date: _____

Short Answer Questions

1. _____

_____

2. _____

_____

_____

_____

Information Sheet-#3	Reporting Inspection Findings

Inspection Records

Inspection reports should be dated, comparable, and kept on file. Inspection records shall be kept throughout the life of the crane. An electronic recordkeeping system may be used. If a computerized maintenance management system (CMMS) such as MAXIMO is used, and maintenance records are not retained in the crane file, the crane file should state where the electronic maintenance records are kept. Forms should be used when conducting inspections that require documentation.

a. ***Initial Inspections.*** An inspection report shall be completed to record data obtained during the inspection. The report shall be signed and dated and kept on file and readily available.

b. ***Pre-use, Daily and Frequent Inspections.*** Written inspection report and record retention is not required. A frequent inspection verification checklist is recommended.

c. ***Periodic Inspections.*** An inspection report shall be completed to record data obtained during the inspection. The report shall be signed and dated by a qualified inspector and kept on file and readily available.

Inspection Reports

Inspection reports detailing what work was performed during an inspection should be filled out annually to record data obtained during the annual inspection.

Engine Inspection Findings Report Form (Sample)

(Record ALL Engine Inspection and Make a Report.)

Engine Identification

Make _____ Serial Number _____

Year _____ Capacity_____

Engine Number _____ Owner, if Leased _____

Date	Details of Inspection Findings

Self-Check 2	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. Explain on how to report engine inspection results? (2pts)
2. What is the importance of inspection record to inspection results reporting? (3pts)

Note: Satisfactory rating –3 points **Unsatisfactory - below 3 points**

Answer Sheet

Name: _____ Date: _____

Score = 5pts

Rating: _____

Short Answer Questions

1. _____
   _____
2. _____
   _____
   _____
   _____

Operation Sheet-1	Check and adjust Valve clearance

Materials: - Manufacturers repair manual, Feeler gauge and appropriate hand tools.

Instructions:-

a) Use the repair manual and find out whether the engine has to be cold or hot during the clearance check and adjustment.

B) Make ready the engine for valve clearance check following the manufacturer's recommendations.

c) Recommended valve clearance for intake (Int) and exhaust valves (Ex) according to the manufacturer's specification.

Valves	Valve clearance (mm)	**Engine temperature (cold/hot)**
Intake (In)		
Exhaust (Ex)		

d) Measure valve or tappet clearance using a feeler or thickness gauge.

e) Check the valve clearance of each cylinder and put the actual values in Table 2 below and decide whether a clearance adjustment is necessary or not.

NB:-

- Do not slacken completely the locking nut while turning the adjusting screw.
- Be aware of hot engine parts, if adjustment is done with hot engine.

Cylinder No:	1		2		3		4	
Valves	In	**Ex**	**In**	**Ex**	**In**	**Ex**	**In**	**Ex**
Valve clearance measured (mm)								
Adjustment required (yes/no)								

Operation Sheet-2	Conduct the compression test.

1) **Material:**

- ♦ Repair manual
- ♦ Spark plug spanner
- ♦ Compression tester

2) Notice:

a) Check the manufacturers recommendations first weather the engine has to be tested when "hot or cold " Usually the test is executed with engine "hot"!

3) **Testing procedure:**

a) Warm-up the engine to normal operating temperature.
b) Remove the sparkplugs of all cylinders using the proper tool.
c) Disconnect terminal 15 of the ignition coil.
d) Crank the engine with starting motor speed for a few seconds only; this will blow out residues of combustion through the plug hole.
e) Starting from the first cylinder, insert the compression tester into the spark plug hole.
f) Open the throttle vale fully to ensure that the maximum amount of air will enter the cylinder.
g) Crank the engine through 5 to 10 compression strokes.

NB:-All cylinders should be tested with the same number of compression strokes.

h) Write down the maximum pressure indicated by the tester or gauge and compare this figure with the normal one given by the vehicle manufacturer.
i) Continue with the next cylinder.

Operation Sheet-3	Timing the fuel injection pump

Materials: - Manufacturers repair manual and appropriate hand tools.

Instructions:-

Unless major repair work is done on the engine, timing should not be required.
Four cylinder firing order - 1 - 3 - 4 - 2

Procedure:

1. Remove fuel lines from injector pump fittings on injector pump.
2. Pull the decompression lever so that it will remain in the decompression position. No decompression lever on Model-12
3. Open throttle fully.
4. Energize the electric fuel pump and turn engine over with starter to ensure that fuel's coming out of each injector pump opening. Have clean rags around opening to soak up fuel.
5. Wipe off any fuel on injector pump body and the top of each injector opening.
6. Turn crankshaft over by hand, being careful not to damage spline on end of crankshaft. Engine rotation will be clockwise. STOP IMMEDIATELY at the first sign of fuel movement in the injector pump fuel fitting, for whichever injector pump is being checked. (No. 1 injector pump is the closest to the V-belt end of the engine).
7. Remove the cover from flywheel timing mark inspection hold located inside of left engine mount (Tool B).
8. Check alignment of mark on flywheel with the timing pointer on the wall of the inspection hole. The 1-Fl mark on the flywheel represents fuel injection of No. 1cylinder. 2-Fl represents No. 2 cylinder, etc.
9. If timing pointer and the flywheel marking 1-Fl is aligned then No. 1 cylinder is properly timed for fuel injection and should require no adjustment. The same will be true for No. 2, No. 3 and No. 4 cylinders if the above steps are followed.
10. In order to determine if timing is off, or if the injection pump is faulty, it is necessary to recheck the timing for each cylinder two or three times.
11. If there are variations in repeatability in the alignment of pointer and timing mark, a faulty fuel injector pump may be suspected.
12. If timing marks repeat to same location but are off 3/16" or more above or below the pointer, this indicates that the engine must be retimed. If alignment of the timing mark is not within 3/16" above or below the pointer, the above steps must be taken to time the engine. If the timing is found to be satisfactory, then reconnect all fuel lines and fittings and tighten. The fuel system must be bled before the engine will operate properly

Operation Sheet-4	Compare compression test result with specification

Materials: - Manufacturers repair manual and appropriate hand tools.

Instructions:-

Write down into the table below the nominal compression pressure values as recommended by the engine manufacturer. Add the actual pressure values as measured and determine the differences in compression pressure between each cylinder.

Take the ⇒ Nominal compression pressure: P = _____ bar, and

Pressure difference between each cylinder: P = _____ bar, from the repair manual.

Fill the table:-

Cylinder No.	1	2	3	4
Normal pressure, in bar				
Actual pressure, in bar				
Pressure difference, in bar				

If low compression or high differences in pressure between cylinders are measured, inject a small quantity of engine oil through the spark plug hole into the cylinder.

Operation Sheet-5	Centrifugal and vacuum advance check

Materials: - Manufacturers repair manual and appropriate hand tools.

Instructions:-

Centrifugal Advance Check

1. With engine operating at specified timing speed and distributor vacuum line disconnected, aim timing light at timing pointer and press trigger while watching position of timing mark.
2. Slowly increase and decrease engine speed from timing speed to about 2000RPM while watching position of timing mark.

- If the timing mark moves away from and returns to its original position, gradually and without hesitation as speed is increased and decreased, the centrifugal advance mechanism is operating satisfactorily.
- If the timing mark moves away from its original position rapidly with little change in engine speed, or moves very little with considerable change in speed, or fails to return to its original position when speed is decreased, the centrifugal advance mechanism is in need of service.
- Jerky changes may indicate sticking advance weights in the distributor. Computerized engine controllers may require special conditions for this test.

Vacuum Advance Check

- With engine speed adjusted to idle at about 1000 rpm and distributor vacuum line connected, aim timing light at timing pointer and press trigger while observing timing mark.

  NOTE: Be aware that some engines equipped with emission control devices may prevent the vacuum advance mechanism from operating when the transmission is in the neutral position.

  Refer to manufacturer's specifications for special instructions.

- Suddenly open and close the throttle, causing the manifold vacuum to momentarily fall, while observing the position of the timing mark.
- If the timing retards when the throttle is opened and advances when the throttle is closed, the vacuum advance mechanism is operating satisfactorily.
- If the timing mark moves very little or there is no change other than that caused by the centrifugal advance, operation of the vacuum advance mechanism is in need of service.

LAP Test	Carry out Engine Inspection

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: complete the following job and report to your instructor

Job 1: Carry out complete Engine Inspection task.

Instruction Sheet	Learning Guide #48:Engine Service

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Carrying out service and adjustments
- Carrying out post-service testing

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Carry out service and adjustments
- Carry out post-service testing

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.
5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).
6. If you earned a satisfactory evaluation proceed to “Information Sheet 2”. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1
7. Submit your accomplished Self-check. This will form part of your training portfolio.

8. Read the information written in the “Information Sheet 2”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
9. Accomplish the “Self-check 2” in page __.
10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).
11. Read the information written in the “Information Sheets 3 and 4”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
12. Accomplish the “Self-check 3” in page __.
13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).
14. If you earned a satisfactory evaluation proceed to “Operation Sheet 1” in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet#1	Carrying out service and adjustments

Fuel System Testing and Correcting

1. Disconnect the hose at the inlet to the carburetor.
2. Cranking the engine check whether there is a spurt of fuel through the hose or not.
3. If there is a spurt of fuel, you may test the fuel pump for pressure and volume before and after the fuel filter. If it is within the specification, then check the condition of the carburetor.
    1. If fuel there is no fuel or pressure and volume are not within specification, and then perform a vacuum test at the inlet to the fuel pump.
    2. If there is no vacuum or is less than the specification, then repair or replace the fuel pump.
    3. If the vacuum is within specification, then go back to check the hoses up to the fuel tank and the fuel tank itself.

Troubleshooting a carburetor

1. Check whether there is fuel in the primary barrel (venture).
2. Check whether there is fuel within the float chamber.
3. If there is no fuel within the float chamber, then check the condition needle valve assembly and the float.
4. Check the condition of the carburetor for Idle and low speed circuit, Part load circuit, Power circuit, Acceleration pump circuit.

Idle mixture and idle speed adjustment

1. Bring the engine to operation temperature.
2. Stop the engine
3. Identify the *idle mixture* and the *idle speed* adjusting screws.
4. Close the *idle mixture* adjusting screw completely (do not use force!).
5. Re-open the idle mixture adjusting screw 2 ½ - 3 rotations.
6. Close the throttle completely using the *idle speed* adjusting screw.
7. Re-open the throttle by 2 ½ - 3 rotations.
8. Start the engine.
9. Bring the engine to its operation temperature.
10. Connect the tachometer according to the manual.
11. Close the idle mixture adjusting screw until the engine RPM begins to drop.
12. Re-open the idle mixture control screw until the increment of the engine RPM. Just stops.

13. By using the idle speed adjusting screw, adjust the idle speed to the given specification (i.e. 800 rpm)
14. Raise the speed again by some RPM above the specification (i.e. to 850 rpm).
15. Close the mixture adjusting screw until the engine RPM reaches again its specification (i.e. 800 rpm)

Most problems with the fuel system are *mechanical problems*, but some cases of trouble involve problems caused by the *fuel* itself.

Mechanical problems

i) Some problems with the carburetor

- Dirt in carburetor jets
- Worn or inoperative accelerating pump
- Needle valve not operating
- Damaged or clogged main metering jet
- Defective gasket in carburetor
- Defective idle adjustment screw

ii) Some problems with the fuel pump

- Condition of inlet valve, outlet valve
- Condition of oil seal
- Diaphragm may be punctured
- Insufficient tension of rocker arm spring

iii) Some problems with the fuel line

- Condition of flexible hoses and fuel pipes
- Leakage at the joints and on the fuel line
- Clogged fuel filter.

A. Battery, Wiring, Fuse, Ballast Resistor, Ignition Coil, Distributor, HT Cables, Spark Plugs – Testing and Correcting/Adjusting

The parts of the ignition system are:

1. Battery
2. Ignition coil
3. Wiring
4. Fuse
5. Spark plugs
6. Ballast Resister
7. Ignition switch
8. Distributor
9. High tension cables

a) Starting System:
   1) Battery
   2) Starter
   3) Ignition/starter switch
b) Ignition System:
   4) Dropping resistor (not generally installed: starter with terminal 15a required)
   5) Ignition coil
   6) Ignition distributor
   7) Spark plugs

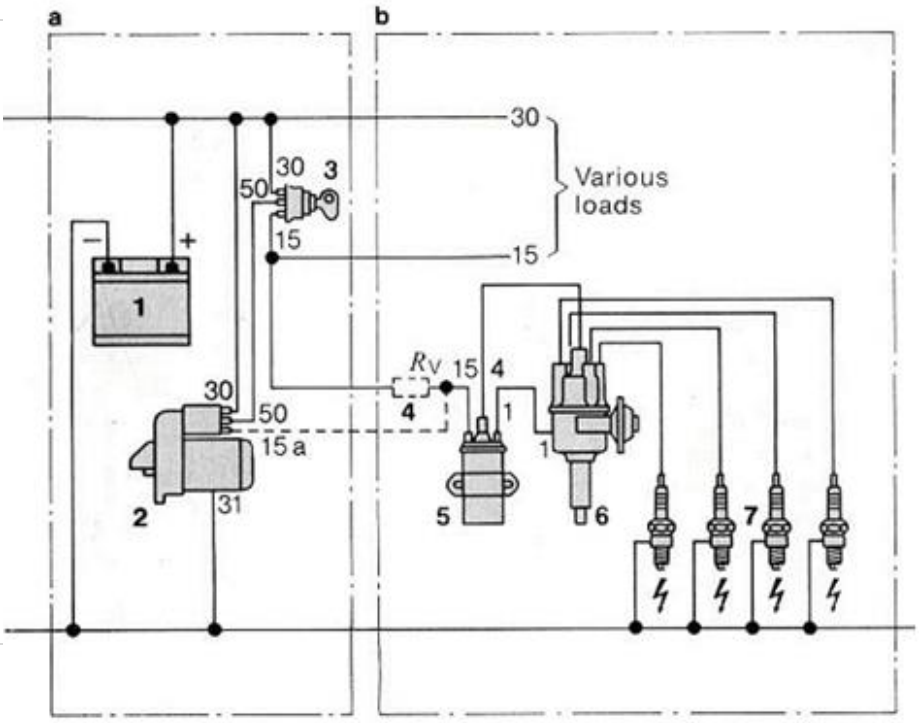


Fig. 3.1 Engine starting and Ignition system circuits

Preventive maintenance

Because of the durability of diesel engines, most maintenance is preventive in nature. Preventive diesel engine maintenance consists of the following operations:

- General inspection
- Lubrication service
- Cooling system service
- Fuel system service
- Servicing and testing starting batteries
- Regular engine exercise

It is generally a good idea to establish and adhere to a schedule of maintenance and service based on the specific power application and the severity of the environment. For example, if the generator set will be used frequently or subjected to extreme operating conditions, the recommended service intervals should be reduced accordingly.

Some of the factors that can affect the maintenance schedule include:

- Using the diesel generator set for continuous duty (prime power)
- Extreme ambient temperatures
- Exposure to weather
- Exposure to salt water
- Exposure to dust, sand or other airborne contaminates

Maintenance Items	Service time				
	Daily	Weekly	Monthly	6 Months	Yearly
Inspection	X				
Check coolant heater	X				
Check coolant level	X				
Check oil level	X				
Check fuel level	X				
Check charge-air piping	X				
Check/clean air cleaner		X			
Check battery charger		X			
Drain fuel filter		X			
Drain water from fuel tank		X			
Check coolant concentration			X		
Check drive belt tension			X		
Drain exhaust condensate			X		
Check starting batteries			X		
Change oil and filter				X	
Change coolant filter				X	
Clean crankcase breather				X	
Change air cleaner element				X	
Check radiator hoses				X	
Change fuel filters				X	
Clean cooling system					X

If the generator set will be subjected to some or all of these extreme operating conditions, it is best to consult with the engine manufacturer to develop an appropriate maintenance schedule. The best way to keep track of maintenance intervals is to use the running time meter on the generator set to keep an accurate log of all service performed. This log will also be important for warranty support. Figure 3.2 shows a typical diesel engine maintenance schedule for generator sets.

Figure 3.2 – **Typical diesel maintenance schedule**.

Lubrication service

Check the engine oil level when the engine is shut down at the interval specified in Figure 3.2. For accurate readings on the engine's dipstick, shut off the engine and wait approximately 10 minutes to allow the oil in the upper portions of the engine to drain back into the crankcase. Follow the engine manufacturer's recommendations for API oil classification and oil viscosity.

Keep the oil level as near as possible to the "full" mark on the dipstick by adding the same quality and brand of oil.

Change the oil and filter at the intervals recommended in Figure 3.2. Check with the engine manufacturer for procedures for draining the oil and replacing the oil filter. Used oil and filters must be disposed of properly to avoid environmental damage or liability.

Cooling system service

Check the coolant level during shutdown periods at the interval specified in Figure 3.2. Remove the radiator cap after allowing the engine to cool and, if necessary, add coolant until the level is about 3/4-inch below the radiator cap lower sealing surface. Heavy duty diesel engines require a balanced coolant mixture of water, antifreeze and coolant additives. Use a coolant solution as recommended by the engine manufacturer.

Inspect the exterior of the radiator for obstructions and remove all dirt or foreign material with a soft brush or cloth. Use care to avoid damaging the fins. If available, use low pressure compressed air or a stream of water in the opposite direction of normal air flow to clean the radiator. Check the operation of the coolant heater by verifying that hot coolant is being discharged from the outlet hose.

Fuel system service

Diesel fuel is subject to contamination and deterioration over time, and one reason for regular generator set exercise is to use up stored fuel over the course of a year before it degrades. In additional to other fuel system service recommended by the engine manufacturer, the fuel filters should be drained at the interval indicated in

FIGURE 3.2. Water vapor accumulates and condenses in the fuel tank and must also be periodically drained from the tank along with any sediment present.

The charge-air piping and hoses should be inspected daily for leaks, holes, cracks or loose connections.

Tighten the hose clamps as necessary. Also, inspect the charge-air cooler for dirt and debris that may be blocking the fins. Check for cracks, holes or other damage.

The engine air intake components should be checked at the interval indicated in FIGURE 1. The frequency of cleaning or replacing air cleaner filter elements is primarily determined by the conditions in which the generator set operates. Air cleaners typically contain a paper cartridge filter element which can be cleaned and reused if not damaged.

Starting batteries

Weak or undercharged starting batteries are the most common cause of standby power system failures. Even when kept fully charged and maintained, lead-acid starting batteries are subject to deterioration over time and must be periodically replaced when they no longer hold a proper charge. Only a regular schedule of inspection and testing under load can prevent generator starting problems. See Figure 3.2 for the recommended inspection interval for the batteries and charging system.

Testing batteries: Merely checking the output voltage of the batteries is not indicative of their ability to deliver adequate starting power. As batteries age, their internal resistance to current flow goes up, and the only accurate measure of terminal voltage must be done under load. On other generators, use a manual battery load tester to verify the condition of each starting battery.

Cleaning batteries: Keep the batteries clean by wiping them with a damp cloth whenever dirt appears excessive. If corrosion is present around the terminals, remove the battery cables and wash the terminals with a solution of baking soda and water (1/4-pound baking soda to one quart of water).
Be careful to prevent the solution from entering the battery cells, and flush the batteries with clean water when done. After replacing the connections, coat the terminals with a light application of petroleum jelly.

Checking specific gravity: Use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell. A fully charged battery will have a specific gravity of 1.260. Charge the battery if the specific gravity reading is below 1.215.

Checking electrolyte level: Check the level of the electrolyte in the batteries at least every 200 hours of operation. If low, fill the battery cells to the bottom of the filler neck with distilled water.

Self-Check 3	Written Test

Directions: Choose the best answer of all the questions listed below and write your answer on the space provided

1. As the percentage of antifreeze in the coolant increases, _____.
    a. the freeze point decreases (up to a point)
    b. the boiling point decreases
    c. the heat transfer increases
    d. all of the above
2. The procedure that should be used when refilling an empty cooling system includes the following:_____.
    a. determine capacity, and then fill the cooling system half with antifreeze and the rest of the way with water.
    b. fill completely with antifreeze, but mix a 50/50 solution for the overflow bottle.
    c. fill the block and one half of the radiator with 100% pure antifreeze and fill the rest of the radiator with water.
    d. fill the radiator with antifreeze, start the engine, drain the radiator, and refill with a 50/50 mixture of antifreeze and water.
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 normal operating can be due to a defective cooling fan. Which technician is correct?
    a. A only
    b. B only
    c. Both A and B
    d. Neither A nor B
5. Technician A says the positive crankcase ventilation (PCV) system uses a valve located between the intake manifold and the valve cover (cylinder head cover). Technician B says that about 20% of the air needed by the engine at idle speed flows through the PCV system. Which technician is correct?
    a. A only
    b. B only
    c. Both A and B
    d. Neither A nor B
6. Turning the oil pump before starting the engine should be done_____
    a. to lubricate engine bearings
    b. to lubricate valve train components
    c. to supply oil to the camshaft
    d. All of the above
7. An engine oil cooler should be inspected for _____.
    a. engine oil leaks
    b. coolant leaks
    c. air leaks
    d. Both a and b

8. Which antifreeze coolant should be used if the manufacturer specifies coolant that is both silicate and phosphate free?
    a. Organic acid technology (OAT), e.g., DEX-COOL (orange)
    b. Ethylene glycol (green)
    c. Asian red
    d. European pink
9. The "hot" light on the dash is being discussed by two technicians. Technician A says that the light comes on if the cooling system temperature is too high for safe operation of the engine. Technician B says that the light comes on whenever there is a decrease (drop) in cooling system pressure. Which technician is correct?
    a. A only
    b. B only
    c. Both A and B
    d. Neither A nor B
10. Normal operating temperature is reached when _____.
    a. the radiator cap releases coolant into the overflow
    b. the upper radiator hose is hot and pressurized
    c. the electric cooling fan has cycled at least once (if the vehicle is so equipped)
    d. either b or c occur
11. For best results, the oil should be drained when the engine is_____?
    a. at normal operating temperature
    b. at room temperature
    c. cold—not yet started
    d. run for 30 seconds, then turned off before draining the oil
12. Two technicians are discussing engine oil. Technician A says that the higher the viscosity, the better. Technician B says that a SAE 20W-50 will work better in a new vehicle instead of the specified SAE 5W-20. Which technician is correct?
    a. A only
    b. B only
    c. Both A and B
    d. Neither A nor B
13. Normal oil pump pressure in an engine is _____.
    a. 3 to 7 psi
    b. 10 to 60 psi
    c. 100 to 150 psi
    d. 180 to 210 psi

16, In typical engine lubrication systems, what components are the last to receive oil?
    a. Main bearings
    b. Rod bearings
    c. Valve trains
    d. Oil filters

Note: Satisfactory rating –9 points **Unsatisfactory - below 9 points**

Answer Sheet

Name: _____ Date: _____

Score = 16pts

Rating: _____

Answer Questions

1..____
2..____
3..____
4..____
5..____
6..____
7..____
8..____
9..____
10. .____
11. .____
12. .____
13. .____
14. .____
15. .____
16. .____

17.

Information Sheet-#2	Carrying out post-service testing

Carrying out post-service Testing

Turning the key switch to the ON position will check the indicator lights on the control panel of the engine. All the indicator lights will be illuminated for 2 seconds after the key-switch is operated. Accordingly, testing and post-service rectification measure can be carried out suspect using the indicating bulbs immediately.

Self-Check 3	Written Test

Directions: Answer all the questions listed below and write your answer on the space provided

1. How to carry out post-service testing of engine?
2. *How do you detect the post-service fault, following "logical inspection" procedures?*

Note: Satisfactory rating –2 points **Unsatisfactory - below 2 points**

Answer Sheet

Name: _____ Date: _____

Score = 3pts

Rating: _____

Short Answer Questions

1. _____

   _____

2. _____

   _____

Operation Sheet-1	Inspect Ignition System -"secondary"

Problem: The engine cranks, but doesn't start. Fuel system and the mechanical engine parts are already tested and without fault.

Instruction: Refer to the starting and ignition system figure shown below to complete the following operation procedure.

Procedure:

1. Disconnect H.T. cable from terminal 4 of the distributor cap and hold it near to terminal 31. Crank the engine.

   Observation:

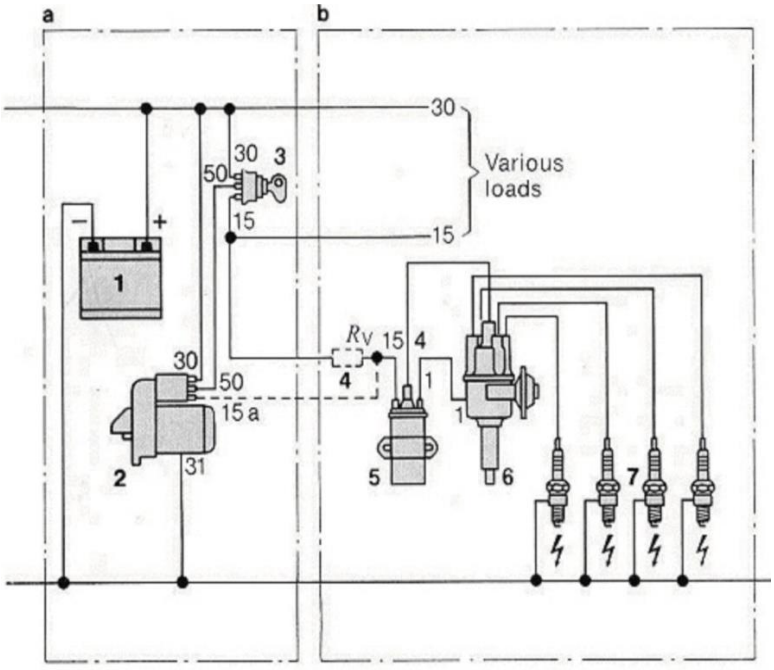
   _____

2. If there is a spark, reconnect the H.T. cable to the distributor cap. Disconnect H.T. cable from spark plug of cylinder No. 1 and ground it. Crank the engine.

   Observation:

   _____

3. If there is a spark, repeat step 2 with all other remaining cylinders.
   Observation:_____



4. If there is spark at all 4 H.T. cables, remove spark plugs and check them.
5. If there is **no spark**, check rotor, distributor cap and the four H.T. cables to the spark plugs! Possible faults are:
   _____
   _____

Observations in Detail:
Rotor_____
Distributor Cap:
_____H.T. cables_____
_____

6. If there is **no spark** at terminal 4 (see step 1 above), check the terminal 4 H.T. cable for continuity.
7. If the terminal 4 H.T.-cable is without fault, check the **primary circuit**! (Do the next Lab.)

Operation Sheet-2	Inspect Ignition system - "primary"

Problem: The engine cranks, but doesn't start. The test of the secondary circuit has shown that there is no spark at terminal 4 of the ignition coil.

Instruction: Refer to the starting and ignition system figure shown in operation-2 to complete the following operation procedure.

Procedure:

Preliminary Remark: For most of the following test descriptions you can use a Voltmeter (result either "12V" or "0V") or a test lamp (result either "light on" or "light off").

3. Check voltage at terminal 15 at the ignition coil against terminal 31 (= …….).
(If the system is equipped with ballast resistor, check also **before and after** the resistor!
Do not forget to consider the resistors own expected voltage drops and possible faults!)
If the ignition -
- is switched on, the **expected** result is (with voltmeter____/ with test lamp: ___)
- is switched off, the **expected** result is (with voltmeter____/ with test lamp: ___)

Observation:

_____

If result is not as expected, check _____

4. Rotate the engine till the contact breaker is fully open (or open it manually by using a screwdriver). This is in which distributor position? _____

Is the contact breaker gap adequate? ☐ Yes or☐ No *(correct it, if required)*

Switch on the ignition. Check voltage of terminal 1 at the ignition coil against terminal 31. The **expected** result is (with voltmeter_____/ with test light: _____)

Observation: _____

5. Measure voltage of terminal 15 against terminal 1 (both at the ignition coil, ignition still on and contact breaker still **open**).
The **expected** result is (with voltmeter_____/ with test light_____)

Observation: _____

If results of step 2 and 3 are not as expected, check_____

6. Rotate the engine till the contact breaker is fully **closed**. Does it properly close?
☐ Yes or, ☐ No?

Repeat measurement of terminal 1 at the coil against ground. (Ignition still switched on!)
The **expected** result is: (with voltmeter_____/ with test light: _____)

Observation:

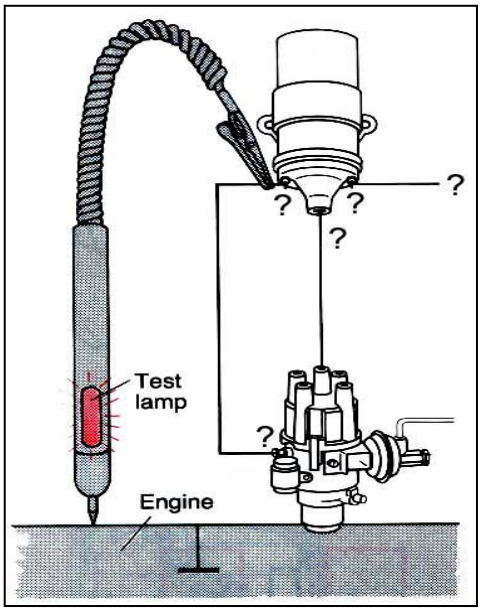
_____

7. Measure voltage of terminal 15 against terminal 1 (both at the ignition coil, ignition still on and contact breaker **closed**).
   The **expected** result is (with voltmeter_____/ with test light: _____)

Observation: _____
If results of step 4 and 5 are not as expected, check_____

8. Measure voltage between both sides directly at the contact breaker (1 and 31). The expected **voltage drop** at the contact breaker is _____

Operation Sheet-3	Ignition Timing Adjustment- "static"



Problem: After the distributor was removed from the engine, disassembled and reassembled, it shall be returned to the engine so that the engine can run immediately afterwards.
(For this teaching & training step you shall assume that the point gap has already been adjusted according to the specifications!).

Question 1: How do you proceed for (re-) installing a distributor to an engine?

Question 2: How do you basically adjust the ignition timing in a way that allows the engine to run?

Procedure

1) Identify cylinder No. 1 **at the engine**

2) Identify position of cylinder No. 1 **at the distributor**!

3) To return the distributor to the engine, several aspects have to be considered:

⇨If gear type drive: _____

⇨If slot / pin type drive: _____

⇨General: _____

4) After you have re-attached the distributor to the engine, connect a 12V-testlight so that it will give light, when the engine comes to "ignite"-position. This is, when

1) The ignition switch is in _____ position, and
2) The contact points are getting in _____Position
3) The lamp is connected to terminals _____And_____

(Before you start, do not forget to check the function of the test-lamp! How / where do test the lamp? _____.)

4) Why does the lamp gives light at "ignite"-position? _____
5) Slowly (!) rotate the engine in its direction of rotation (☐ clockwise? or ☐ Counterclockwise?) Until the light goes "on". How much is the reading at the pulley / housing? _____ take care for proper **spelling!**)
6) Does this reading correspond with the specifications? ☐Yes or, ☐ No

(Follow the next working steps only if **"no**"!)

Observation: The ignition is ☐ too _____or☐ too ____or ☐ correct (= according to specs)

7) First rotate the engine **backward** (= _____) until the light goes "off" and add some more degrees as required in order to overcome the _____(?)
8) Then rotate the engine forward again (slowly!) until it comes to the proper (=specified) position of crankshaft angle for the ignition. This is, when _____
9) Now **rotate the distributor** to the required direction, which is necessary to bring it to the correct ignition position. If it was before the adjustment
   Too much retarded, you shall rotate it _____ was too much advanced, you shall rotate it _____
10) Now tighten the distributor screw.
11) Rotate the engine backward. (AGAIN: do not forget to consider the …spelling!)
12) Repeat steps 6 - 9 in order to check your adjustment.

Observation: ignition is now ☐ within the specification ☐ not correct

13) If ignition is still not within the specification, repeat steps 8 - 11 again!

Operation Sheet-4	Adjust Ignition Timing - “dynamic”

Procedure

Accurate Ignition Timing Depends On Distributor Breaker Point Dwell, The Engine Speed being correct, the distributor vacuum line being disconnected (most engines), and knowing the location of the timing mark. Always check the manufacturer's specifications before setting the timing on any engine. A wrong setting can produce poor engine performance, poor fuel economy, and overheating or engine damage.

Preparation and Hookup

1. Check distributor breaker point dwell and if necessary, adjust to manufacturer's specification. Replace breaker points if needed.
2. Disconnect vacuum hose from distributor vacuum advance unit and plug hose to insure proper operation of the carburetor.
3. Connect timing light battery leads to a 12 Volt vehicle battery; red to positive (+) and black to negative.
4. Connect timing light inductive pickup or clip lead to No. 1 spark plug cable as follows: Place the Inductive Pickup around the appropriate spark plug wire. For best results the pickup should be hooked up with its label side facing toward the spark plug end of the wire, but placed near the distributor and away from the spark plug. This provides a "cleaner" electrical signal and keeps away from the hot manifold.

1. Initial Timing Check

1) Start engine and adjust speed to that specified for ignition timing.
2) With timing light aimed at timing pointer, press trigger and observe position of timing mark when light flashes. Refer to manufacturer's specifications for correct setting.

Note: For the Timing-Advance Tester, be sure that the control knob is fully counterclockwise in the **Timing** position.

Be sure to view the timing mark from a position that allows your eyes to be squarely in line with the timing mark and measurement scale. An error in timing could result if the mark is viewed from another angle.

3) To adjust, loosen distributor-locking screw and turn distributor until specified timing mark is lined up with pointer.
4) Tighten the distributor locking screw, and recheck timing.

LAP Test	Carry out Engine Service

Name: _____ Date: _____

Time started: _____ Time finished: _____

Direction: complete the following job and report to your instructor

Job 1: Carry out complete Engine service task.

Instruction Sheet	Learning Guide #49: Complete work processes

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics

- Making final inspection
- Cleaning work area, disposing of waste and non-recyclable materials, and collecting recyclable material
- Checking and storing tools and equipment
- Processing workplace documentation

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to –

- Make final inspection
- Clean work area, dispose of waste and non-recyclable materials, and collect recyclable material
- Check and store tools and equipment
- Process workplace documentation

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described in number 3 to 20.
3. Read the information written in the “Information Sheets 1”. Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.
4. Accomplish the “Self-check 1” in page __.

5. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 1).

6. If you earned a satisfactory evaluation proceed to "Information Sheet 2". However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to Learning Activity #1

7. Submit your accomplished Self-check. This will form part of your training portfolio.

8. Read the information written in the "Information Sheet 2". Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.

9. Accomplish the "Self-check 2" in page __.

10. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 2).

11. Read the information written in the "Information Sheets 3 and 4". Try to understand what are being discussed. Ask you Instructor for assistance if you have hard time understanding them.

12. Accomplish the "Self-check 3" in page __.

13. Ask from your Instructor the key to correction (key answers) or you can request your Instructor to correct your work. (You are to get the key answer only after you finished answering the Self-check 3).

14. If you earned a satisfactory evaluation proceed to "Operation Sheet 1" in page _. However, if your rating is unsatisfactory, see your Instructor for further instructions or go back to for each Learning Activities.

Information Sheet-1	Making final inspection

General

1. **Workmanship.** Workmanship shall be a level of quality adequate to assure that processed products meet the performance requirements of the engineering documentation and criteria delineated herein.

2. **Inspection**. Inspection for acceptability shall be performed on all solder connections, parts mounting and condition, conductor routing, and PCB features to the requirements specified in this publication. Parts and conductors shall not be physically disturbed to aid inspection.

d. Verify that no damage exists on parts or PCB's prior to there being assembled and soldered. In addition, parts and PCB's shall be inspected to verify that solder ability has been maintained.

e. Verify that the facility cleanliness, environmental conditions, and lighting requirements are being met.

Magnification Aids

Inspection optics shall conform to the requirements. Visual inspection shall be aided by magnification between 4X and 10X. Additional magnification shall be used as necessary to resolve suspected defects.

Self-Check 2	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. What is the final inspection criteria for engine inspection and servicing? (5pts)
2. What does mean for engine inspection and servicing performance and products quality assurance? (5pts)
3. What are methods for engine inspection and service final inspection? (3pts)

Note: Satisfactory rating –7 points Unsatisfactory - below 7 points

Answer Sheet

Name: _____ Date: _____

Score = 13pts

Rating: _____

Short Answer Questions

1. _____

   _____

2. _____
3. _____
4. _____

   _____

Information Sheet-2	Cleaning work area, disposing of waste and non-recyclable materials, and collecting recyclable material

1. Housekeeping

Poor housekeeping can result in an increased risk of injury and a decrease in work efficiency.

By implementing a good housekeeping plan, areas are kept clean and free of waste and the risk of injuries occurring due to slip, trips and falls, together with injuries resulting from hitting stationary objects, are reduced. Items should be stored correctly with no parts protruding onto walkways.

Electrical cords should not be on the floor, tools should have designated areas for storage and bins for waste should be readily available and be easy to empty.

Structured programs that focus on organization, cleanliness and standardization can be introduced to the workplace to assist with this. Cleanliness can be maintained in a ‘clean as you go’ manner or the need for constant housekeeping can be eliminated from the source e.g. leaks, etc.

1. Cleaning, checking, maintaining and storing work area, tools and equipment

Identify work areas to be cleaned and maintained, work equipment to be cleaned and maintained, Identify and locate instructions in relation to cleaning and maintenance, Assess area to be cleaned. Select appropriate cleaning equipment and chemicals. Select the protective clothing and equipment to be used. Dispose of waste, Return area to operational condition, Clean, check and store cleaning equipment and chemicals

2. Preparing Tools and Equipment for maintenance and Storing

Keeping tools properly storing, cleaning, and maintaining will save time and money. In order to keep tools in good working condition during storage, there are some basic preparatory steps that should be taken. It is important to follow the cleaning and storage instructions, especially for larger power tools such as power saws or plate compactor.

Self-Check 2	Written Test

Directions: **Answer all the questions listed below and write your answer on the space provided**

1. How to manage wastes, cleanness and recycled materials when we perform engine inspection and servicing?
2. What if we don't keep cleaning and wastes after or when we carried out engine inspection and service activities?

Note: Satisfactory rating –8 points **Unsatisfactory - below 8 points**

Answer Sheet

Name: _____ Date: _____

Score =15pts

Rating: _____

Short Answer Questions

1. .____
   _____
2. _____
   _____

Information Sheet-3	Checking and storing tools and equipment

Checking of Tools, Equipment, and Materials

Tools and Equipment. Tools and equipment shall be checked and stored after carrying out inspection and servicing of engine (refer to the manufacturer's specification for more information).

Self-Check 3	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. Describe how to inspect and store tools and equipment after finalizing activities?
2. How to inspect defects for tools and equipment after performing?

Note: Satisfactory rating –4 points **Unsatisfactory - below 4 points**

Answer Sheet

Name: _____ Date: _____

Score = 7pts

Rating: _____

Short Answer Questions

1. _____

   _____

2. _____

   _____

   _____

Information Sheet-4	Processing workplace documentation

Document Inspections and Tests

Documentation

Quality Assurance personnel shall verify that all required documentation is current and approved. The documentation shall include: is an organized examination or formal evaluation exercise. In engineering, inspection involves the measurements, tests, and gages applied to certain characteristics in regard to an object or activity. The results are usually compared to specified requirements and standards for determining whether the item or activity is in line with these targets.

Self-Check 4	Written Test

Directions Answer all the questions listed below and write your answer on the space provided

1. What are the activities we apply when processing workplace documentation? (7pts)

Note: Satisfactory rating –4 points **Unsatisfactory - below 4 points**

Answer Sheet

Name: _____ Date: _____

Score = 7pts

Rating: _____

Short Answer Questions

Q1._____

_____

_____

_____

_____

_____

Operation Sheet-1	Making final inspection

Name _____

Instructions: Follow the following procedures to make Final Inspection

- If engine does work (when first switched on), switch it off immediately.
- Most faults in engines are due to inspection and servicing errors, or incorrectly assembled parts. Faulty parts are very rare.
- Check the engine for any faults or mal-functioning.
- Check that all systems are correctly performing.
- Check all the engine operation system.
- If no faults can be found try getting the help of an experienced person, such as your Instructor or a technician.

LAP Test	Completing Engine inspection and Service Process

Name: _____ Date: _____

Time started: _____ Time finished: _____

Task 1: Complete engine inspection and service working process

References

1) Perkins-Operation and Maintenance Manual –1206E-E66TA Industrial Engine
2) 701-01 Safety Precautions MAN B&W
3) Vehicle Servicing-Module Title: Applying Automotive Mechanical System Fundamentals (prepared by Ethiopian TVET agency, TVET instructors)
1) Job Family: Installation, Maintenance, and Repair (/category/career-groups/installation-maintenance-and-repair)

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