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HEAVY MACHINE OPERATOR

LEARNER GUIDE

National Vocational Certificate Level 2

Version 1 - November, 2019

NAVTTC

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Contents

Introduction

Welcome to Learner's Guide for the *Heavy Machine Operator* Programme. It will help Learners to complete the Programme and to go on to complete further study or go straight into employment.

The *Heavy Machine Operator* Programme is planned to engage young people with a Programme of development that will provide them with the knowledge, skills and understanding of Heavy Machinery to start their career in Pakistan. The Programme has been developed to address specific issues, such as the national, regional and local cultures, the manpower availability within the country, and meeting the needs and expectations of their company.

The main elements of learner's guide are:

- **Introduction:**
  - This includes a brief description of guide and guidelines for Learners to use it effectively
- **Modules:**
  - The modules form the sections in the learner's guide
- **Learning Units:**
  - Learning Units are the main sections within each module
- **Learning outcomes**:
  - Learning outcomes of each learning units are taken from the curriculum document
- **Learning Elements:**
  - This is the main content of learner's guide with detail of knowledge and skills (practical activities, projects, assignments and practices etc.). Learners will be required to achieve learning outcomes stated in the curriculum
  - This section will include examples, photographs and illustrations relating to each learning outcome
- **Summary of Modules**:
  - This contains the summary of the modules that make up Your learner's guide
- **Frequently Asked Questions**:
  - These have been added to provide further explanation and clarity on some of the difficult aspects of the course. This will help the learners in Preparation for their assessment.
- **Multiple Choice Questions for Self-test**:
  - These are provided as an exercise at the end of learner's guide to help Learners in preparation of their assessment

Overview of the Curriculum for Heavy Machine Operator:

Module Title and Aim	Learning Units	Theory Days/hours	Workplace Days/hours	Timeframe of Modules
Module A: **Comply Personal Health and Safety Guidelines** **Aim:** This Competency Standard identifies the competencies required to protect/apply occupational Safety, Health and Environment at workplace according to the industry's approved guidelines, procedures and interprets environmental rules/regulations. Trainee will be expected to identify and use Personal Protective Equipment (PPE) according to the work place requirements. The underpinning knowledge regarding Observe Occupational Safety and Health (OSH) will be sufficient to provide the basis for the job at workplace.	**LU1:** Identify Personal Hazards at work place **LU2:** Apply personal protective and safety equipment (PPE) **LU3:** Comply with occupational safety and health (OSH) **LU4:** Dispose of hazardous waste/materials from the designated area	**06**	**24**	**30**
Module B: **Communicate the Workplace Policy and Procedure** **Aim:** This unit describes the performance outcomes, skills and knowledge required to develop communication skills in the workplace. It covers gathering, conveying and receiving information, along with completing assigned written information under direct supervision.	**LU1.** Identify workplace communication procedures **LU2.** Communicate at workplace **LU3.** Draft Written Information **LU4.** Review Documents	**04**	**16**	**20**
Module C: **Perform Basic Communication (Specific)** **Aim:** This unit describes the skills and knowledge required to assist in the development of communication competence by providing information	**LU1.** Communicate in a team to achieve intended outcomes **LU2.** Follow Supervisor's instructions as per organizational SOPs	**06**	**24**	**30**

regarding different forms of communication and their appropriate use.	**LU3.** Develop Generic communication skills at workplace			
Module D: **Perform Basic Computer Application (Specific)** **Aim:** This unit describes the skills and knowledge required to use spreadsheet to prepare a page of document, develops familiarity with Word, Excel, email, and computer graphics basics.	**LU1.** Create Word Documents **LU2.** Create Excel Documents **LU3.** Use internet for Browsing	**08**	**32**	**40**
Module E: **Maintain Machine (with Engine Off)** **Aim:** This module covers the skills and knowledge required to Inspect and service lubrication system, Inspect and service electrical system, Inspect and service hydraulic system, Inspect and service cooling system, Inspect and service air intake system, Inspect and service fuel system, Inspect and service suspension system, Inspect and service drive train, Inspect and service braking system, Inspect and service load bearing structure, Inspect and service operator station/cab, Inspect safety equipment, Inspect and service attachments and Inspect and service supporting pneumatic (air-filled) system	**LU-1:** Inspect and Service of lubrication system **LU-2:** Inspect and Service electrical system **LU-3:** Inspect and Service hydraulic system **LU-4:** Inspect and Service cooling system **LU-5:** Inspect and Service of air intake system **LU-6:** Inspect and Service of fuel system **LU-7:** Inspect and Service of suspension system **LU-8:** Inspect and Service of drive train **LU-9:** Inspect and Service of braking system **LU-10:** Inspect and Service of load bearing structure **LU-11:** Inspect and Service of operator station/Cab **LU-12:** Inspect Equipment safety **LU-13:** Inspect and Service of attachments **LU-14:** Inspect and Service of supporting pneumatic (Air-filled) system	**40**	**160**	**200**
Module F: **Maintain Machine (with Engine Running)** **Aim:** This module covers the skills and knowledge required to Start engine monitor warning systems, Warm up engine, Cycle equipment functions, comply with scheduled maintenance requirements and Maintain Logbook	**LU-1:** Monitor warning systems **LU-2:** Warm up engine **LU-3:** Cycle equipment functions **LU-4:** Scheduled Maintenance Requirements **LU-5:** Logbook	**08**	**32**	**40**

Module G: **Park Machines** **Aim:** This module covers the skills and knowledge required to Clean under carriage and attachments before parking, Park equipment in appropriate location, Shut down and secure equipment, Perform housekeeping tasks and Perform visual inspection.	**LU-1:** Clean under carriage and attachments before parking **LU-2:** Park equipment in appropriate location **LU-3:** Shut down and secure equipment **LU-4:** Housekeeping tasks **LU-5:** Visual inspection	**10**	**40**	**50**
	TOTAL	**82**	**328**	**410**

HEAVY MACHINE OPERATOR

Module-E

LEARNER GUIDE

National Vocational Certificate Level 2

Version 1 - November, 2019

Modules

Module E: Maintain Machine (with Engine Off)

Objective: This module covers the skills and knowledge required to Inspect and service lubrication system, Inspect and service electrical system, Inspect and service hydraulic system, Inspect and service cooling system, Inspect and service air intake system, Inspect and service fuel system, Inspect and service suspension system, Inspect and service drive train, Inspect and service braking system, Inspect and service load bearing structure, Inspect and service operator station/Cab, Inspect safety equipment, Inspect and service Attachments and Inspect and service supporting pneumatic (Air-filled) system

Duration: 200 Hours **Theory: 40 Hours** **Practice: 160 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU-1: Inspect and service lubrication system	**The students will be able to** • Locate components to be inspected • Identify low oil levels, dirty filler cap • Select appropriate tools • Adjust oil levels • Identify and report leakages	• Describe lubrication systems, their components and importance • Describe state of the lubrication components • Describe levels of lubricants to be maintained	• Engine oil • Hydraulic oil • Transmission oil • Differential oil • Brake oil • Oil filter

Lubrication system

Lubricating systems are used to introduce oil, grease and other lubricants to moving machine parts. The lubricants reduce friction between parts, and therefore increase the longevity of all components. Without lubrication, most machines would overheat or suffer extreme damage. Anyone who has ever neglected to keep his machine properly oiled knows firsthand just how extensive this damage can be.

Proper lubrication may be the single most important aspect of machine's life. A well-oiled automobile will outlast poorly maintained models by many years. Industrial machinery is no different, and a good lubrication system can help in saving a lot of money and hassle.

In lubricants, the most important factor is the fluid's viscosity. Viscosity is the ability of the substance to resist flow under an applied force. The viscosity of lubricants changes and degrades with temperature, which means that they may become permanently less effective after being subjected to extreme conditions. The thickness of the liquid film is also a factor, as it can lead to surface fatigue.

When dealing with any lubricating system, make sure to service all filters and to keep dust and debris out of the lubricant. Also make sure to

regularly change lubricants according to manufacturer recommendations, and to check systems daily. Any changes in performance should alert users to potential problems.

Low Oil Pressure

Low oil pressure is indicated when the oil indicator light glows, oil gauge reads low, or when the engine lifters or bearings rattle. The most common causes of low oil pressure are as follows:

1. Low oil level (oil not high enough in pan to cover oil pickup)
2. Worn connecting rod or main bearings (pump cannot provide enough oil volume)
3. Thin or diluted oil (low viscosity or fuel in the oil)
4. Weak or broken pressure relief valve spring (valve opening too easily)
5. Cracked or loose pump pickup tube (air being pulled into the oil pump)
6. Worn oil pump (excess clearance between rotor or gears and housing)
7. Clogged oil pickup screen (reduce amount of oil entering pump)

A low oil level is a common cause of low oil pressure. Always check the oil level first when troubleshooting a low oil pressure problem.

High Oil Pressure

High Oil Pressure

High oil pressure is seldom a problem. When it occurs, the oil pressure gauge will read high. The most frequent causes of high oil pressure are as follows:

1. Pressure relief valve struck open (not opening at specified pressure)
2. High relief valve spring tension (strong spring or spring has been improperly shimmed)
3. High oil viscosity (excessively thick oil or use of oil additive that increases viscosity)
4. Restricted oil gallery (defective block casting or debris in oil passage)

Indicator or Gauge Problems

A bad oil pressure indicator or gauge may scare the operator into believing there are major problems. The indicator light may stay on or flicker, pointing to a low oil pressure problem. The gauge may read low or high, also indicating a lubrication system problem.

Inspect the indicator or gauge circuit for problems. The wire going to the sending unit may have fallen off. The sending unit wire may also be shorted to ground (light stays on or gauge always reads high). To check the action of the indicator or gauge, remove the wire from the sending unit. Touch it on a metal part of the engine. This should make the indicator light glow or the oil pressure gauge read maximum. If it does, the sending unit may be defective. If it does not, then the circuit, indicator, or gauge may be faulty.

NOTE: Always check the service manual before testing an indicator or gauge circuit. Some manufacturers recommend a special gauge tester. This is especially important with some computer-controlled systems.

Choosing the right lubrication for your machine

When you buy lubrication for the engine parts of machinery, it's crucial for the product to have the proper viscosity. For the lubrication to last throughout the service life of an engine, the lube must maintain its viscosity through hot and cold weather, without melting in the heat or freezing in sub-zero temperatures.

In an improperly lubricated engine, friction could generate between moving metal parts. As the friction develops, the surfaces are liable to wear down and corrode. Over time, the rust could spread across one or both parts and lead to the formation of holes or cracks. Meanwhile, the corresponding engine parts will function increasingly less effectively. To ensure you're properly lubricating your engine parts, read the label on each product you inspect to see whether it is right for the parts in question.

Oil viscosity and standard ratings

Viscosity, or thickness, is one of the most important factors to consider when choosing oil. Proper oil viscosity is vital to the performance of the engine. If you live in a hot climate, like Sindh or Baluchistan, you'll need a viscosity that won't run thin during humid months. If you live in a cold area, like Gilgit Baltistan and Kashmir, you'll need an oil that won't get sludgy in the winter. Some engines require an oil with a mineral base. However, many engines built in recent years need an oil that is either semi-synthetic or fully synthetic.

The impact of dirty oil on your engine

With a diesel engine, one of the most expensive mistakes is to neglect to change the oil. Dirty oil can severely damage your engine, resulting in costly repairs. Oil filters provide long-lasting performance that helps prevent these problems. Fewer oil changes can seem like a money-saving measure. However, the cost of a new camshaft or piston is much higher than the cost of an oil change.

Choosing the right filter for your machine

For the performance and service life of motorized equipment, engine filters must be clean and intact at all times. A piece of motorized machinery will generally consist of the following engine filters:

- Oil filters — the engine component that keeps oil clean and pure
- Transmission filters — a part of the transmission that captures excess fluid
- Hydraulic filters — an engine part that balances temperatures and keeps the system sealed
- Air filters — a component that protects the engine from outside dust and dirt
- Coolant filters — a filter that distributes coolant and weeds out contaminants

For any given piece of motorized equipment, it's essential to have the proper filter for the corresponding make and model of the machine in question. If a filter is ill-suited for the parts in question, it may allow improper distribution of fluids and an unrestrained flow of contaminants through the system. To ensure you get the right type of filter every time, check the owner's manual for the machine or run an online search to see which size and make of filters are suited for the parts in question.

In each part of an engine that distributes fluids or allows air to pass through, fuel filters and engine filters block the passage of harmful particles that could otherwise contaminate oil and wear down the components of an engine.

The role of oil filters

Oil filters are vital for the longevity and efficient operation of heavy equipment. They help remove contaminants from all types of oil that, over time, can damage internal components.

If you perform your own oil changes, be sure to use the type of oil recommended by the manufacturer. There are three categories of oil:

- Conventional — composed of 75-80 percent crude oil
- Synthetic — a base with synthetic ingredients
- Blend — a mix of conventional and synthetic

Next to the various oil brands on most shelves are the additives. Antioxidants, a common additive, combat oxidation and the thickening of oil. Other additives include detergents, which prevent the build-up of dirt on hot surfaces. Additives even help eliminate contamination on engine parts. For machines that have already been used for hundreds of hours, conditioning additives help stop seal leaks.

Lubricating system maintenance

There are certain lubricating system service jobs that are more or less done automatically when an engine is repaired. For example, the oil pan is removed and cleaned during such engine overhaul jobs as replacing bearing or rings. When the crankshaft is removed, it is usual procedure to clean out the oil passages in the crankshaft. Also, the oil passages in the cylinder block should be cleaned out as part of the overhaul.
As a Construction Mechanic, Learner will be required to maintain the lubrication system. This maintenance normally consists of changing the oil and filter(s). Occasionally Learner will be required to perform such maintenance tasks as replacing lines and fittings, servicing or replacing the oil pump and relief valve, and flushing the system. The following discussion provides information that will aid Learner in carrying out these duties.

Oil and Filter Change

It is extremely important that the oil and filter(s) of the engine are serviced regularly. Lack of oil and filter maintenance will greatly shorten engine service life.
Manufacturers give a maximum number of miles or hours a machine can be operated between oil changes. Newer automotive machines can be operated 5,000 miles between changes. Older automotive machines should have their oil changed about every 3,000 miles. Most construction equipment average between 200 and 250 hours of operation between oil changes. However, depending on the climate and working conditions the miles and hours between oil changes can be greatly reduced. Refer to the service manual for exact intervals.

To change the engine oil, warm up the engine to full operating temperature. This will help suspend debris in the oil and make the oil drain more thoroughly. Unscrew the drain plug and allow the oil to flow into a catchment pan. Be careful of hot oil; it can cause painful burns.
Usually the filter elements are replaced at the same time the oil is changed. The most common filters are the spin-on filter or replaceable element type oil filter.

Spin-on, throwaway oil filter - replaced as a complete unit. Unscrew the filter from the base by hand or a filter wrench and throw the filter away. When replacing, wipe the base clean with a cloth and place a small amount of oil or grease on the gasket to ensure a good seal. Screw on a new filter, tightening at least a half a turn after the gasket contacts the base. Do not use a filter wrench because the filter canister could distort and leak.

Replaceable element oil filter - removed from the filter housing and replaced. Place a pan underneath the filter to catch oil from the filter. Remove the fastening bolt and lift off the cover or filter housing. Remove the gasket from the cover or housing and throw it away. Take out the old element and throw it away. Clean the inside of the filter housing and cover it. Install a new element and insert a new cover or housing gasket (ensure the gasket is completely seated in the recess). Replace the cover or housing and fasten it to the center bolt securely.

After the oil has been completely drained and the drain plug replaced, fill the Crankcase to the full mark on the dipstick with the proper grade and weight of oil. Start and idle the engine. Check the oil pressure immediately. Inspect the filter or filter housing for leaks. Stop the engine and check the Crankcase oil level and add to the full mark.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU-2: Inspect and service electrical system	**The students will be able to** • Locate components to be inspected • Identify service needs, defects and hazardous conditions through visual/physical inspection • Select appropriate tools for rectification of minor defects • Check water level of batteries • Replace batteries.	• Describe electrical systems, their components and importance • Describe state of the electrical components and batteries	• Fuses of all types • Electrical leads • Insulation tape • Wire clips • Batteries

Electrical Systems:

The fuses and basic electrical system of the machines are found inside the driver/operator cabin and in dashboard or under it. The electrical system consists of very sensitive wiring, fuses and cables which can only be checked by a qualified engineer. The operator can visually observe the electrical system and if notice any burning smell or see any burned fuse or open wiring. If any such case is found the machine should be stopped immediately and shut down.

The open wires, circuits which can be damaged due to weather are mainly found outside the operator cabin and are for use of extra indicators, horns, warning lights, fog lights, any other extra electrical devices installed for doing a specific job. Such wires, circuits, electrical boxes should be cleaned after every rain or snowfall. The wires exposed to sun must be checked so they will not melt due to heat of sun.

The components of the electrical system which needs daily inspection are:

- Lights
- Electrical lines
- Battery terminals
- Fuses
- Spark plugs

Great deal can go wrong if an electrical distribution system is not adequately maintained. As electrical loads cycle between high and low demand, thermal expansion and contraction cause connections to loosen. Electrical panels that are never cleaned accumulate dust and dirt that deposit on these connections. The loose and dirty connections provide a high resistance path that are directly responsible for more than 30 percent of electrical failures. Another 17 percent of electrical failures are attributed to live electrical components being exposed to moisture.

With a comprehensive electrical preventive maintenance program, both of these conditions — which account for almost half of all electrical losses — can be corrected. (See Table 1 below).

TABLE 1: Top Causes of Electrical Distribution System Problems

Loose Connections/parts	30.3%
Moisture	17.4%
Line Disturbance (other than lightning)	10.4%
Defective/inadequate insulation	9.9%
Lightning	8.1%
Foreign objects/short circuiting	7.3%
Collision	3.9%
Overloading/inadequate capacity	2.4%
Accumulation of dust, dirt and oil	2.2%
All other causes	8.1%

Major Causes of electrical system Failures Based on Data

According to the Institute of Electrical and Electronics Engineers (IEEE), the failure rate of electrical components is three times higher for systems where preventive maintenance is not performed.
https://caterpillar.scene7.com/is/content/Caterpillar/C10505678

Regular Inspection and Maintenance of Batteries:

https://www.centurybatteries.com.au/technical-support/battery-care-maintenance

Regular testing and inspection will help to maximize battery life. A routine inspection at least once a month is recommended to maintain optimum performance.

How to examining your battery:

Check the battery's state of charge. Most batteries have a State of Charge Indicator on top of the battery that will give you an on the spot diagnosis of the battery condition. However, a more reliable way to check is with a voltmeter to determine the stabilized voltage or if the vent caps are removable a hydrometer to determine the specific gravity (SG) of the electrolyte.

- Ensure the battery top is clean, dry, free of dirt and grime. A dirty battery can discharge across the grime on top of the battery casing.
- Inspect the terminals, screws, clamps and cables for breakage, damage or loose connections. These should be clean, tight and free of corrosion.

- Apply a thin coating of high temperature grease to posts and cable connections for added protection.
- Inspect the battery case for obvious signs of physical damage or warpage. This usually indicates the battery has been overheated or has been overcharged.
- If you have a maintainable battery, it is important to check if the battery has sufficient electrolyte covering the battery plates. If topping up is required, do not over fill as the fluid levels will rise when the battery is fully charged and may overflow. Top up using distilled or demineralized water and never fill with Sulphuric acid.
- When servicing a sealed maintenance free (SMF) battery, check the State of Charge Indicator. This gives you a snap shot of the battery's condition and whether the battery needs to be charged or replaced. The vehicle may still start the engine although the indicator outlines to replace the battery. If the State of Charge Indicator advises 'Replace Battery' it is important that the battery is replaced as the electrolyte levels may be below the plates which can lead to an internal explosion.
- For batteries used in seasonal applications and stored long term, fully recharge the battery prior to storing. Check the state of charge or voltage regularly. Should the voltage drop below 12.5V, recharge the battery. It is important to check the battery completely before reconnecting to electrical devices.

If you are unsure about the condition or state of charge of the battery, take it to your local Century battery reseller. They can inspect and test your battery and provide you with professional advice and assistance.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU-3: Inspect and service hydraulic system	**The students will be able to** • Locate components to be inspected • Identify service needs, defects and hazardous conditions through visual/physical inspection • Identify and report leakages and noise of the hydraulic system • Check hydraulic oil levels • Replace hoses/pipes	• Describe hydraulic systems, their components and importance • Describe state of the hydraulic components • Describe levels of lubricants to be maintained • Describe leakage and overheating of components	• Hydraulic oil • Hydraulic filter • Hydraulic hoses

HYDRAULIC SYSTEM:
Hydraulic system is an important part of the Heavy Machines used in construction sector. When a piece of construction equipment is leaking hydraulic fluid internally or externally, it can cause a pressure loss that negatively affects the equipment's productivity and safety. If a hydraulic system completely fails on a Dozer, Grader, Loader, Excavator etc., the equipment simply won't work and must be taken off the job until the system is repaired or replaced. This results in the cost of equipment downtime.

Leaking hydraulic fluid also can substantially raise maintenance costs because leaking causes permanent damage to the systems.

What need to be done

This is important to check hydraulic systems every time equipment is serviced, no less than once a month.
This includes the inspection of the oil level, the filter, the clarity of the oil (it should be translucent), and whether the oil is gritty to the touch. These all provide signs of needed maintenance.
But hydraulic problems can happen anytime, so it's important that equipment operators be alert for signs of hydraulic problems. Although operators are often discouraged from removing the breathing cap and dipstick from their equipment, they can spot signs of external and internal leaking. By immediately reporting these problems to maintenance, they can prevent permanent damage to the hydraulic system. They can also protect themselves, because hydraulic system failures often lead to on-the-job injuries.

Tips for Operators:

- Before using equipment, conduct a pre-use inspection that includes checking for hydraulic fluid gathered on the ground, fluid around fittings, and fluid on the hydraulic cylinder. (The Checker inspection checklists include hydraulic systems.)
- During operation, keep an eye out for fluid leaks that develop.

- If hydraulically supported equipment begins "drifting" during operation (e.g., if an operator must continually fight to keep the load raised on an excavator), recognize that this is likely a hydraulic fluid issue. Even if no external leaks are apparent, drifting is a sign of internal leaking. This leaking not only impairs productivity because the equipment isn't operating as efficiently as it should; it's a safety red flag because it could lead to a complete pressure loss, resulting in loads being dropped and similar accidents.

There are four major purposes of a hydraulic filter:

- Clean the fluids that provide the force between the power unit and actuator
- Keep the system sealed
- Provide lubrication and prevent surface friction
- Keep the temperature balanced and even out the transfer of heat

If one of these functions doesn't work properly, the entire hydraulic system could become imbalanced and stop working. Clean hydraulic filters can prevent these problems by keeping the system clean, sealed, lubed and cool. When hydraulic equipment gets damaged, the repair costs are generally high. Therefore, it's crucial the filter system in a piece of hydraulic equipment is clean and free of impurities. When the equipment is clean, production costs are lower and productivity increases. Additionally, clean hydraulic filtration improves workplace safety. Investing in a new filter can prevent expenses down the line by providing long-lasting, optimum performance.

Inspections

Recommended Service Intervals

1) **10-hour or daily inspection**
   • Check hydraulic fluid level
   • Check hydraulic cylinders and pumps for leaks
   • Check hoses, lines and hydraulic tank area for leaks or damage.

2) **250-hour or monthly inspection**
   • Perform 10-hour preventive maintenance checks
   • Check hydraulic oil cooler for leaks or plugging
   • Check all hydraulic lines for damaged, missing or loose connections

3) **500-hour or quarterly inspection**
   • Perform 10- and 250-hour preventive maintenance checks
   • Perform S•O•S sampling of hydraulic oil
   • Change hydraulic filter
   • Check hydraulic pumps and mountings for loose or missing hardware.

4) **1,000-hour or six-month inspection**
   • Perform 10-, 250- and 500-hour preventive maintenance checks
   • Check pump weep holes for leaks.

5) **2,000-hour or annual inspection**
   • Perform 10-, 250-, 500- and 1,000-hour preventive maintenance checks
   • Check hydraulic system pressure
   • Check hydraulic system cycle times and drift rates

The final element in hydraulic system management involves inspecting and “listening to” the equipment. Operator can help maintain system performance and catch problems early by:

- Following the inspection and maintenance schedule.
- Paying attention to the repair indicators.
- Perform machine Inspection Once a year or every 2,000 hours,

During these inspections:

- Conduct a detailed visual walkaround inspection of the hydraulics, engine compartment, cab, power train and ground engaging tools
- Drift test all hydraulic cylinders
- Perform complete checks of cycle times and system pressures
- Stall test the hydraulic system
- Take a sample of the hydraulic oil and perform S•O•S Services.

http://www.foleyinc.com/content/uploads/2014/06/Cat-Hydraulic-System-Management-Guide.pdf

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU4. Inspect and service cooling system	**The students will be able to** • Adopt appropriate safety measures. • Ensure unobstructed airflow through radiator • Locate components to be inspected • Adjust coolant level • Replace belts and hoses	• Describe cooling systems, their components and importance • Describe state of the cooling components • Describe levels of coolant to be maintained • Describe defects in cooling systems	• Coolant • Fan belt

COOLING SYSTEM:
The cooling system serves three important functions.

1. It removes excess heat from the engine;
2. It maintains the engine operating temperature where it works most efficiently; and finally,
3. It brings the engine up to the right operating temperature as quickly as possible.

The cooling system is composed of six main parts—an engine, a radiator, a water pump, a cooling fan, hoses, and a thermostat. During the combustion process, some of the fuel energy is converted into heat. This heat is transferred to the coolant being circulated through the engine by the water pump. Hoses machinery the hot coolant to the radiator, where the heat is transferred to air that is pulled past the engine by the cooling fan. The coolant is then carried back to the water pump and recirculated.

Inspection Tips
Always test coolant strength while the engine is cool, and never open a radiator cap while the engine is hot. Of course, the best way to inspect the function of the engine cooling system is to bring it up to actual running temperature.

To do a thorough inspection, the specifications, tolerances and requirements of the particular machine re-inspecting are necessary for reference, so make sure you have the proper repair information at hand. Aftermarket repair manuals, specification guides, CD-ROM systems or factory manuals should contain the needed information to compare with the findings of Learner inspection.

Here are a few of the items to be checked while doing an inspection:

1. **Coolant.** Make sure the system is filled to the proper level and that the correct coolant is used. Also inspect the coolant for oil, rust, corrosion or other contaminants. Check coolant strength using a quality hydrometer or refractometer.
2. **Mechanical Fan Clutch.** Rotate the fan by hand, if possible, to check for excessive noise, stiffness or looseness. Inspect the blades for signs of damage that could lead to imbalance and eventual failure.
3. **Fan Belt.** Inspect this all-important component for signs of wear, cracking or glazing, and for proper tension. Make sure all pulleys are aligned.

4. **Electric Cooling Fan.** Operate the electric fan and look for quiet, smooth operation. Inspect the electrical harness and connections for damage or corrosion, and make sure all wires are properly routed. Inspect the fan blades for signs of damage.
5. **Fan Shroud.** Make sure the fan shroud is properly mounted and doesn't block the flow of air or interfere with fan operation. Occasionally, during a front-end collision repair, the shroud is reinstalled improperly.
6. **Hoses.** Make sure the hoses are in good condition, with no hardness, cracking or deterioration. Inspect all clamps and connections for proper fit and tightness. Hoses can rot internally from electrolytic corrosion. They typically should be replaced about every 36,000 to 50,000 miles, but check the machine maker's recommendation.
7. **Radiator.** Inspect the exterior for leaks and signs of corrosion, clogged fins and plugged or damaged overflow tubes. Pay close attention to any clues indicating a previous repair. Look inside the radiator fill neck for signs of oily deposits, which could indicate a blown head gasket.
8. **Radiator Cap.** Visually inspect the cap gasket, spring and venting system to make sure the cap is free of contaminants and corrosion. This may seem obvious, but also make sure the cap is the correct one for the machine. The pressure relief rating must be up to spec for optimum operation of the cooling system. A pressure tester and adapter can be used to test the operation and pressure rating of the cap. If the cap does not function within 2 psi of the required rating, replace it.
9. **Water Pump.** Make sure the water pump pulley is properly aligned with other drive pulleys. A wobbly pulley may indicate shaft seal damage or a bent shaft. Check the hose fittings for proper fit and sealing. Listen for noises, which would indicate internal problems with the impeller or bearing. Check the pump body for excessive vibration, which also could indicate internal problems.

Overheating

Overheating is still the most common problem encountered with cooling systems. Some factors that cause it are:

- Corrosion, scale or rust that clogs the system.
- Fan belt slippage.
- Fan drive clutch failure.
- An inoperative or malfunctioning thermostat.
- Inadequate airflow through the radiator.
- Water pump damage.
- Pressure loss from leaks, including the radiator cap.
- Use of an improper coolant or mixture.
- Excessive exertion caused by towing or hauling heavier loads than the cooling system was designed to handle.
- Stress imposed by the air conditioning or an overheating automatic transmission.

Inspecting for Leaks

Finding an elusive cooling system leak may go beyond inspection and require testing. Be sure to let the company know that testing is not part of the inspection and may be needed to expose or determine the extent of a possible leak.

The best way to find a cooling system leak is by pressure testing or dye testing. **Pressure testing** involves the use of a pressure pump, which forces a leak to increase in volume. **Dye testing** introduces a fluorescent dye into the coolant, which exposes leaks when viewed under ultraviolet light.

The importance of coolant filters

The purpose of a coolant filter is to distribute coolant additives into the engine. At the same time, the coolant filter safeguards the engine from contaminants. If a coolant filter becomes clogged with dirt and impurities, it can fail to cool the engine parts, leading to overheating during peak machine operation. A poorly maintained coolant system can even cause major engine failure.

Using a Checklist

Using the checklist that follows this article to do a thorough inspection will help discover any problems with a machine's cooling system. It also will give Learner an accurate record of the condition of the system. It's based on a set of Uniform Inspection Guidelines for cooling system.

Inspect the entire cooling system and write down everything on the checklist. Include right on the form the reason for *suggested* or *required* repair or replacement. For example, if the coolant is found to be near but slightly less than the OEM replacement interval, the decision to replace should be *suggested* to the company, because the coolant "is close to the end of its useful life." However, if the coolant is at or beyond the OEM replacement interval, replacement is *required* because the coolant "does not meet the machine manufacturer's design specs."

The written inspection checklist provides a method of communication and mutual understanding, as well as a detailed reference for future repairs or service.

Cooling system checklist

Complete the inspection checklist to ensure:

- you identify all cooling system faults
- you make accurate recommendations and quotes.

Cooling System Checklist

Customer: _____ Phone: _____ Date: _____

Vehicle/Make Year Registration Km's

Components	Inspection results						Recommendation
Hoses: Upper radiator Lower radiator By pass Heater	OK	Hard/ brittle	Split/ cracked	Soft/spongy	Oil soaked	Replace	
Fanbelts: Alt/Gen Power steering A-C compressor	OK	Frayed	Split/ cracked	Glazed	Loose	Replace	
Water pump	OK	Worn shaft bearing	Bleed hole leaks	Gasket leaks	Fan clutch loose	Replace/ power flush	
Coolant Recovery tank	OK	Dirty	Empty	Refill	Damaged		
Radiator cap Pressure check:	OK	Swollen gasket	Broken gasket	Corroded cap	Weak spring	Replace	
Radiator Pressure check:	OK	Fins blocked	Rusty/oily	leaks	Blocked cores	Need flush	
Coolant:	OK	Dirty	Rusty	Oily	Foamy	Needs flush	
Thermostat:	OK	Dirty	Rusty	Oily	Foamy	Needs flush	
Electric cooling fan:	OK	Damaged fan	Noisy fan motor	Fan not operating	Faulty temp. sender		
Welsh plugs:	OK	Leaking coolant					
Heater core tap:	OK	Leaking coolant	Heater is hot enough	Heater controls work	Heater tap operates		

Figure 2: Cooling System Check List

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU5. Inspect and service air intake system	**The students will be able to** • Locate components to be inspected • Check air service indicators • Select appropriate tools • Clean primary air filter. • Replace intake hoses and clamps	• Describe air intake systems, their components and importance • Describe state of air intake systems • Describe defects in air intake systems	• Air element • Intake hoses • Clamps

AIR INTAKE SYSTEM:

Every internal combustion engine, from tiny scooter engines to colossal ship engines, requires two basic things to function – oxygen and fuel. The air intake system is critical to the function of the engine; collecting air and directing it to individual cylinders, The cold-air intake tube is usually located, where it can pull air from outside the engine bay, such as a fender, the grille, or hood scoop. The cold-air intake tube marks the beginning of air's passage through the air intake system, the only opening through which air can enter. Air from outside the engine bay is typically lower in temperature and denser, therefore richer in oxygen, which is better for combustion, power output, and engine efficiency.

Mass Air Flow Meter:

To properly gauge, how much fuel to inject at any given moment, the engine control module (ECM) needs to know how much air is coming into the air intake system. Most machines use a mass air flow meter (MAF) for this purpose, while others use a manifold absolute pressure (MAP) sensor, usually located on the intake manifold. Some engines, such as turbocharged engines, may use both.

On MAF-equipped machines, air passes through a screen and vanes to "straighten" it. A small part of this air passes through the sensor portion of the MAF which contains a hot wire or hot film measuring device. Electricity heats up the wire or film, leading to a decrease in current; while air flow cools the wire or film leading an increase in current. The ECM correlates the resulting current flow with air mass, a critical calculation in fuel injection systems. Most air intake systems include an intake air temperature (IAT) sensor somewhere near the MAF, sometimes part of the same unit.

Air Intake Tube:

After being measured, the air continues through the air intake tube to the throttle body. Along the way, there may be resonator chambers, "empty" bottles designed to absorb and cancel out vibrations in the air stream, smoothing airflow on its way to the throttle body. It also does one good to note that, especially after the MAF, there can be no leaks in the air intake system. Allowing unmetered air into the system would skew air-fuel ratios. At a minimum, this might cause the ECM to detect a malfunction, setting diagnostic trouble codes (DTC) and the Check Engine Light (CEL). At worst, the engine may not start or may run poorly.

Throttle Body:

The throttle body is connected, either electronically or via cable, to the accelerator pedal and cruise control system, if equipped. When depress the accelerator, the throttle plate, or "butterfly" valve, opens to allow more air to flow into the engine, resulting in an increase in engine power and speed. With cruise control engaged, a separate cable or electrical signal is used to operate the throttle body, maintaining the driver's desired machine speed.

Idle Air Control:

At idle, such as sitting at a stop light or when coasting, a small amount of air still needs to go to the engine to keep it running. Some newer machines, with Electronic Throttle Control (ETC), engine idle speed is controlled by minute adjustments to the throttle valve. On most other machines, a separate Idle Air Control (IAC) valve controls a small amount of air to maintain engine idle speed. The IAC may be part of the throttle body or connected to the intake via a smaller intake hose, off the main intake hose.

Intake Manifold

After intake air passes through the throttle body, it passes into the intake manifold, a series of tubes that delivers air to the intake valves at each cylinder. Simple intake manifolds move intake air along the shortest route, while more complex versions may direct air along a more circuitous route or even multiple routes, depending on engine speed and load. Controlling air flow this way can make for more power or efficiency, depending on demand.

Intake Valves

Finally, just before getting to the cylinder, intake air is controlled by the intake valves. On the intake stroke, usually 10 ° to 20 ° BTDC (before top dead center), the intake valve opens to allow the cylinder to pull in air as the piston goes down. A few degrees ABDC (After Bottom Dead Center), the intake valve closes, allowing the piston to compress the air as it comes back to TDC.

As Learner can see, the air intake system is slightly more complicated than a simple tube going to the throttle body. From outside the machine to the intake valves, intake air takes a meandering route, designed to deliver clean and measured air to the cylinders. Knowing the function of each part of the air intake system can make diagnosis and repair easier, as well.

Engine Air Filter:

The air then passes through the engine air filter, usually located in an “air box.” Pure “air” is a mixture of gases – 78% nitrogen, 21% oxygen, and trace amounts of other gases. Depending on location and season, air can also contain numerous contaminants, such as soot, pollen, dust, dirt, leaves, and insects. Some of these contaminants can be abrasive, causing excessive wear in engine parts, while others can clog the system.

A screen usually keeps out most larger particles, such as insects and leaves, while the air filter catches finer particles, such as dust, dirt, and pollen. The typical air filter captures 80% to 90% of particles down to 5 µm (5 microns is about the size of a red blood cell). Premium air filters capture 90% to 95% of particles down to 1 µm (some bacteria can be about 1 micron in size).

The importance of air filters

The air filter blocks out dirt, dust and debris, which can cause damage if they reach the engine. Clean filtration boosts engine performance and lengthens engine life. With a clean air filter, equipment has better fuel economy and performance. A clean air filter also leads to lower

emissions. To ensure clean air filtration in all driving environments, Air filters come in four main varieties — high-efficiency, activated carbon, standard and lower-restriction.

When air filters get dirty

The dirtier an air filter becomes, the weaker its filtration capabilities. One of the tell-tale signs of a weakened air filter is decreased fuel economy. Bad air filtration can also foul up equipment's ignition system and lead to ignition difficulties. The majority of air filters have either a white or off-white appearance. After 250 hours of use, an air filter is due for an inspection. By this point, it might show noticeable signs of dirt, but not in all cases. In any event, you should replace air filters after 500 hours, even if they appear clean.

DOs and DONTs of Filter Cleaning:

- **DO – CLEAN FILTER REGULARLY**

A visual check of machine's air filter isn't always an accurate indicator that air filter is clean. Small particles can be trapped deep within the air filter foam. Beware that operation of machine in grueling conditions, such as sand and silt beds, may require a filter replacement following every ride. Use your best judgement. Please wear solvent gloves when cleaning air filters for protection against harsh chemicals.

- **DON'T – CLEAN AIR FILTER WITH GASOLINE**

There are mechanics who swear by using gasoline to clean air filters. While it strips foam filters of old oil residue and contaminants, gasoline also breaks down the foam cells and glue that bonds the foam strips together. Use air filter-specific applications to properly clean an air filter. Properly dispose off cleaning chemicals when done

- **DO – USE AN AIR FILTER-SPECIFIC OIL**

Not all oils are created equally. Its light viscosity causes the oil to bleed through the air filter foam and potentially reach the engine. Air filter oil – whether spray-on or out of a bottle – is designed to penetrate the foam cells and evaporate, leaving a sticky residue to trap foreign particles. Remember to liberally apply oil to the filter. The oil's purpose is to prevent dirt and debris from passing through. Failing to use enough oil is counterproductive to the filter's job.

- **DON'T – WRING OUT THE AIR FILTER**

Wringing (twisting) out the air filter is a sin of air filter maintenance. Subjecting the filter to such abuse causes the foam to tear. Squeez excess oil out with a firm grip after applying a healthy dose of air filter oil. We repeat – do not wring out the air filter.

- **DO – CLEAN THE AIRBOX**

Failing to clean the airbox when changing the air filter is the equivalent of not flossing after brushing teeth. There's no good reason why Operator should do one without the other. A dirty airbox can quickly contaminate a new air filter, thus reducing its effectiveness. Invest in a plastic air intake cover and use it when cleaning the airbox. Soapy water and a rag will do the trick.

- **DON’T – FORGET TO TAKE TIME**

There’s no substitute for time. After cleaning the air filter with kerosene or a filter-specific application, let it dry naturally. Following that step, be sure to wash the filter with soap and warm water. This process ensures that all contaminants have been removed. Once complete, let the air filter dry. It is not recommended to use of a clothing dryer, as the repeated tumbling can tear the filter foam and break down the seam glue.

- **DO – INSPECT AIR FILTER OFTEN**

An air filter is designed to stop particles from passing through the intake system, but it won’t last forever. When cleaning air filter be sure to check for tearing in the foam, notice if the foam is breaking down, and inspect the glue seams. If any of these areas are suspect we suggest replacing the air filter. Avid motorcyclists should consider having several air filters on hand in preparation for the next ride. Simply batch-clean the air filters and keep the extras in clean, air-tight storage bags.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU6. Inspect and service fuel system	**The students will be able to** • Locate components to be inspected • Identify and read fuel gauges and level indicator • Select appropriate tools • Identify service needs, defects and hazardous conditions through visual/physical inspection • Perform basic maintenance such as cleaning of fuel strainer • Report fuel leakage	• Describe fuel systems, their components and importance • Describe defects in fuel systems	• Fuel filter • Fuel

FUEL SYSTEM

The function of the fuel system is to inject a precise amount of atomized and pressurized fuel into each engine cylinder at the proper time. Combustion in an engine occurs when this rush of fuel is mixed with hot compressed air. (No electrical spark is used as in a gasoline engine.)

The fuel system consists of the following components.

FUEL TANKS

There are many different types and shapes of fuel tanks. Each size and shape is designed for a specific purpose. The fuel tank must be capable of storing enough fuel to operate the engine for a reasonable length of time. The tank must be closed to prevent contamination by foreign objects. It must also be vented to allow air to enter, replacing any fuel demanded by the engine. Three other tank openings are required--one to fill, one to discharge, and one to drain.

FUEL LINES

There are three types of fuel lines. These include heavyweight lines for the high pressures found between the injection pump and the injectors, medium weight lines for the light or medium fuel pressures found between the fuel tank and injection pump, and lightweight lines where there is little or no pressure.

FUEL FILTERS

Fuel must be filtered not once, but several times in most systems. A typical system might have three stages of progressive filters--a filter screen at the tank or transfer pump, a primary fuel filter, and a secondary fuel filter. In series filters, all the fuel goes through one filter and then through the other. In parallel filters, part of the fuel goes through each filter.

FUEL TRANSFER PUMPS

Simple fuel systems use gravity or air pressure to get fuel from the tank to the injection pump. On modern high speed engines, a fuel transfer pump is normally used. This pump, driven by the engine, supplies fuel automatically to the diesel injection system. The pump often has a hand primer lever for bleeding air from the system. Modern injection pumps are almost all jerk pumps which use the plunger and cam method of fuel injection.

FUEL INJECTION SYSTEMS

There are four primary systems for injecting fuel:

1. Individual pump and injector for each cylinder
2. Combined pump and injector for each cylinder (unit injector type)
3. One pump serving injectors for several cylinders (distributor type)
4. Pumps in a common housing with injectors for each cylinder (common rail system)

FUEL INJECTORS

Fuel injectors are arguably the most important fuel system component. The job of the injectors is to deliver a precise amount of atomized and pressurized fuel into each cylinder. Highly atomized, pressurized fuel distributed evenly throughout the cylinder results in increased power and fuel economy, decreased engine noise, and smoother operation.

Fuel system inspection and maintenance in engine fuel and fuel metering systems:

Inspect the entire system for wear, damage, or leaks. Make sure that all units are securely attached and properly safe tied. The drain plugs or valves in the fuel system should be opened to check for the presence of sediment or water. The filter and sump should also be checked for sediment, water, or slime. The filters or screens, including those provided for flowmeters and auxiliary pumps, must be clean and free from corrosion. The controls should be checked for freedom of movement, security of locking, and freedom from damage due to chafing. The fuel vents should be checked for correct positioning and freedom from obstruction; otherwise, fuel flow or pressure fueling may be affected. Filler neck drains should be checked for freedom from obstruction.

If booster pumps are installed, the system should be checked for leaks by operating the pumps. During this check, the ammeter or load meter should be read and the readings of all the pumps, where applicable, should be approximately the same.

Fuel Tanks

The tanks be inspected for corrosion on the external surfaces, for security of attachment, and for correct adjustment of straps and slings. Check the fittings and connections for leaks or failures. Where applicable, the cartridge should be inspected and renewed at the specified periods.

Lines and Fittings

Be sure that the lines are properly supported and that the nuts and clamps are securely tightened. To tighten hose clamps to the proper torque, use a hose-clamp torque wrench. If this wrench is not available, tighten the clamp finger-tight plus the number of turns specified for the hose and clamp. If the clamps do not seal at the specified torque, replace the clamps, the hose, or both. After installing a new hose, check the clamps daily and tighten if necessary. When this daily check indicates that cold flow has ceased, inspect the clamps at less frequent intervals.
Replace the hose if the plys have separated, if there is excessive cold flow, or if the hose is hard and inflexible. Permanent impressions from the clamp and cracks in the tube or cover stock indicate excessive cold flow. Replace any hose that has collapsed at the bends or as a result of misaligned fittings or lines. Some hoses tend to flare at the ends beyond the clamps. This is not an unsatisfactory condition unless leakage is present.

Pumps

During an inspection of booster pumps, check for the following conditions:
1. Proper operation
2. Leaks and condition of fuel and electrical connections
3. Wear of motor brushes

Be sure the drain lines are free of traps, bends, or restrictions. Check the engine-driven pump for leaks and security of mounting. Check the vent and drain lines for obstructions.

Fuel Pressure Gauge

Check the pointer for zero tolerance and excessive oscillation. Check the cover glass for looseness and for proper range markings. Check the lines and connections for leaks. Be sure that there is no obstruction in the vent. Replace the instrument if it is defective.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU7. Inspect and service suspension system	**The students will be able to** • Locate components to be inspected • Select appropriate tools • Check gashes or bulges and tires • Check the machine tracks, nuts, bolts, sprockets and track chain • Grease, bearings, bush and pins • Change damaged grease fittings	• Describe suspension systems, their components and importance • Describe state of suspension systems • Describe defects in suspension system	• Grease • Bushes

Suspension System:

The parts of a Machine that keep it connected to the road, from the tires up, are collectively referred to as the suspension. The suspension supports the machine, but it does much more than that: a good suspension allows machine to ride smoothly over bumps, to turn safely and reliably, and to maintain its balance during emergency maneuvers. A modern suspension needs to work on smooth asphalt or rough gravel, when carrying a lone driver or a full complement of passengers and load, in stop-and-go traffics. Because the system is critical to both comfort and safe, it's in every driver's/operator's interest to keep the suspension working as well as it should.

Modern suspensions don't require very much maintenance. As long as we do a couple of things routinely, keeping a suspension in good working condition is fairly straightforward.

How to keep a suspension in good working order

One of components of the suspension that should be checked most frequently are the tires. First, it's important to check the inflation of all tires regularly. Some drive machine has their own tire gauges and check at every fill-up; that's usually not necessary but checking every 1,000 to 3,000 miles is a very good idea.

Under-inflation, by even a few pounds can decrease fuel economy, increase tire wear, and even render a machine unsafe to drive, so if tire pressure is lower than recommended it's important to add air to achieve proper inflation. After adding air, keep an eye (and a tire gauge) on that tire; if it loses air consistently (a mechanic may be able to patch a leak, or the tire or wheel may need replacement).

Some machine owners don't check their tires' pressure because they think they'll be able to see or feel when a tire is low on air. That approach was OK in the past, but modern tires don't look noticeably different until they've lost almost all their air; it's possible for a tire to be dangerously under-inflated and still look and feel normal. It's important to check the air with a tire gauge.

Every 1,000 to 3,000 miles, check tire inflation and check tread depth.

At every oil change, check the power steering fluid; top off if necessary. On the manufacturer's schedule (often around every 10,000 miles), rotate tires if applicable. Every 15,000 to 30,000 miles depending on the machine's use, or when replacing tires, have the wheels aligned.

Every 15,000 miles or at every alignment, check all suspension components for wear. If the machine is in an accident or if the ride or handling change, check all suspension components for wear or damage. Lube Chassis every time Learner change oil, or at least every 10,000 miles. Align front end whenever experiencing abnormal tire wear

- Inspect ball joins every 20,000 miles
- Check steering linkage and free play every 20,000 miles
- Clean and repack front end bearings and replace seal every two years 24,000 miles
- Inspect rear suspension every 20,000 miles
- Check bellows on rack-and-pinion unit every time the chassis is lubed. Leaking units should be replaced.
- Replace OE shocks after 50,000 miles.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU8. Inspect and service Drive Train	**The students will be able to** ➢Locate components to be inspected ➢Select appropriate tools ➢Identify service needs, defects and hazardous conditions through visual/physical inspection ➢Check wear, leaks and damage to components • Identify defective undercarriage components	• Describe undercarriage systems, their components and importance • Describe state of undercarriage • Describe defects in undercarriage systems	• Nil

WHAT IS THE DRIVETRAIN?

The Drivetrain, also called the powertrain, provides power to the wheels so the machine can move. The drivetrain includes:

- Transmission
- Driveshaft
- Axles
- Wheels/Tracks
- Engine
- Exhaust system

It's a very complex system with a lot of moving parts. There are four types of drivetrain arrangements – rear-wheel, front-wheel, four-wheel and all-wheel drive.

ENGINE AND TRANSMISSION

The two biggest parts of drivetrain are also the two needed for machine to even function. The engine provides all the power to move the machine, and the transmission allows the engine to operate within a range of speeds.

CLUTCH OR TORQUE CONVERTER

The component allowing engine to keep running when the machine isn't moving sits between the engine and transmission. In a manual transmission, it's the clutch. In an automatic transmission, it's the torque converter.

DIFFERENTIAL

From the transmission, power then moves to the differential. When machine is driven around a corner, the inside wheel is traveling a shorter distance than the outside wheel, so the outside wheel needs to move more quickly to make up the difference. The differential is what allows the wheels to move at different speeds.
https://www.petersoncat.com/sites/cat/files/downloads/drive_train_mgmt.pdf

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU9. Inspect and service braking system	**The students will be able to** ➢Locate components to be inspected ➢Select appropriate tools ➢Identify service needs, defects and hazardous conditions through visual/physical inspection ➢Top-up fluid reservoir ➢Identify defective components of braking system	➢ Describe braking systems, their components and importance ➢ Describe state of braking ➢ Describe defects in braking systems ➢ Describe levels of brake oil/power oil to be maintained	➢ Brake fluid ➢ Brake oil filter

BRAKING SYSTEM:

Brake system inspection is an absolute must to ensure safe driving conditions. During a brake inspection the entire brake system is checked. This includes the following:

The brake pedal, brake fluid, brake lines and hoses, and the brake assemblies (whether they are disc brakes or drum brakes). Parking brakes should also be checked.

A. Checking how the brake system of a Machine is working starts with the brake pedal. There are three things to check when it comes to the brake pedal. The brake pedals height should be checked along with measuring free play and the brake pedal reserve distance. All of these measurements should be compared with the machine manufacturer's specifications. The brake pedal height is the measurement of the brake pedal to the floor when the brake pedal is at rest. Free play means that when Operator step on the pedal the brakes aren't applied right away.

   The free play is measured by the pedal movement from rest until the brakes are actually applied. Pedal free play is actually required, but it is important the free play measurement is in accordance with the specifications of the manufacturer. Lastly is brake pedal reserve distance. This is the distance from the pedal to the floor when the brakes are applied.

   So, if the pedal's height is off or if there is excessive free play, there may be problems with pedal bushings and return springs. If the reserve distance is incorrect, there may be problems with the cylinder pushrod. Next, brake fluid should be checked. Brake fluid provides the necessary force to activate the brake shoes and compress the brake pads or brake shoes. Brake fluid is kept in the master cylinder and experts say it should be changed every year or two to ensure the brakes work properly.

B. Along with checking the brake fluid, the hoses and lines should be checked. If the master cylinder is low, there may be a leak somewhere in the lines. The lines and hoses can be visually checked for cracks, and the actual brake assembly can be checked for moisture. Learner can also place cardboard under machine and step on brakes several times. Then check the cardboard for any leaks. Finally, the brake assemblies are checked.

C. To inspect the brakes, the front and rear wheels are removed to get a better view of the brake assemblies. There are two different types of brake assemblies: disc brakes and drum brakes.

1. Let's discuss inspecting disc brakes first. There are three things that must be inspected on disc brakes: the brake pads, brake rotor, and the caliper. The brake pads are located on each side of the rotor and are actually pushed against the rotor to stop the wheel and stop machine. The pads create the necessary friction to stop the machine. The pads are checked for excessive wear to make sure there isn't metal rubbing on metal. The brake rotor is the iron disc that is connected to the tire's hub. Rotors must be inspected for excessive wear. Brake pads and rotors have matching wear patterns, and if a brake pad needs to be replaced, the rotor will have to be machined smooth. A rotor can be machined smooth only so many times before it is worn too much. Each rotor must have a certain width, which is inscribed on the rotor, and if the rotor is too worn, it must be replaced. The rotor should also be inspected for any heat cracks or other damage. The last part of a disc brake is the caliper. The caliper is a device located over the top of the rotor and contains both brake pads. There are two types of calipers: floating calipers and fixed calipers. A floating caliper can compress itself and contains only one piston. When the brakes are applied, brake fluid will force the piston into the brake pad, which will press against the rotor. Then the other side of the caliper will press the other brake pad against the rotor to stop the wheel and machine. A fixed caliper doesn't move; so, it contains two pistons located on each side of the rotor. When the brakes are applied, brake fluid forces both pistons into each brake pad which press against each side of the rotor to stop the machine. Calipers must be inspected to check for leaks.

2. The second type of brake assembly is the drum brake. Drum brakes are usually located on rear wheels because of the need for a parking brake. Parking brakes are added much easier to a drum brake than to a disc brake. Drum brakes contain several different parts: brake shoes, which are like brake pads; a backing plate, which basically holds everything together and is attached to the axle; brake drum, which is like the brake rotor; wheel or brake cylinder, which contains the pistons; return springs; and a self-adjusting system that will adjust the position of the brake pad when the brake isn't applied. When the brakes are applied, brake fluid forces the pistons to push against the brake shoes, which press against the drum, which will stop the wheel and machine. Then, when the brake is released, the return springs send the brake shoes back to their original position. Brake shoes are located very close to the drum so that when Learner step on brake pedal, the brakes are immediately applied. Over time, the surface of the brake shoes wears and the position of the shoes must be adjusted so it doesn't have to travel a farther distance to come into contact with the drum. If the drum brakes didn't have a self-adjusting system, Learner would have to press down farther and harder on brake pedal before the brakes would be applied. When a drum brake is inspected, there are many more parts that need to be checked than in a disc brake. The brake shoes need to be checked for excessive wear so they don't damage the drum. The brake drums, like the rotor, need to be checked for excessive wear or cracks. They also have to be machined smooth when a brake shoe is replaced and can only be machined down so far; then they must be replaced. Wheel or brake cylinders need to be inspected for any signs of leaking. The return springs need to be checked because if they are too worn and don't return the brake shoes back to their original position, away from the drum, the brake shoes can experience rapid and excessive wear.

D. Finally, the self-adjusting system must be inspected to make sure it is clean and properly lubricated. Parking brakes should also be inspected at this time. A parking brake, or emergency brake, must be inspected to make sure that the cables and levers are working properly. Parking

brakes work separately from regular hydraulic brakes. They are a necessity to keep the machine from rolling down a hill when it is parked. It must also be working properly if regular hydraulic brakes ever fail.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU10. Inspect and service load bearing structure	**The students will be able to** • Locate components to be inspected • Select appropriate tools • Identify service needs, defects and hazardous conditions through visual/physical inspection • Grease, bushes and pins	• Describe load bearing structures, their components and importance • Describe state of load bearing structures • Describe defects in load bearing structures	• Grease

What is load-bearing

Load-Bearing is the weight that is carried by a structure.

Maintenance of load bearing structure:

1. The load bearing Begin Walk Around
2. Check transmission fluid level
3. Look for wear in driveline area
4. Inspect all hoses for wear and leaks
5. Check for loose lug nuts and general wheel condition
6. Look at tires for imbedded stones, foreign material, cuts, overall tread condition, and sidewall condition
7. Check tire pressure and verify correctness before beginning work Move To the Lift Arms
8. Inspect pin areas for wear
9. Look for loose or broken greasing tubes
10. Look for loose or leaking lines, fittings or hose clamps
11. Check coupler for wear (if equipped) Move To the Bucket
12. Inspect the cutting edge
13. If cutting edge isn't square with the ground Learner may have an under inflated tire
14. Inspect the edge for loose, broken or missing parts
15. Look for unusual wear patterns and cracked welds around the bucket
16. Examine the cylinder rod
17. Make sure the tilt cylinder rod isn't scratched or dented Move To the Next Wheel
18. Inspect tire as Learner did on the other side
19. Check the center articulation area

20. Look at The cab area, check for broken glass or mirrors
21. Move to the next wheel and inspect as Learner did on the other side.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU11. Inspect and service operator station/Cab	**The students will be able to** • Locate and identify controls inside operator station/Cab • Identify missing or defective components or controls • Clean front/rear wind screen, windows and mirrors • Adjust mirrors • Replace broken mirror/frame • Adjust seat and seat belt • Check nobs of all lights and indicators	• Describe controls inside the operator station/cab • Describe defective controls • Describe importance of controls and operating procedures	• Fuses • Bulbs

INSIDE THE CAB

1. Seat Adjustment and pedal travel should be checked. Pedal travel should be checked to ensure that the pedals are functioning properly and are not jammed.

1. Seat belt &mounting should be checked for damage, wear and adjustment. They are mandatory for the safety of the operator when operating the machine.

2. Fire Extinguishers have to be present in the cabin and be charged. Any damage to fire extinguishers should be reported. Fires getting out of hand can cause a lot of damage.

3. Horn, backup alarm and lights should be checked to ensure they are functioning properly. Failure of any of these things can lead to accidents on rather noisy sites.

4. Controls and gauge lenses should be checked for damage, cleanliness and its operational states. Malfunctioning gauges and controls can led to under or over utilization of the machines and eventually cause damage.

6. Overall Cab Interior Cleanliness should be maintained.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU12. Inspect safety equipment	**The students will be able to** • Ensure safety equipment is securely mounted • Replace expired fire extinguisher • Ensure wearing of PPE	• Describe safety equipment and their importance • Describe defects in safety equipment	• Fire extinguisher and refill materials

First Aid:

- The implication, importance and need of First Aid Box for the Heavy Machinery Operator is very important
- The possible hazards an operator can face on a job site like headache, vomiting, dust allergy, dust in eyes, sudden pain in body part like back bone or foot, stomach pain, minor burn, minor bruise or cut etc. can be treated at spot and then in case of major injury this first aid provides enough time to go to hospital
- There are set of standard medicines and tools of a first aid kit which are given to the operator by the company.
- The types of medicines are very basic like "pain killer, antiheadache, antivenom, antiseptic, anti-motion, anti-constipation tablets. Healing Cream for open cuts and wounds, eye and ear drops, Pyodine, these medicines are used by operators in case of any emergency or hazard, the first aid box should be placed in operator cabin at a place where it can be reached easily and the expiry date of medicines must also be checked from time to time.
- Tools like scissor, cutter and bandages must be present in the first aid box in working condition
- First Aid Box must be kept inside the operator cabin at a place safe from dust or heat to avoid any damage to the medicines.
- The box must never be locked or placed at a nonaccess able place so in case of emergency the reach to the box must always be easy.
- The first aid box must be placed at a visible place.
- There shall be a Check List in the First Aid Box so that the available medicine can be checked against it.

Personal Protective Gear for Heavy Equipment Operators

Those flip-flops are unsafe because they don't protect the feet. A worksite that has heavy equipment is a work site that requires good work boots, usually with steel toes. These boots, along with good socks, are designed to stay on your feet and keep your mind on the job instead of your toes. Other ways to protect your body might vary depending on the type of industry:

- Clothing that will keep you from getting caught in moving machinery parts
- Gloves that keep your hands from slipping and also protect
- Safety glasses that keep dust and other junk out of your eyes
- Ear plugs or ear muffs that keep you from going deaf

- Respirators or masks that keep silica or other junk out of your lungs
- Hard hats that keep your skull from getting cracked
- Reflective safety vests that keep you visible
- Sunscreen that keeps you from getting skin cancer
- A water bottle that keeps you hydrated


Safety helmets must be worn where appropriate
Foot protection must be worn where appropriate
Use ear protection where appropriate
Wear eye protection where appropriate
Use hand protection where appropriate
Face masks must be used where appropriate

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU13. Inspect and service Attachments	**The students will be able to** • Identify service needs, defects and hazardous conditions through visual/physical inspection • Select appropriate tools • Perform basic maintenance such as greasing, bushing and pins • Report worn teeth	• Describe importance of service attachments • Describe defects of service attachments	• Grease

ISNPECTION AND SERVICE:

Regularly timing and documenting the cycles for all machine motions enables system performance investigation to take place as early as possible**.**

Many basic checks need to be carried out regularly to avoid being caught off guard. The operator can be trained to take care of all of the daily maintenance tasks such as fluid level checks and leak inspections. The service shop should only need to duplicate these tasks after major teardown and repair work has been machined out. Other tasks that require more skill and thoroughness are best left to the shop technician.

Using a scientific-based approach to understanding how long a component should operate reliably is critical to cost-effective operation of all hydraulic components. In part 1, we discussed the importance of keeping an eye on the following:

1. Fluid levels
2. Leaks and safety
3. Temperatures
4. Pressures

Leaks and safety—If Operator see dripping or hydraulic fluid spraying from any hose, tube, fitting or component housing, do not touch any surfaces at or near that leak location. A fluid injection injury could be fatal or leave Learner disabled for life. Be sure to achieve a zero pressure state before any close inspection of a leaking component, or disassembly of any fluid line connection.

The operator should be trained to watch for the normal hydraulic fluid temperature as reported on the instruments in the cab. Any increase in temperatures should be reported without delay.

Hoses — The outer wrap hydraulic hose is subjected to all temperature extremes, direct sunlight, rain and many other environmental effects. Add to this the flexing cycles and the moments of system overheating that may have occurred and hydraulic hose can be weakened even from the inside.

Hoses on mobile machines suffer abrasion damage more than any other wear effect. It should be the operator's job to keep a close watch for hose deterioration.

By the time a hose has been in place for several years on a steadily operating mobile machine, it is near the end of its predictable service life. For continuous operations such as waste disposal and recycling trucks in an urban center, or machines in a mine or on a construction site, carefull tracking of historical records together with hours of service may provide optimal hose change frequencies. For small fleets or even single machines, it may be necessary to replace critical hoses in the high-pressure circuits every two to three years.

Overall mechanical lubrication — Obviously a mobile machine has more systems to maintain than just the hydraulics. Gearbox lube and the greasing of swing gears and bearings, along with the pins where the cylinders mount and pivot can directly impact hydraulic system performance. Failing to grease can show up as a hydraulic cylinder slowdown or stall, and possibly an over-temperature condition as well. If enough mechanical binding occurs, pressures may reach maximum values with minimum payloads on a lifting boom and a relief valve may crack open, dividing flow.

Like the braking system, the reliability of hydraulic steering is key to human safety. Also similar to the braking system, an accumulator may be involved. It will likely be larger than the brake accumulator because unlike the braking system, steering is a flow-based motion control system. Steering in some machine designs has done away with the steering wheel and orbital valve in favor of the joystick. Operator strain and fatigue is minimized, but again, electronics, fine proportional valves and pilot systems may be present, minimizing contamination tolerance.

https://www.mobilehydraulictips.com/can-keep-mobile-machine-running-efficiently-part-2/

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU14. Inspect and service supporting pneumatic (Air-filled) system	**The students will be able to** • Locate components to be inspected • Select appropriate tools • Identify service needs, defects and hazardous conditions through visual/physical inspection • Perform basic maintenance, such as choked drain valves • Replace air lines	• Describe importance of pneumatic parts (Air-filled/operated) and systems • Describe defects of pneumatic parts (Air-filled/operated) and systems	• Nil

Pneumatics is a branch of engineering that makes use of gas or pressurized air.

Pneumatic systems used in industry are commonly powered by compressed air or compressed inert gases. A centrally located and electrically powered compressor powers cylinders, air motors, and other pneumatic devices. A pneumatic system controlled through manual or automatic solenoid valves is selected when it provides a lower cost, more flexible, or safer alternative to electric motors and actuators. Pneumatics also has applications in dentistry, construction, mining, and other areas.

In general, hydraulic systems are used for precise controlling of large force applications and pneumatic systems for lightweight and speedy applications. Hydraulic-based components are made using steel and pneumatic components are made using plastics and non-ferrous materials.

Multiple Choice Questions:

Question 1 What is the lubrication system

A It is the radiator of the machine

B It includes all hydraulic and fuel system

C It is the system of flowing water in the machine

D It is the system to keep machine cold

Question 2 What is not included in the electrical system

A The control panel of the machine

B The fuel and temperature gages

C The headlights of the machine

D The warning lights on the panel

Question 3 Air filter is the part of

A Pneumatic System

B Cooling System

C Fuel System

D Braking System

Question 4 Oil Filter is part of

A Pneumatic System

B Cooling System

C Fuel System

D Braking System

Question 5 Function of Suspension system is

A To lift heavy loads

B To balance the weight of the machine

C To drive the machine

D None of the above

HEAVY MACHINE OPERATOR

Module-F

LEARNER GUIDE

National Vocational Certificate Level 2

Version 1 - November, 2019

Module F: Maintain Machine (with Engine Running)

Objective: This module covers the skills and knowledge required to Start engine monitor warning systems, Warm up engine, Cycle equipment functions, Comply with Scheduled Maintenance Requirements and Maintain Logbook

Duration: 40 Hours **Theory: 8 Hours** **Practice: 32 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Start engine monitor warning systems	**The students will be able to** • Identify leaks and burnt lights • Select appropriate tools • Replace fuses and tighten loose fittings	• Describe basic warning indicators of machine	• Nil

Engine running inspection procedure

- Perform walk around inspection.
- Mount the machine using 3 points of contact.
- Turn the battery disconnect switch to ON.
- Ensure circuit breaker reset button remains depressed.
- Adjust seat, adjust mirrors, fasten seat belt.
- Move hydraulic lockout control to the LOCKED position.
- Move the joysticks to HOLD position.
- Make sure all personnel are clear of machine and sound horn.
- Use ether start aid switch if necessary (per OMM).
- Turn the key start switch to ON.
- Observe monitoring system self-test and add fluids if necessary.
- Ensure that ‘Intake Air Heater On” is not shown on the message display.
- Turn engine speed dial to “Medium” position.
- Turn the key start switch to START and crank engine.
- Allow machine to warm up (per required time in OMM).
- Engage and disengage attachment controls to help speed warm-up of hydraulic components.
- Turn engine speed dial to medium…run engine for 5 minutes. Continuously move joystick from BUCKET DUMP to HOLD.
- Cycle all controls to allow warm oil to circulate through all hydraulic cylinders and lines.
- Check gauges, indicators and action light frequently.

1. Safety tips for driving and operating heavy equipment:

Operators must check the heavy machinery thoroughly before driving and operating for anything.

- ✓ Before starting the equipment, ensure that the equipment has been serviced according to the schedule.
- ✓ Many attachments are used with the heavy earth moving equipment including backhoe loaders and the like. Hence, see to it that as a responsible operator, lower all the attachments and set the brakes.
- ✓ Operators should also ensure that the work area is absolutely clear before moving or backing up the equipment.
- ✓ Make sure that Operator don't leave the machine on a slope with the engine running as this may put the machine into motion.
- ✓ Take extra care while working near the edges of cuts or fills.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU2. Warm up engine	**The students will be able to** • Monitor instrument panel • Warm up engine according to manufacturer's instructions	• Describe procedure of engine warming up and its importance	• Machine

WARMING UP ENGINE PROCEDURES

- Make sure area is clear
- Turn the engine speed dial to the operating range
- Move hydraulic lockout control to UNLOCKED position
- Raise boom
- Select desired travel speed
- Ensure the position of the upper structure and undercarriage is known. The drive sprockets should be at the rear of the machine
- Turn engine speed dial to desired speed

Push both travel levers forward at the same time to travel forward

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU3. Cycle equipment functions	**The students will be able to** • Activate all functions, such as brakes, steering, lights, wipers and hydraulic functions • Identify problems with functions • Perform required service	• Describe pre-work routine /cycle equipment functions and its importance	• Nil

The Pre- and Post-Operation Equipment Inspection Checklist

- Check tires, rims or undercarriage for damage or abnormal wear and clear away debris, a machine can be hobbled by the inefficiencies of the tires or tracks it sits on. Identify and report any damage or potential damage.
- Check fluid levels – engine and hydraulic oil, diesel and diesel exhaust fluid (DEF), and coolant. Fluids are the lifeblood of each machine and require specified levels to operate properly. A sudden drop in fluid levels may point to any number of problems with the machine that require immediate attention (blown hoses, leaking filter, etc.).
- Clear any accumulated debris from around the radiator and other engine components. The engine is made of moving parts and belts that generate heat and friction – and systems designed to cool the engine compartment require room to breathe. It's important to check and remove any clutter or material from the jobsite that may have found its way into the engine compartment.
- Check the fuel, oil, air and other filters for signs of damage or leaking. Filters are often a quick and easy item to replace – and operating with properly working filters can prevent any number of problems with the machine.
- Check belts (alternator, fan, etc.). A worn and frayed belt is another wear item that is relatively easy to replace. If noticed before it fails, then the operator can communicate with the maintenance team to replace during scheduled downtime or the next PM to ensure it doesn't create unplanned downtime during the course of the work day.
- Identify greasing points and frequency. Every machine and every OEM is different – and keeping the machine properly greased is critical considering the power and friction created by these giant pieces of steel working together. It can also help keep out moisture and abrasive materials from the jobsite that can work into joints and friction points if not properly greased.
- Check for leaking or pooled fluid around and under the machine. This is an easy indicator that something isn't right, and the source of that fluid should be identified and addressed/fixed before operation, and those fluids should be replaced.
- Check auxiliary hydraulic connections and pressure. Simply check the integrity of the coupling structure and that it hasn't been damaged. Newer equipment often includes pressure relieving quick disconnects – take the time to relieve the pressure when disconnecting attachments.
- Check for new signs of structural damage, scratches or dents on the machine. This is almost more important post-operation than it is pre-operation. Once done for the day, noticing and identifying any damage to the machine ensures that needed repairs are made before the next shift starts, and also allows the operator to identify how that damage occurred. Is there another structure on site that the machine came into contact with? Is there damage elsewhere on site that needs to be addressed? Similarly, if damage is noticed before a shift starts, and it was not there when the operator inspected it the day before, that pinpoints that something happened overnight or that there was possible unauthorized use of the machine.

- Check for damage on ground engaging tools (buckets, teeth, etc.). A machine's performance is affected greatly by the efficiency of how its working tools engage with the material it is digging into and moving. Worn or broken buckets and teeth lead to inefficient operation, greater fuel use, and greater wear and tear to the machine as a whole. Identifying and addressing these elements of the machine before they become problematic will make the operator more productive and efficient.
- Inspect the attachment mount-up to ensure proper connection. This includes checking that the coupler is flush and fully engaged (either via manual or automatic/hydraulic means), and that the hydraulic hoses (and electrical connections, if applicable) are properly connected.
- Inspect the operator compartment and clear away any debris or obstructions. Clutter can be distracting – and anything in the cab that ultimately prevents the full range of controls from being engaged is a hazard to operation.
- Check and set mirrors. This might seem obvious, but visibility is critical to jobsite awareness, safety and productivity. Having mirrors set to the operator's preference will make them a better operator.
- Familiarize yourself with the control style and change as needed. Most of today's machine's come with rather simple pattern selectors that allow the operator to use the control pattern that they are most familiar with. This will lead to greater productivity and greater operator satisfaction.
- Identify auxiliary/attachment controls. Each type and style of machine controls attachments differently – operators should identify how to properly work their attachment prior to attempting to use it.
- Start the engine and review console indicators and warnings. Today's machines are built to give the operator more feedback on the workings of internal systems than ever previously available. Take note of any flashing symbols or warning lights, check the owner's manual and consult with maintenance staff prior to operation.

Review all external surroundings from the cab. Know the work site, and the people and structures that exist inside the working envelope. This will ensure optimal jobsite safety and productivity.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU4. Comply with Scheduled Maintenance Requirements	**The students will be able to** • Comply with safety requirements • Read indicators/warning signals and remove the problem • Maintain record and documentation. • Perform scheduled maintenance	• Describe maintenance and its importance • Describe types and techniques of scheduled maintenance.	• Nil

Types of system maintenance

- **Poor Maintenance:** The guiding philosophy at some machine still seems to be, "If it is not broken, don't fix it." The shortsighted, poor maintenance practices that result from this line of thinking will inevitably result in needing to replace a costly.

- **Preventive maintenance**: Preventive maintenance programs include regularly scheduled monitoring of operating conditions, replacement of air filter and lubricant filters, and lubricant sampling and replacement.

- **Predictive Maintenance**: This type of maintenance involves monitoring of machine conditions and trends including operating parameters (power requirement, pressure drops, operating temperatures, vibration levels, etc.). Well trained operators know when to check pump oil levels, drain the water in the tank, replace the belts, and much more.

- **Proactive Maintenance**: Proactive maintenance involves controlling a situation — in this case the continued peak performance of the machine — by taking steps to prevent any issues that may arise with a machine.

What should be on a planned maintenance schedule?

Manufacturers often use the terms preventative and planned maintenance interchangeably. Routine maintenance is perhaps a more accurate term. It refers to scheduled maintenance for equipment and facilities that can prevent equipment from prematurely breaking down.
All equipment eventually wears out. The goal of planned maintenance is to keep equipment operating as efficiently as possible, for as long as possible.

Although Operator can use an old-fashioned printed calendar system, service management software offers a better way to manage planned maintenance. With a sound schedule of planned maintenance activities at manufacturing facility, Learner can prevent costly delays resulting from defective equipment. Let's take a look at what should be on the average planned maintenance schedule, and why it is important.

- **Filters** - This includes air filters, fuel filter and oil filter.
- **Belts** - Belts may need to be changed on conveyors and other equipment. Belts should be inspected frequently for signs of wear and changed before they break.
- **Machine maintenance** - To maintain a fleet of machines, planned maintenance such as state inspections, oil changes, tire rotation, and cleaning can be added to service management software to ensure it is conducted on a reoccurring schedule.
- **Calibration of instruments** - Delicate instruments may need to be re-calibrated after a certain number of uses.
- **Compressors** - Compressors should be inspected to make sure there are no cracks or wear that can lead to safety hazards.
- **Cleaning and changing lights** - Light fixtures can get dirty and reduce the light reaching production areas. Bulbs that burn out need to be replaced to ensure that there is adequate light in the warehouse, distribution center, and manufacturing areas.
- **Lubrication:** Lubricate all the moving parts of the machine well as they will fail if they aren't lubricated properly. Too little as well as too much lubrication can be harmful for the machine. So, Learner need to lubricate the machine wisely.

These are just a few areas of routine maintenance to consider. Another great tip for properly maintaining the equipment is to make sure it stays as clean as possible and dirt and debris are removed regularly. If possible, keep the equipment housed in a building.
Create and follow a maintenance schedule. Include notations on how often each part of the machinery should be inspected for problems, repairs and general maintenance. • Pay close attention to wear and tear signs as they may signal problems that can cause machinery to malfunction more often or result in costly repairs or component replacements before regular inspection. Some common signs of wear and tear are vibration, heat and belt shape.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU5. Maintain Logbook	**The students will be able to** • Record fuel consumption • Record oil change • Record time period/mileage of machine for schedule maintenance.	• Describe log book and its parts • Describe procedure to maintain Logbook	• Writing instruments (pen, pencil, register etc)

8 Tips for Effective Log Book Management

The machine is a vital part of business. Following are the Eight (8) tips to improve managing the equipment in inventory.

1. Know what Learner have

Do Learner know exactly what equipment is in inventory? Learner might have an idea, even though we believe the combined value of all supporting equipment is probably higher than expect. A list of the equipment in inventory from a year ago is worth less than the paper it is printed on. Equipment inventory list should be:

- **Complete**: Include all of assets
- **Accurate**: Provide enough information – value, location, capabilities, …
- **Up-to-date**: Always reflect changing inventory

2. Track how it is used

Once Learner know what Learner have, the next step is knowing exactly how it is being used. There are several questions Learner should be able to answer for each piece of equipment in inventory:

- **How** often is it used
- **Who** uses it
- **When** and **where** is it used

When know what Learner have and how it is used Learner can make informed decisions about current and future equipment management strategy. Time to start making improvements!

3. Right asset, right place, right time

If Learner have multiple locations, how should Learner divide assets between them? An equal division sounds logical but is not effective, as demand for equipment is unlikely to be the same everywhere. With accurate and up-to-date usage data Learner can deploy assets where they are needed most. **Why have equipment gathering dust in one place when there is a shortage elsewhere?**
Demand and supply fluctuate over time as well. Offering a discount might let Learner make money on items that weren't going to be used anyway, or Learner can rent extra equipment to bridge short periods of increased demand.

4. Don't spend more – spend smarter
One way to ensure that the right equipment is available at the right time is to buy more of everything. But this is inherently wasteful – some of the extra equipment will be put to good use, while the rest will simply sit in storage. Luckily we can avoid this waste, based on the information we gathered in the earlier steps. **By prioritizing spending on the equipment** that is used most Learner can get the most bang for bucks!

5. Fix things before they break
Would Learner rather:

- **A**: Spend an hour every week making sure equipment is in great shape
- **B**: Spend a day every month repairing equipment that has broken down

Even looking simply at time spent maintenance is clearly the best choice. And while equipment always seems to break down at the worst time possible, Learner can plan maintenance ahead of time. Equipment that is used all the time is obviously more valuable to business than equipment that is used once a week. But it is also more likely to break down, so it is in higher need of regular maintenance. Plan maintenance based on need, instead of a fixed schedule for all equipment, to make optimal use of time. And because Learner know when equipment is most likely to be idle Learner can schedule maintenance to reduce its impact on the rest of business.

6. Find underlying issues
If an important piece of equipment breaks down once, it's an annoyance. But what if it keeps breaking down, over and over? Now that Learner have data on equipment, use it!

Look for trends so Learner can find underlying issues instead of scratching the surface.
Perhaps the breakdowns are caused by an employee who didn't receive the proper training and has been using the equipment the wrong way. In this case replacing the equipment won't solve the problem – it'll just cost Learner more money in the long run!

7. Buy the best
Inevitably equipment will have to be replaced or upgraded. But here again Learner can use the information gathered to spend money smarter.

- Which brands cause the most issues?
- Which equipment is liked best?
- Which equipment loses Learner the most time and money by breaking down?

8. Use The Right Equipment Inventory System
Learner can of course try to keep track of this information with pen and paper, for instance using an equipment signout form to know who's using the gear – just as Learner can still use horse-drawn carts to get around.

Spreadsheets are another option – but that option has drawbacks as well.
Using a modern, user-friendly equipment inventory system is the best solution for this matter. It automates a lot of the background work, so Learner can focus on the things that really matter.

Multiple Choice Questions

Question 6 What to do when you start an engine?

A Start engine and Monitor warning signs and indicators

B Start engine and drive

C Start engine and observe the hydraulic system

D Start engine and lift loads

Question 7 What is the standard time for warming up engine?

A 05 Minutes

B 10 Minutes

C 15 Minutes

D 30 Minutes

Question 8 Why is it important to perform cycle function?

A To avoid risking the operator safety

B To prevent machinery from breaking down

C To avoid fuel wastage

D To ensure that the sound of the machine is fine

Question 9 Which TWO of the following are causes of machinery break down?

A Un even working areas

B Wrong selection of machine as per the capacity and capability of machine

C Water seepage in Machine blade

D Use of Low quality supplies and lubricants

Question 10 What is the importance of maintaining a log book?

A Prevent expensive repair works from happening

B Helps Learner create specialised maintenance programs

C Prevent problems regarding warranty claims

D It increases the safety of operators

E All of the above

HEAVY MACHINE OPERATOR

Module-G

LEARNER GUIDE

National Vocational Certificate Level 2

Version 1 - November, 2019

Module G: Park Machines

Objective: This module covers the skills and knowledge required to Clean under carriage and attachments before parking, Park equipment in appropriate location, Shut down and secure equipment, Perform housekeeping tasks and Perform visual inspection.

Duration: 50 Hours **Theory: 10 Hours** **Practice: 40 Hours**

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU1. Clean under carriage and attachments before parking	**The students will be able to** • Clean machine body, wheels, & undercarriage • Clean attachments according to manufacturer's specifications and company policy and procedure	• Describe importance of cleaning tracks, wheels, rollers, and attachments.	• Cloth rag

CLEANING THE UNDERCARRIAGE:

HEAVY EQUIPMENT WASHING AND DEGREASING
Cleaning heavy equipment has to be done time to time. Most commonly is it cleaned for maintenance and preventative breakdown; it must also be done for company branding and appearance. Whatever needs are for cleaning heavy equipment, it can be a tough and long task if not done properly.

Types of grease

Fresh and soft grease – this grease is the easiest to get off and not mixed with any dirt
Grease mixed with dirt – this grease is more challenging to remove as it is combined with dirt and other contaminants
Aged and hard grease mixed with grease– this grease is very difficult to remove and requires strong degreaser to come off.

Areas to look for
Moving components joints– these areas must be greased on a regular basis so keeping these clean make them easier to grease
Hydraulic lines– keeping these clean are important so finding leaks or worn out lines is much easier.
Fuel tank caps– machines have to be fueled up, having a clean cap and the area around it prevents contaminants from going into the fuel tank, plus nicer to handle the cap!
Engine bay– this is the most important part of machine, having a dirty motor causes motor to run hot and prematurely wear out. More importantly inspecting the motor and detecting damage leaks is important to keep machine running smoothly!
These are just a few key areas.

How to wash heavy equipment professionally
This requires a hot water pressure washer

First step– Hot water pressure wash while up streaming a degreaser or truck washing soap to emulsify the **fresh and soft grease** and some **grease mixed with dirt.** Make sure to spent extra time on the **Areas to look for.**
Second step– Apply Strong degreaser using a chemical sprayer to the machine and let it dwell for at least minutes 15 minutes. Then hot wash the Machine to a final clean.
Third Step (Optional) – To give the machine a show room clean, apply a two-step (acid followed by alkaline soap), Then spray on a high gloss wax finish to make it look like brand new!
Whether working with a back hoe, an excavator, a forklift, or a bulldozer, projects will see better results when the tools are working (and looking) their best. These machines should be cleaned and inspected regularly to ensure they're in good working condition, and won't break down mid-job.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU2. Park equipment in appropriate location	**The students will be able to** • Identify appropriate parking location • Park equipment according to company policy and procedure • Lower the attachments to the ground level • Put paddings under the attachment if the machine is to be parked for longer duration	Describe suitable and safe parking locations, such as dry and clean surface, level, away from fuel storage or water courses, secure areas.	• Nil

APPROPRIATE PARKING RULES:

1. Parked away from access ways
    - θ overhangs
    - θ fueling site
    - θ Parked away from excavations and trenches
    - θ Parked clear of fire hazard θ
    - θ Parked clear of entrances, exits
    - θ Parked away from firefighting and electrical equipment
    - θ Parked on firm level ground or if on an incline facing up the slope
    - θ Lower bucket with cutting edge on ground
    - θ Engine stopped in accordance with manufacturer's operation manual (idle engine before turning off)
    - θ Secure parking brake or leave in park position
    - θ Remove keys
2. Park on level ground, place in neutral, and set parking brake.
3. Return to parking area; stop and secure motor grader; follow shutdown
4. procedure.
5. Set parking brake and put transmission into neutral.
6. Lower all hydraulic equipment to the ground, place transmission into
7. neutral, and set the parking brake.
8. Check to see if parking brake is set, machine is in neutral.

Proper parking is critical for ensuring the safety of operators and those working around them, and for keeping machine in top condition. Things like temperature and ground conditions affect proper safety protocol, and even the most experienced operators can forget the basics, or get sloppy and complacent over time.

- As an operator of the heavy equipment make sure to lower the attachments and set the parking brake and put the lever in the neutral position before dismounting the equipment after the day's work.
- Park the equipment in such a way that it does not obstruct the traffic.

Thus, as responsible operators of heavy earth moving equipment, you need to follow these tips to operate the equipment safely, increase its lifespan and prevent dangerous injuries. These small but important tips can help to increase productivity as well as efficiency of the machine.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU3. Shut down and secure equipment	**The students will be able to** • Shut down equipment according to the manufacturer's specifications • Secure equipment against movement and damage	• Describe parts and procedure of shutdown	• Machines

SHUTTING DOWN & SECURING EQUIPMENT:

- When shutting down the unit, be sure it's parked on a level surface with the bucket attachment lowered to the ground.
- Turn off the auto-idle switch and run the engine at half throttle without load for a few minutes to help cool the turbocharger down.
- Set the RPM to low idle before shutting the engine off with the key switch.
- Don't forget to lock up the cab when exiting the equipment.

Post Operation / Parking:

Having finished the earth moving operation, the machine should be stationed in a place off the work area or access road. The following points should be noted:

Ø Park on level ground, with the parking brake firmly applied and blocked by suitable wedges, where appropriate. For wheeled machine, the wheels should be chocked by suitable wedges and never chock the wheels with rocks. Avoid parking near edges of slopes and excavations.

Ø Lower the attachments or working tools to the ground.

Ø Park equipment at safe location and hang tag out

Ø Always lower attachments and set the parking brake before dismounting the equipment.

Ø Always set the brake, lower the equipment, and place the shift lever in neutral at the end of each work shift.

Ø Remove the ignition key and hand it back to the site personnel for safe custody.

Ø Secure the equipment when finished for the day. Make sure it is clear of traffic. If it is not clear, mark it with glares or red lights.

Ø Lock it up.

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU4. Perform housekeeping tasks	**The students will be able to** • Clean wind shields, side rails, steps and instrument panel • Sweep floor • Remove garbage • Apply glass/mirror covers	• Describe importance of housekeeping and its procedures	• Cloth rags • Brooms • Glass cleaner

Importance of House Keeping

The job site really does a job on your heavy machinery, exposing it to dirt, grease, salt, and more. Keeping it clean is a vital part of preventive maintenance. Read on to discover five benefits of maintaining a clean fleet.

1. Clean Equipment = Less Downtime

One of the best parts of being a heavy equipment operator is that, at the end of a long day, you see tangible results of your hard work. This could be a cleared construction site ready for crews to lay the foundation, trenches ready for piping, or any of the myriad jobs accomplished using heavy equipment.

Of course, at the end of that long day, your equipment also shows the results of your hard work. The dirt you see, however, is nothing compared to the dirt you don't see. Your loaders, trenchers, and more pick up dirt and debris from the job site, thanks in part to the grease that keeps its parts moving. To keep those parts moving, you have to keep them clean.

2. Prolong the Life of Your Equipment

Your heavy equipment fleet represents an enormous investment. Even if that "fleet" consists of a single machine, that single machine required a significant amount of capital. It's in your best interest to protect that investment. Keeping it clean is a key component of that.

It's no secret that well-maintained equipment lasts longer. You know this; that's why you regularly check your fluids and perform preventive maintenance. Incorporating power washing as part of your preventive maintenance routine eradicates the buildup of the grease and debris that interfere with efficient operation. When your equipment has to work harder, that takes a toll, shortening the life of your investment.

Power washing your equipment improves its aesthetic value, as well. The same dirt, debris, and grease buildup negatively impacting your heavy equipment's mechanics also does a number on its paint job.

3. Improved Safety

Poorly maintained equipment presents a safety hazard to your crew. Contaminant buildup leads to problems with your electrical and hydraulic systems, as well as other mechanical issues. Faulty, malfunctioning equipment presents a danger to your entire crew, from the operator to anyone working in the vicinity of the machine.

Your mechanics are also safer working on clean equipment, since power washing knocks loose all matter of debris that otherwise hits your maintenance team.

4. Pride of Ownership

A clean, well-maintained heavy equipment fleet makes a statement to your clients (and prospective clients!) that yours is a professional organization. You're demonstrating the pride you take in your team, in your company, and in the work you do.

Consider also the impression you make on the job site, with the customer, the public, and even other contractors. They may not notice that your equipment is clean, but they'll definitely notice equipment covered with mud, dirt, and grease.

5. It Pays to be Clean

There are a number of ways it pays to keep your heavy equipment clean, including:

- When your equipment is down for maintenance, it's not making you money
- Dirty equipment breaks down more frequently, leading to costly repairs
- Dirty equipment presents a safety danger, increasing your danger of compensation claims

Learning Unit	Learning Outcomes	Learning Elements	Materials Required
LU5. Perform visual inspection	**The students will be able to** • Check parked equipment visually • Identify existing or potential problems • Communicate to appropriate personnel such as supervisor/mechanic	• Describe importance of visual inspection/end shift routine and its procedures	• Nil

Protocols for visual inspection

- Walk around the equipment and check the work area. Make sure there's enough space for the machine to machinery out its work.
- Before turning off the equipment, inspect the boom, the dipper arm, and the bucket. Look for any cracks or dents. Make sure the locking pin and the safety clip are in the right position.
- Inspect the undercarriage area. Check the sprockets, idler wheels, track links, and rollers. Look for signs of wear and tear.
- Next, check the hydraulic fluid and coolant level. Don't forget to inspect the radiator and look for leaks.
- Open up the engine bay and perform an oil check with a dipstick. Learner should do this after every four hours of operation.
- Lubricate the bushings if required.
- Get inside the cab to make sure the indicator lights and the controls are in proper working order.
- Test the equipment by fully extending the boom arm and the dipper arm. Listen for unusual sounds.
- Lift the boom arm up in the air and turn off the machine. Wait and see whether the boom arm moves downwards. If it does, you will know there's an internal bypass in the cylinders.
- Test the boom arm and bucket functions repeatedly to find out if there's any excessive movement.
- Check the levers and joysticks to ensure they're working properly.

Be well aware of the safe operating limits of the equipment. If not sure, refer to the manual .

Multiple Choice Questions

Question 11 Is the following statement true or false?

"The correct time to clean undercarriage is after starting the job"

A TRUE

B FALSE

Question 12 Which of the following is necessary for Parking of Machine safely?

A Parking Shed

B Loading ramp

C Inclined surface

D Dry and clean surface, level ground, away from fuel storage or water courses

Question 13 Which is the best practice to adopt while shutting down the machine?

A Perform visual inspection of Machine before shutdown

B Lower all the attachments to ground

C Inspect the undercarriage for leakages

D All of the above

Question 14 Housekeeping of Machine do not involve?

A Leveling the lubricant level

B Cleaning of mirrors

C Cleaning of screens and lights

D Cleaning of operator cabin

Question 15 What is the importance of performing visual inspection?

A It helps in reporting any damage timely

B It supports in saving time when starting the job

C It shows the real time physical condition of machine after work

D All of the above

Frequently asked questions (FAQ's)

1. What is Competency Based Training (CBT) and how is it different from currently offered trainings in institutes?	Competency-based training (CBT) is an approach to vocational education and training that places emphasis on what a person can do in the workplace as a result of completing a program of training. Compared to conventional programs, the competency based training is not primarily content based; it rather focuses on the competence requirement of the envisaged job role. The whole qualification refers to certain industry standard criterion and is modularized in nature rather than being course oriented.
2. What is the passing criterion for CBT certificate?	You shall be required to be declared "Competent" in the summative assessment to attain the certificate.
3. What are the entry requirements for this course?	The entry requirement for this course is 8th Grade or equivalent.
4. How can I progress in my educational career after attaining this certificate?	You shall be eligible to take admission in the National Vocational Certificate Level-3 in Leather Products Development Technician (Pattern Maker). You shall be able to progress further to National Vocational Certificate Level-4 in Heavy Construction Machinery Operator Course; and take admission in a level-5, DAE or equivalent course (if applicable). In certain case, You may be required to attain an equivalence certificate from The Inter Board Committee of Chairmen (IBCC).
5. If I have the experience and skills mentioned in the competency standards, do I still need to attend the course to attain this certificate?	You can opt to take part in the Recognition of Prior Learning (RPL) program by contacting the relevant training institute and getting assessed by providing the required evidences.
6. What is the entry requirement for Recognition of Prior Learning program (RPL)?	There is no general entry requirement. The institute shall assess You, identify Your competence gaps and offer You courses to cover the gaps; after which You can take up the final assessment.
7. Is there any age restriction for entry in this course or Recognition of Prior Learning program (RPL)?	There are no age restrictions to enter this course or take up the Recognition of Prior Learning program

8. What is the duration of this course?	The duration of the course work is 1,510 hrs. (11 months)
9. What are the class timings?	The classes are normally offered 25 days a month from 08:00am to 01:30pm. These may vary according to the practices of certain institutes.
10. What is equivalence of this certificate with other qualifications?	As per the national vocational qualifications framework, the level-4 certificate is equivalent to Matriculation. The equivalence certificate can be obtained from The Inter Board Committee of Chairmen (IBCC).
11. What is the importance of this certificate in National and International job market?	This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). These standards are also recognized worldwide as all the standards are coded using international methodology and are accessible to the employers worldwide through NAVTTC website.
12. Which jobs can I get after attaining this certificate? Are there job for this certificate in public sector as well?	You shall be able to take up jobs in the local or overseas construction companies in heavy machinery operator job profile.
13. What are possible career progressions in industry after attaining this certificate?	You shall be able to progress up to the level of supervisor after attaining sufficient experience, knowledge and skills during the job. Attaining additional relevant qualifications may aid Your career advancement to even higher levels.
14. Is this certificate recognized by any competent authority in Pakistan?	This certificate is based on the nationally standardized and notified competency standards by National Vocational and Technical Training Commission (NAVTTC). The official certificates shall be awarded by the relevant certificate awarding body.
15. Is on-the-job training mandatory for this certificate? If yes, what is the duration of on-the-job training?	On-the-job training is not a requirement for final / summative assessment of this certificate. However, taking up on-the-job training after or during the course work may add Your chances to get a job afterwards.
16. How much salary can I get on job after attaining this certificate?	The minimum wages announced by the Government of Pakistan in 2019 are PKR 17,500. This may vary in subsequent years and different regions of the country. Progressive employers may pay more than the mentioned amount. The heavy Machinery Operator normally earns 20,000 to 25,000 in the start.

17. Are there any alternative certificates which I can take up?	There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.
18. What is the teaching language of this course?	The leaching language of this course is Urdu and English.
19. Is it possible to switch to other certificate programs during the course?	There are some short courses offered by some training institutes on this subject. Some institutes may still be offering conventional certificate courses in the field.
20. What is the examination / assessment system in this program?	Competency based assessments are organized by training institutes during the course which serve the purpose of assessing the progress and preparedness of each student. Final / summative assessments are organized by the relevant qualification awarding bodies at the end of the certificate program. You shall be required to be declared “Competent” in the summative assessment to attain the certificate.
21. Does this certificate enable me to work as freelancer?	You can start Your small business by purchasing Your own heavy construction machine and can start earning 50,000 per month. You may need additional skills on entrepreneurship to support Your initiative.

MCQ's answer Sheet:

Question # 01 = B
Question # 02 = B
Question # 03 = A
Question # 04 = D
Question # 05 = D
Question # 06 = A
Question # 07 = C
Question # 08 = B
Question # 09 = B&D
Question # 10 = E
Question # 11 = B
Question # 12 = D
Question # 13 = D
Question # 14 = A
Question # 15 = D

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