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Unit Introduction

What you will learn in this unit

By the end of this unit, you will be able to demonstrate knowledge of:

- Major mechanical components and problems
- Pre-start, shutdown, and maintenance procedures

Why it's important for you to learn this unit

Understanding the mechanical systems is critical knowledge enabling effective inspections, maintenance and detection of deficiencies. In this unit you will learn about the major mechanical components, the required maintenance and how to recognize indicators of equipment failure. It is vital that heavy machinery be properly inspected, maintained, and that start up and post-operational procedures are followed to ensure the safety of the operator and those working around them.

Are you ready to take this unit?

Prior to starting this unit, it is recommended you have completed the following unit:

- 1002 – Describe Forestry Industry

Does this unit apply to you?

This unit applies to the following occupations:

- All Road Building Equipment
- All Mechanized Harvesting Equipment

Section 1082-01: Major Mechanical Components and Problems

What you need to know about this section

By the end of this section, you will be able to demonstrate knowledge of the following key points:

1.1 Major mechanical components requiring maintenance and inspection

1.2 Potential failures, symptoms, and indicators of failure

Key Point 1.1: Major Mechanical Components Requiring Maintenance and Inspection

Heavy equipment operators must have a basic understanding of the mechanical systems of heavy equipment, and be able to apply that knowledge in the field.

Competent inspections, maintenance, and monitoring of heavy equipment depend on the ability to correctly identify major mechanical components, understand their purpose, and understand how each component works to achieve that purpose. An operator needs to be able to effectively communicate with mechanics and other service professionals.

Module 1083, Describe Heavy Equipment Mechanical Systems, describes the basic functions of the main mechanical systems common to all heavy equipment, while this module, 1082, focuses on performing inspections, basic repair and maintenance, and troubleshooting potential problems.

It's up to you to identify the components specific to your machine, and be diligent at thoroughly inspecting and monitoring your machine as you operate it. Your machine's operator's manual is a good resource. You're also responsible for keeping maintenance and inspection records up to date.

The following components require regular maintenance and inspection:

1. Engine and related systems
2. Hydraulic system
3. Fuel system
4. Drive system
5. Undercarriage
6. Track systems or wheels and tires
7. Brakes
8. Electrical system components
9. Swing system
10. Boom, stick, and attachments
11. Safety systems
12. Operator controls

Learning Point

Heavy equipment operators must inspect and maintain their equipment daily and keep complete, accurate records.

Major Mechanical Components Requiring Maintenance and Inspection —Self-Quiz

1. Which of the following is the operator's responsibility?

   - ☐ Daily maintenance of the hydraulic system
   - ☐ Understanding major components of the machine and how they work
   - ☐ Inspecting the machine before operating to ensure it's safe and reliable
   - ☐ All of these answers

Now check your answers on the next page.

Major Mechanical Components Requiring Maintenance and Inspection —Self-Quiz Answers

1. Which of the following is the operator’s responsibility?

Answer: **All of these answers**

Key Point 1.2: Potential Failures, Symptoms, and Indicators of Failure

As the equipment operator, you are responsible for monitoring the mechanical condition of your machine.

If you suspect a problem exists, respond appropriately. The range of responses includes:

- Simple awareness of a minor problem that you would report and schedule for service
- Maintenance or basic repair that you would perform before continuing
- Immediate shut down of the machine

When in doubt, err on the side of caution and inform your employer immediately.

Failing to recognize early signs of problems can lead to increased repair costs. Failure to identify serious conditions requiring immediate removal from service can result in significant consequences, including:

- Hazards to the safety of the operator and other personnel on site, including loss of control of lifts, loss of steering control, inadequate braking, and hazards from the failure of pressurized tires or hydraulic and fuel systems
- Environmental impacts, including fluid leaks, fire, and pollutants
- Damage to equipment and components that may be beyond repair

Gauges and warning systems

Responding to gauges and warning systems is important. The following gauges are usually in the instrument group in the cab and should be checked regularly and never ignored:

- Engine temperature
- High engine coolant temperature
- Unusual voltage (indicates problems with the charging system)
- Low engine oil pressure

Instrument groups. Needle-and-scale gauges in left photo (from ITA HEO manual) and digital gauges in right photo (from Chris Cole, RPF, PEng)

You must also check that the Low Engine Oil Pressure Warning System is working. The warning light should be on when the key is turned to the first position, and must go out within a few seconds after the engine starts.

CAUTION!
Never ignore an oil pressure warning system. Immediate shut down is generally required for either low oil pressure or excessive coolant temperature.

Monitoring systems

Some machines have a monitoring system of sensors, warning lights, and audible signals (beepers and buzzers). These systems indicate different levels of urgency, depending on the severity of the problem:

- A **flashing indicator light** generally means the system needs attention soon

- A constantly **illuminated indicator light** generally means the operator must change the machine operation or remedy the mechanical condition, otherwise damage could result
- An **alarm** sound usually means the operator must change machine operations or shut down immediately, or the machine will be damaged

Systems vary but will typically warn the operator about:

- Excessive hydraulic oil temperature
- Low coolant fluid level
- Low hydraulic oil level
- Excessive restriction in the air filter
- Excessive restriction in the hydraulic filter

Using your senses

Operators must rely on their senses to identify problems as they develop. In general, symptoms of problems include unusual noises, vibration, change in machine performance, smells, leaks, and cracks.

Change in performance (lack of power/improper function)

An operator may notice a change in machine performance, especially under load. Changes could include:

- The engine takes longer to rev up to higher RPMs
- The engine doesn't reach higher RPMs when needed
- Hydraulic component movements are slower or weaker
- Winching movements are slower or weaker
- The machine can't track up hill
- Prolonged lack of power may be less noticeable, but may be characterized by excessive engine heating, excessive fuel consumption, and inability of the machine to perform its intended functions efficiently

If any of these symptoms exist, check for the following causes:

- Dirty engine air intake filters
- Contaminated or poor quality fuel
- Dirty hydraulic oil filters
- Excessively worn hydraulic oil pumps
- Air leaks into the fuel system
- Clogged or dirty internal fuel system components
- Leaves and debris blocking air flow in or out of the engine

Smells

Antifreeze, fuel, and different types of oil each have a distinct smell. Often the first sign of a fluid leak is an odour.

Detecting the odour of antifreeze, for example, should immediately focus your attention to assessing the engine temperature and cooling system function.

Smelling battery electrolyte can alert you to a problem in the charging system (over charging).

Detecting the odour of hydraulic oil should prompt you to visually check the tracks and belly pans.

Fumes can result from overcharging batteries, slipping belts, overheated components and other conditions.

Sounds

Hearing or feeling unusual rattles, vibrations, or clunks are other examples of using your senses to be aware of potential mechanical trouble. Problems such as a loose bolt or clamp or a bearing failing or beginning to seize could be detected by noise or vibration.

Generally, a visual inspection will determine the problem, but the senses of smell, hearing, and feel will often be the first sign.

Visual inspections

A visual inspection is the key to discovering problems early. Experience and mechanical knowledge will improve your ability to focus your inspections on the most likely areas of failure.

Some points to consider:

- Cracks are most likely to appear at the corners and welded seams on fabricated steel components, including buckets and blades, booms, and C-frames.
- Hydraulic leaks often develop at seals and O-rings, and on hoses where the fittings are pressed to the hose. Also check hydraulic cylinders for leaks at the packing, where the rod slips through the seal group into the cylinder.
- Check for rubbing hoses, exposed or protruding wire reinforcing of hoses, and bubbled outer layers of hoses. These all indicate likely failure in the future.
- Keep an eye out for unusual exhaust colour, such as black exhaust (could be a sign of oil getting into the combustion chamber) or exhaust that looks like steam (could be a cracked block).
- Although it’s impossible to check every bolt and fastener, you should scan hardware that tends to come loose regularly, including:
    - Bolts that mount the control valve bank, pumps, alternator, starter, radiator, fan shroud, and other major components
    - Bolts for belly pans and other guarding
    - Bolts and clamps for hydraulic hoses
    - Retaining bolts and/or locking pins that hold pins in place for hydraulic cylinder mounts

Potential Failures, Symptoms, and Indicators of Failure—Self-Quiz

1. True or false
   Operators can rely on monitoring systems to warn them of any issues with the equipment.

   ☐ True

   ☐ False

2. Detecting the odour of hydraulic oil should prompt the operator to:

   ☐ Visually check the tracks and belly pans

   ☐ Check for leaks at seals, O-rings, and where fittings are pressed to the hoses

   ☐ Check hydraulic cylinders for leakage

   ☐ All of these answers

Now check your answers on the next page.

Potential Failures, Symptoms, and Indicators of Failure—Self-Quiz Answers

1. True or false
   Operators can rely on monitoring systems to warn them about any issues with the equipment.

   Answer: **False**
   Monitoring systems are just one tool at the operator's disposal, along with visual inspections and attention to noises, vibrations, and odours.

2. Detecting the odour of hydraulic oil should prompt the operator to:

   Answer: **All of these answers**

Section 1082-2: Pre-Start, Shutdown, and Maintenance

What you need to know about this section

By the end of this section, you will be able to demonstrate knowledge of the following key points:

2.1 Pre-start procedures

2.2 Shutdown procedures

2.3 Maintenance procedures

Key Point 2.1: Pre-Start Procedures

Pre-operational checks and start-up procedures are critical for safe and reliable operation of heavy equipment.

Operator's manuals usually have check lists for each machine to guide your inspections. General procedures include visual checks for loose, damaged, or leaking components, checking for correct levels of all fluids, and checks to confirm proper operation of all systems before putting the machine to work. Warming up the engine is essential.

Pre-operational checks

To ensure your machine is operating safely and efficiently, you must perform a pre-operational check.

This check covers key components of the machine and helps identify maintenance issues and repairs that may be required. Appropriate responses could range from immediate removal from service, to maintenance or basic repair that you will be expected to perform, or reporting conditions that will require service later.

Learning Point

Pre-operational checks require thoroughness and understanding. Checking for leaks or loose hardware involves more than a “quick look.”

A pre-operational check should follow recommended procedures from the manufacturer and/or employer and should include the following checks:

Note: The equipment should still be locked out from the last maintenance. See Key Point 2.3, Maintenance Procedures for lockout details.

General walk around

- Check for obstacles and hazards
- Look for visible fluid leaks or seepage on belly pans, component cases, and on the ground below the machine

Fuel system check

- If you are not sure of gauge operation, check fuel level visually

Engine oil check

- Wipe dipstick before checking
- Some dipsticks have dual markings for idling or engine stopped measurements

Coolant check

- To prevent injury, remove the radiator cap when the engine is cool
- Check coolant level: ensure at least one inch of fluid over radiator core fins
- Check radiator and oil cooler for debris and excessive dirt blocking air flow

Drive belt check

- Check for proper tension and condition and adjust if necessary

Brake check

- Check brake lines, filters, and fluid levels

Transmission fluid check

- Check level with sight glass or dipstick, depending on manufacturer
- Some dipsticks have dual markings for machine off or idling in neutral
- Look for signs of discolouration or sediment

Pump drivecase fluid check

- Some machines have a “dry” pump drive coupling that does not require checking
- Check level with dipstick (located between engine and pumps) and add gear oil as required
- Look for signs of leaks

Swing drivecase fluid check

- Check level with dipstick (located below swing motor) and add gear oil as required
- Look for signs of leaks
- Visually check mounting bolts fastening case to frame

Hydraulic system fluid check

- Check level in sight glass mounted on hydraulic oil reservoir
- Ensure boom, stick, etc. are in correct position for checking level
- Look for signs of discolouration or contamination

Hydraulic system components check

- Look for wear, damage, and leaks on hoses, cylinders, and other components
- Hoses can be weakened by rubbing, chafing and pinching. Hoses leaking hydraulic fluid near high heat sources are a fire risk, and weakened hoses are susceptible to damage under pressure. A compromised hose should be replaced immediately

Electrical system components check

CAUTION!
Use extra caution when inspecting batteries.

- Note any loose or damaged wiring/connections
- All wiring should be inspected for wear, abrasion, and bare spots. Bare wires coming into contact with each other or metal will cause an electrical short and potentially a fire
- Check battery connections/corrosion
- Check electrolyte level, if possible (maintenance-free batteries prevent this)

Air induction check

- Check air filter, preferably by observing restriction indicator. Avoid disturbing/removing filters unless necessary
- Check pre-cleaners, if equipped, and clean as required
- Empty the dust unloading valve on the filter canister, if equipped

- Visually check for secure filter mounting and intake hose condition/connections

Undercarriage check

- Check track tension
- Look for bent or missing pads, and missing or loose bolts for pads
- Check final drive for leaks
- Check sprockets for worn or broken teeth and loose mounting bolts
- Inspect bottom and top rollers for excessive wear, damage, and loose bolts

Wheels and tires check

- Inspect condition of wheels, tires and chains
- Look for loose nuts
- Check tire pressure, tread, and valve stems

Articulation joint check

- Debris accumulates in the area under the cab. If left it poses a potential fire hazard, so it should be removed daily

Hardware and attachments check

- Look for cracks, especially at corners and seams
- Check linkages for signs of wear or damage
- Ensure the grapple is securely mounted (if applicable)
- Inspect pins and pin retaining bolts/locks for grapple mounting, cylinders
- Inspect component mounting bolts, including battery tie downs, alternator, and starter
- Check engine mounts, gear case bolts, drive system, guards, metalwork, etc.
- Check cutting edges or teeth on buckets and blades

Safety systems check

- Inspect seat belts
- Test lockouts
- Check for safe and secure mounting of grapple and blade
- Check lights, horn, back-up alarm, wipers, heater/defrost
- Check operation of gauges and warning lights
- Inspect fire extinguishers and water tanks

Operator controls check

Note: Some checks require vehicle to be in motion.

- Check operation of throttle
- Operate steering lock and note any issues
- Ensure drive system is functioning properly
- Check function of hydraulic lockout

- Check operation of brakes. Watch for excessive pedal travel, pulsation, etc.
- Check function of bucket/attachments

Many employers use checklists to ensure thorough inspections and reporting of conditions that require maintenance or repair.

Reference

Inspection Checklist
See the sample checklist from equipment manufacturer MacAllister Machinery at

https://www.macallister.com/wp-content/uploads/sites/2/preventive-maintenance-checklist-pdf.pdf

When you are finished, continue in this section.

Start-up procedures

Once you're satisfied the machine is ready to operate, follow a start-up procedure like the one below, along with any procedures recommended by the manufacturer. Warming up the engine is essential. Specific procedures will vary by machine, and adjustments are made for cold weather start-up.

1. With the parking brake on, ensure all controls are in neutral position and that blade and attachment controls are in the "hold" position.
2. Switch the ignition key to the "ON" position (engine oil pressure indicator will light up).
3. Move hand throttle to "low idle" position. Start and run the engine for at least five minutes.
4. Check all gauges for proper function (most machines perform an automatic self-test).
5. Shift transmission to low.
6. Press the brake pedal and release the parking brake. Move forward and check for proper braking.
7. Turn wheel and check steering operation.
8. Operate the controls to ensure they work properly.
9. Shift the gear back to neutral and reset the parking brake.
10. Re-check for leaks, vibration, or unusual noises.

Pre-Start Procedures—Self-Quiz

1. True or false:
   It is only necessary to warm up the engine if the temperature is below five degrees Celsius.

   ☐ True

   ☐ False

2. What is the main purpose of a pre-operational check?

   ☐ Adherence to company policy

   ☐ WorkSafeBC compliance

   ☐ Identification of maintenance or service issues

   ☐ Completion of checklist

3. Pre-operational checks and start-up procedures are necessary to:

   ☐ Ensure the machine is safe to operate

   ☐ Lengthen the life of the engine and other components

   ☐ Minimize machine downtime and maximize efficiency

   ☐ All of these answers

Now check your answers on the next page.

Pre-Start Procedures—Self-Quiz Answers

1. It is only necessary to warm up the engine if the temperature is below five degrees Celsius.

   Answer: **False**

2. What is the main purpose of a pre-operational check?

   Answer: **Identification of maintenance or service issues**

3. Pre-operational checks and start-up procedures are necessary to:

   Answer: **All of these answers**

Key Point 2.2: Shutdown Procedures

Proper shutdown will minimize engine and component wear and reduce potential damage. It is essential to properly cool the engine and mechanical systems. Follow these basic steps, along with any procedures recommended by the manufacturer and/or employer:

1. Park the machine in a position that is:

- Safe – on firm ground, clear of other vehicles and machinery
- Level – for accurate fluid level checks at the start of the next shift
- Accessible for service vehicles (for repairs and maintenance, starting trouble, fueling, etc.)

2. Lower any attachments to the ground.
3. Engage the hydraulic lockout lever and reduce the engine speed setting.
4. Run the engine at approximately ¼ speed for two to five minutes to cool down the engine and reduce hot spots.
5. Walk around the equipment to inspect for leaks, cracks, or loose hardware.
6. For tracked equipment, shovel off any material accumulated in the track frames.
7. Switch off the ignition and remove the key.
8. Set the parking brake. Chock the wheels, if necessary.
9. Lock all doors, hood, guards, and any other security measures.
10. If a battery isolation switch is provided, disconnect the batteries (night switch).
11. Clean all grease fittings and lubricate. See Key Point 2.3, Maintenance Procedures, for more information.
12. Record and report any deficiencies.
13. Some machines have battery disconnect switches, equipment guards, or security locks. Make sure you're aware of these features, their locations, and how and when to use them.

Shutdown Procedures—Self-Quiz

1. The machine should be parked in a level position to ensure:
   - ☐ It’s safe to get in and out of
   - ☐ Fluid levels can be accurately checked
   - ☐ The ground underneath is firm
   - ☐ The tracks are level while the machine is not running

Now check your answers on the next page.

Shutdown Procedures—Self-Quiz Answers

1. The machine should be parked in a level position to ensure:

   Answer: **Fluid levels can be accurately checked**

Key Point 2.3: Maintenance Procedures

Equipment maintenance is essential to prevent downtime and to ensure the equipment can be safely operated.

Daily maintenance and record keeping are important parts of your job.

CAUTION!
Immobilize your equipment before doing any maintenance work.

Lockout your equipment

All mobile equipment must be locked out when maintenance or inspection work is being done.

Locking out the machine immobilizes it so it won't roll or fall on you while you're working on it. Proper lockout also signals to others the machine should not be mobilized.

Reference
BC Forest Safety
Read Safety Alert: "Chock it - Block it - Lock it"
Immobilize your equipment
http://bcforestsafe.org/node/1337
When you are finished, continue in this section.

Each machine has its own lockout procedure depending on its components. The procedure will change slightly when multiple people are working on the machine.

The following are examples of lockout procedures for a feller buncher.

Note: Brightly coloured safety tape can be applied to the steering wheel/controls and the windshield, especially if lockout tags aren't available.

Feller Buncher Lockout - Tagout	**Feller Buncher Lockout - Tagout**	**Feller Buncher Tagout**
(If one person working on machine)	**(If two or more persons working on machine)**	***For buncher without master switch***
Shut down procedure: 1. Notify other affected employees. 2. Power off head. 3. Wait for saw to stop or stop against stump. 4. Lower head to the ground. 5. Shut down engine. 6. Set hydraulic lockout lever. 7. Turn off master switch. 8. Put on personal lock and tag on master switch. 9. Test to verify zero energy (electrical, hydraulic, & gravity).	**Shut down procedure:** 1. Notify other affected employees. 2. Power off head. 3. Wait for saw to stop or stop against stump. 4. Lower head to the ground. 5. Shut down engine. 6. Set hydraulic lockout lever. 7. Turn off master switch. 8. Each worker attaches personal lock to scissor lockout hasp on master switch. 9. Test to verify zero energy (electrical, hydraulic, & gravity).	**Shut down procedure:** 1. Notify other affected employees. 2. Power off head. 3. Wait for saw to stop or stop against stump. 4. Lower head to ground. 5. Shut down engine. 6. Key out and in pocket. 7. Put lockout tag initialed by all workers on ignition switch. 8. Test to verify zero energy (electrical, hydraulic, & gravity).
Start-up procedure: 1. Remove personal lock from master switch. 2. Start machine.	**Start-up procedure:** 1. Each employee removes own lock from scissor lockout hasp on master switch 2. Start machine when all locks removed.	**Start-up procedure:** 1. Each employee crosses off their initials on lockout tag when their work is completed. 2. Start machine when all initials on tag crossed off.
		
Lockout tag (front)	**Lockout tag (back)**	**Scissor lockout hasp – with marked locks**

Examples of lockout procedures

Owner's manuals include maintenance information, and service charts are sometimes affixed to the machine. Most employers will expect you to complete some or all of the following tasks:

- Greasing (daily)
- Fluids (daily)
- Fuel (daily)
- Fuel system (weekly and as needed)
- Air induction (daily)
- Battery and electrical (daily)
- Track tension (daily)
- Wheels and tires (daily)
- Buckets and blades (daily)
- Cleaning (daily)
- Tightening loose hardware (as needed)
- Replacing O-rings (as needed)
- Adjusting belt tension (as needed)

Greasing (daily)

Maintaining the machine will always include a daily greasing. Familiarize yourself with every service point (grease nipple) on your machine. Wipe off grease nipples before use to prevent abrasive particles from entering during application. Wipe off excess grease to help to keep the machine clean.

Grease nipple. Photo credit: Chris Cole, RPF, P.Eng.

Exact locations vary by machine, but will always include:

- Pin and bushings at both ends of each hydraulic cylinder
- Pin and bushings forming the connection between the main frame and boom, boom and stick, and attachment and stick
- Linkages between attachments, their cylinders, and the stick
- Swing bearing (grease this weekly)

The amount of grease to apply varies, and equipment owners differ on frequency (daily for most points, weekly for some) and quantity (the number of trigger squeezes, or shots, from a loaded grease gun). In the absence of specific instructions from your employer, follow these guidelines:

- Apply 2 to 3 shots for small areas, like fan bearings, small u-joints, linkages, and hinges
- Use 8 to 10 shots for common pins and bushings
- Use approximately 20 shots where one nipple feeds a large area

Fluids (daily)

Daily fluid check includes checking the following:

- Engine oil
- Coolant
- Transmission fluid
- Pump drivecase fluid
- Swing drivecase fluid
- Hydraulic system fluid

Engine oil

- Wipe dipstick with a clean rag before checking. Some dipsticks have dual markings for idling or engine stopped measurements
- Use the correct type and viscosity as advised by the manufacturer
- Avoid contamination with dirt or water

Coolant

- To prevent injury, remove the radiator cap when the engine is cool
- Check coolant level: ensure at least one inch of fluid over radiator core fins
- Check radiator and oil cooler for debris and excessive dirt blocking air flow
- Coolant must be a mix of water and antifreeze, typically premixed at 50/50

Transmission fluid

- Check level with sight glass or dipstick, depending on manufacturer. Some dipsticks have dual markings for machine off or idling in neutral
- Look for signs of discolouration or sediment

Pump drivecase fluid

- Some machines have a ‘dry’ pump drive coupling that does not require checking
- Otherwise, check level with dipstick (located between engine and pumps) and add gear oil as required

- Be careful not to overfill the small reservoir. Add minor quantities—maybe 1/10th of a litre—then recheck dipstick
- Look for signs of leaks. If leaks or drips are observed, tighten all hose clamps and bolts. If the source of the leak is not found, notify your supervisor. A mechanic may be required
- Visually check mounting bolts that fasten pumps to case, hoses, and other components in the pump drive system. Bolts are sometimes marked with paint to show the rotation position when tight. This makes it easy to spot when they've loosened
- If a hose is cracked, contact your supervisor. They will help you decide whether a mechanic is required. Record the part numbers and sizes of hose and fittings (take photos of parts and leak). Parts will likely need to be ordered. If your supervisor determines you can replace the hose, you'll need to drain the fluid beforehand. Use a bucket to contain the drained fluid

Swing drivecase fluid

- Check level with dipstick (located below swing motor) and add gear oil as required
- Look for signs of leaks and report them to your supervisor. Leaks would likely have to be repaired in shop by a mechanic
- Visually check mounting bolts that fasten case to frame. Bolts are sometimes marked with paint to show the rotation position when tight. This makes it easy to spot when they've loosened

Hose clamps and hydraulic hose fittings marked for tightening (photo from Chris Cole, RPF, PEng)

Hydraulic system fluid

- Check the hydraulic fluid reservoir and top up if needed. If there is dirt or debris around the cap, wipe it off before unscrewing to avoid contamination with dirt or water
- Ensure boom, stick, etc. are in the correct position for checking level. If unsure, check the operators manual
- Look for signs of discolouration or contamination

Fuel (daily)

Top up fuel tanks daily to reduce water condensation in the tank. Check the fuel level visually if you're not sure of gauge operation.

Fuel system (weekly and as needed)

Fuel systems have three levels of protection:

- the sump
- the water separator (with sediment bowl)
- the fuel filter

Sump

Fuel tanks are designed with a basic sump—a low point in the tank where contaminants like water and debris settle. Fuel is lighter than water, so water will settle to the bottom of the tank.

Drain the sump the first time you operate a machine, then at weekly intervals thereafter:

- Have a container or absorbent pad in place to contain the spillage, then open the drain valve and drain the sump until clean diesel begins to flow. Do this at the beginning of a shift before the movement of the machine has disturbed the fuel and mixed the solids and water with the fuel
- These drains are sometimes plugged with sediment and scale. A piece of mechanic's wire (hay wire) will usually clear the restriction

Water separator and sediment bowl

Located on the fuel line, there may be a water separator with a sediment bowl, the second level of protection. The bowl is clear so you can see if water or sediment is present. Drain the bowl until clean diesel fuel begins to flow.

Fuel filter

Fuel filters help prevent fuel system wear. While specifications vary by manufacturer, all fuel filters are designed to trap very fine particles, some as small as 2 microns (a human hair has a diameter of 80 microns). They also prevent premature fuel pump and injector wear.

Fuel filters, unlike oil filters, do not have a bypass feature. This means that if it's plugged, no fuel will flow—effectively starving the engine and causing it to stall. It's for this reason that **the typical first step in troubleshooting an engine running poorly (or not at all) is to change the fuel filters.** Often operators are expected to do this.

The process will vary by machine, but changing the fuel filter generally involves the following steps:

1. Use a filter wrench to remove the spin-on type (counter clockwise to loosen threads).
2. Lubricate the seal of the new filter.
3. Clean the area and ensure the filter doesn't touch anything that could be oily or dirty. The goal is to keep the filter mounting face completely free of contamination. Even a small amount of debris can do serious damage to the injection pump and injectors.
4. Carefully align the filter with the mounting threads—avoid cross threading—and spin on clockwise to tighten. Tighten until the seal fully contacts the housing, and then continue to twist the filter by hand only another ¾ turn. Do not over torque. A filter wrench is not necessary to achieve the correct torque.
5. Loosen (don't remove) a bleed screw or fitting on the outlet circuit of the filter housing to allow air to escape.
6. Operate the priming pump until clear fuel, without air bubbles, escapes from the bleed screw.
7. Tighten the bleed screw or fitting carefully. These are fragile and will be easily broken by over tightening.
8. Start the engine and inspect the filter and bleed screw or fitting for leaks. If there is a leak, the O-ring likely did not seat properly in the slot, so reposition or replace it and tighten again.

Note that using the priming pump as the only means of removing air helps reduce the risk of contaminants. Some operators and mechanics choose to pre–fill the filter with fuel, but this can cause contaminants to enter the injection pump.

Air induction (daily)

The job of the air induction system is to provide clean air at adequate flow to ensure efficient combustion in the engine.

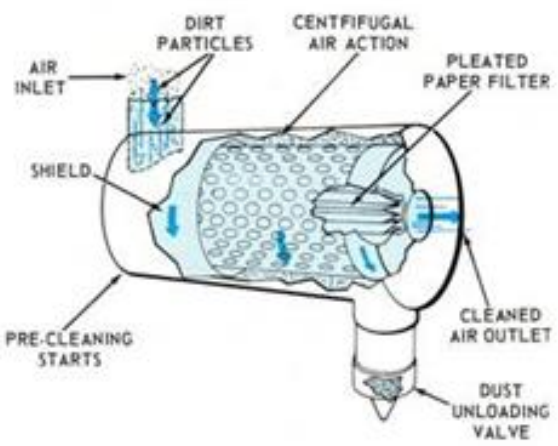
Pre cleaner

There is often a pre cleaner to remove larger particles. In most pre-cleaner systems, air is taken in through fan-like vanes and spun at high speeds in a bowl-shaped device, allowing heavier particles to settle out as flow slows. The bowl is generally clear to allow operators to see the level of accumulated dust. **Visually inspect daily, and empty the bowl when the dust level rises to one inch.**

Emptying the dust bowl (photo from ITA HEO manual)

Dust unloading valve

A dust unloading valve is often installed at the bottom of the air filter housing. This is a small, flexible rubber fitting designed to be squeezed to open a slit, allowing the dust that has settled to drop out. **Daily inspections should include opening this valve and checking for a tight seal of the filter housing and lines and secure mounting hardware.**



Dry air cleaner with unloading valve (photo from ITA HEO manual)

Air filter, housing, and lines

Proper air filtration is essential to protect the engine from dust and other contaminants. Even a small amount of dust can cause major damage or greatly reduce the life of your engine.

Your goal is to ensure that the filter, the housing, and the steel and flexible lines leading to the engine are in perfect condition, and that all connections are secure. The system must completely prevent contaminants from entering the engine.

The air filter removes particles while allowing adequate flow of intake air to ensure efficient combustion. Fuel economy, clean combustion, and maximum power output of the engine depend on good air flow. A filter that is clogged will prevent this.

Constantly removing the filter to inspect it for clogging is not good practice because of the likelihood that a small amount of dust will enter the inner surfaces every time the filter is disturbed. Many machines are equipped with air flow restriction indicators that allow the operator to check for proper air flow without removing the filter.

Air filter indicators can be mounted directly to the air filter housing or induction piping with a threaded or grommet fitting. Other options allow for the installation of a remote or instrument panel mount for more convenient reading.

Certain models of air filter indicators are graduated while others simply feature a “red zone” that indicates reduced flow.

Typical air filter gauges: dash-mounted (left) and filter-mounted (right) (photo from ITA HEO manual)

Maintenance procedures for air filters vary by employer. Some employers insist on replacing dirty filters, while others may encourage cleaning with compressed air (at reduced pressure) to expel particles so the filter can be re-used.

Special nozzles are available that reduce air pressure to blow out air filters with reduced risk of damaging the filter element. The nozzle should be positioned in the inside of the filter to blow outwards through the paper element. It’s important to avoid dust entering the inner surfaces of the filter or the filter housing canister of the machine.

It should be obvious that the engine must be turned off before removing the filter and must never be running without a properly installed filter.

Typical filters include a large circular seal that fits against the back of the filter housing, and often a smaller seal that fits around the wing nut that fastens the filter onto the threaded mounting stud. Both should be carefully inspected and installed to ensure a perfect seal to keep dust out of the inner area of the filter.

Never take a chance with any defect in seals or filters.

Battery and electrical (daily)

Daily battery and electrical maintenance includes the following:

- Check battery connections for tightness and corrosion. Clean or tighten as required
- Note any loose or damaged wiring/connections, battery connections/corrosion
- Check electrolyte fluid level and top up if necessary

Note: The majority of modern batteries are maintenance-free sealed units, so this may not be necessary.

- Check that any vents are clear of debris
- Wipe any visible residue from the top of the battery. Accumulated dirt and fluids can cause a trickle power discharge
- Replace burned-out light bulbs. Ensure correct voltage

Track tension (daily)

Track systems include a large spring that is mounted behind the idler. The spring can provide recoil movement to absorb shock loads and to help prevent severe strain or over-tightening of the track due to soil buildup.

This spring works with a grease-filled cylinder as the mechanism for adjusting track tension. **Adding grease to the cylinder tightens the track, and releasing grease from the cylinder loosens the track:**

- Adding grease to the cylinder extends the piston length, pushing the idler yoke and moving the idler forward to decrease slack (or sag) in the track. Grease is simply pumped into a relief valve with a grease fitting
- Conversely, track sag is increased by loosening the relief valve to allow grease to escape. Backing off the threads a single turn or less is usually sufficient. When enough grease pours out to achieve the desired slack, re-tighten the valve

Adjusting track tension (photo from ITA HEO manual)

Operators should develop the ability to assess track tension by observing the slack at the top of the track group, and by noticing the degree of bounce or slack when the tracks are being moved to propel the machine. These indicators will prompt the operator to check the tension more accurately, as follows:

1. Swing the attachment (such as the bucket, processor head, etc.) to the side, lower it to the ground, and continue downward pressure until the track is raised just enough to clear the ground (12 to 18 inches).
2. Rotate the track backwards to allow soil to fall clear at the top of the track chain.
3. Rotate the track a short distance forward and backward, stopping after a rearwards rotation so the track sag is at the bottom.
4. Measure the track sag at the centre, where the distance is greatest (see white arrow in picture above, right), from the bottom of the track pad to the surface of the track frame where the bottom rollers mount.

Note: Operator's manuals specify the track sag dimension for each model. Machines that have longer undercarriages will have greater track sag dimensions. With experience, you'll learn to assess the sag visually.

Wheels and tires (daily)

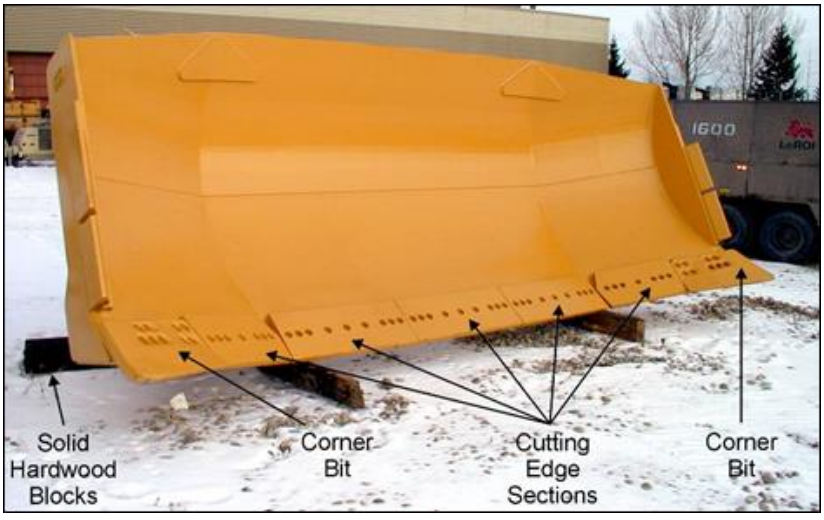
Daily wheels and tires maintenance include the following:

- Inspect condition of wheels, tires and chains
- Check that mounting nuts are tight
- Check the tire pressure with a pressure gauge and ensure it's within the range specified by the manufacturer
- Check tire tread and valve stems
- Note any signs of tire or wheel damage
- Inspect axles and drive shafts

Buckets and Blades

Blades

Cutting edge segments on blades are replaceable, and the edges are also reversible, allowing "flipping" when one edge is worn.



Common features of blades (photo from ITA HEO manual)

When replacing cutting edges, make sure all surfaces are clean of paint and dirt, and grind off any burrs or damage that will prevent cutting edges or adapters from fitting properly. A poor fit will cause mounting bolts to come loose. Be sure to torque all fasteners to manufacturer's specifications.

Digging buckets

Digging buckets have bolt-on cutting edges, or disposable teeth pinned to a weld-on shank. Replace worn teeth before they wear through and cause damage to the shank. The cost of teeth is relatively cheap compared to the cost of a new bucket.

Bucket missing replaceable tooth (photo from ITA HEO manual)

Hard surfacing

Hard surfacing is used to promote the extended wear properties of many ground engaging attachments. This involves applying hard materials by arc welding with special rod or wire to surfaces that are the most prone to wear, like the leading edges and bottom edges of buckets.

Cleaning (daily)

Daily cleaning of buckets and blades include the following:

- Shovel soil and rocks from track frames. When working during periods of cold weather, soil and rock that is warmed by the machine during use may freeze solid overnight when the machine is parked. Frozen soil around track rollers may cause the rollers to seize and be damaged or ruined during subsequent use
- Remove any garbage from the machine
- Sweep out the cab. Wipe off the instrument panels and consoles
- Wipe up any excess grease
- Clean windows and mirrors

- Remove any accumulated debris, dirt, or leaves from engine, pivot points, radiator, oil coolers, etc.
- Organic debris, such as leaves and twigs, is a constant menace. It presents a considerable fire hazard when in contact with areas that reach potential ignition temperature. Debris accumulations should be monitored daily and removed. Best practice is to remove the debris by hand daily and remove it completely at least weekly. An air compressor may be used to back blow debris from radiators when a fan reversing function is not available. Don't forget to remove accumulations from the belly pan. Debris accumulations can be ignition points or additional fuel for a fire
- Before a machine can be loaded onto a trailer for transport on public roads, all rock, soil, and loose debris must be removed so it does not fall onto the road and damage a trailing vehicle

Tightening loose hardware (as needed)

If you discover any loose nuts or bolts during inspection, tighten them with a torque wrench according to the manufacturer's specifications.

When checking the torque value of wheel lug nuts, wait for the wheels to cool to ambient temperature (never torque a hot wheel). Loosen and retighten to value and in sequence, using the torque procedures provided by the manufacturer.

Replacing O-rings (as needed)

O-rings are one of the most common seals used in machine design. If a connection is leaking or if you see damage to an O-ring when inspecting, replace the O-ring.

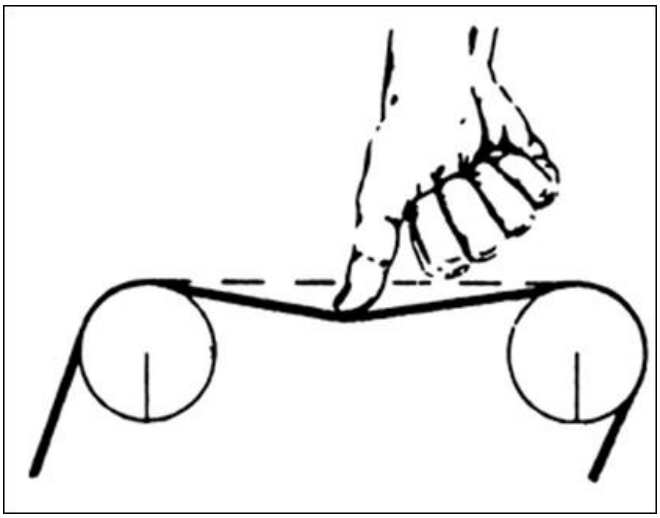
Replacement O-rings

Source: Caterpillar Parts https://parts.cat.com/en/catcorp/o-ring-products/o-ring-seal-kits/271-0459.

Adjusting belt tension (as needed)

Adjust belt tension to the manufacturer's specifications. The owner's manual will specify how much the belt should flex when you apply pressure.

If there are signs of excessive wear or damage, replace the belt according to the owner's manual specifications.



Checking belt tension with thumb pressure

Image from mazdabg.com http://www.mazdabg.com/ftp-uploads/Mazda/--Repair%20Instructions--/1972-1986%20Mazda%20Truck/9057CH01_TENSION_CHECKING___ADJUSTING.htm.

Maintenance Procedures—Self-Quiz

1. Which of the following would an operator NOT be expected to do?
   - ☐ Change bucket blades
   - ☐ Replace fuel filter
   - ☐ Change hoses
   - ☐ Complete mechanical safety inspection
   - ☐ Drain fuel system sump
2. What tool would an operator use to adjust track tension?
   - ☐ Torque wrench
   - ☐ Allen wrench
   - ☐ Grease gun
   - ☐ Pry bar
3. Which is NOT part of the fuel system?
   - ☐ Sediment bowl
   - ☐ Sump
   - ☐ Pre-cleaner
   - ☐ Filter
4. How frequently should logging equipment be greased under normal use?
   - ☐ Daily
   - ☐ Weekly
   - ☐ As directed by your supervisor
   - ☐ At the beginning and end of each shift

Now check your answers on the next page.

Maintenance Procedures—Self-Quiz Answers

1. Which of the following would an operator NOT be expected to do?

   Answer: **Complete mechanical safety inspection**

   A complete mechanical safety inspection is a term used for a detailed safety inspection by a licensed mechanic.

2. What tool would an operator use to adjust track tension?

   Answer: **Grease gun**

3. Which is NOT part of the fuel system?

   Answer: **Pre-cleaner**

4. How frequently should logging equipment be greased under normal use?

   Answer: **Daily**