



THE HEART OF EVERY GREAT MACHINE

M0092374-03 (en-us)
May 2023

Operation and Maintenance Manual

404J-22 Industrial Engine

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions correctly.

Incorrect operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the "Safety Alert Symbol" and followed by a "Signal Word" such as "DANGER", "WARNING" or "CAUTION". The Safety Alert "WARNING" label is shown below.



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by "NOTICE" labels on the product and in this publication.

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. If a tool, procedure, work method or operating technique that is not specifically recommended by Perkins is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Perkins dealers or Perkins distributors have the most current information available.



When replacement parts are required for this product Perkins recommends using Perkins replacement parts.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner's choosing.

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Foreword

California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.



WARNING – This product can expose you to chemicals including ethylene glycol, which is known to the State of California to cause birth defects or other reproductive harm. For more information go to:

www.P65Warnings.ca.gov

Do not ingest this chemical. Wash hands after handling to avoid incidental ingestion.



WARNING – This product can expose you to chemicals including lead and lead compounds, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information go to:

www.P65Warnings.ca.gov

Wash hands after handling components that may contain lead.

Literature Information

This manual contains safety, operation instructions, lubrication, and maintenance information. This manual should be stored in or near the engine area in a literature holder or literature storage area. Read, study, and keep the manual with the literature and engine information.

English is the primary language for all Perkins publications. The English used facilitates translation and consistency.

Some photographs or illustrations in this manual show details or attachments that may be different from your engine. Guards and covers may have been removed for illustrative purposes. Continuing improvement and advancement of product design may have caused changes to your engine which are not included in this manual. Whenever a question arises regarding your engine, or this manual, please consult with your Perkins dealer or your Perkins distributor for the latest available information.

Safety

This safety section lists basic safety precautions. In addition, this section identifies hazardous, warning situations. Read and understand the basic precautions listed in the safety section before operating or performing lubrication, maintenance, and repair on this product.

Operation

Operating techniques outlined in this manual are basic. The operating techniques assist with developing the skills and techniques required to operate the engine more efficiently and economically. Skill and techniques develop as the operator gains knowledge of the engine and the capabilities of the engine.

The operation section is a reference for operators. Photographs and illustrations guide the operator through procedures of inspecting, starting, operating, and stopping the engine. This section also includes a discussion of electronic diagnostic information.

Maintenance

The maintenance section is a guide to engine care. The illustrated, step-by-step instructions are grouped by service hours and/or calendar time maintenance intervals. Items in the maintenance schedule are referenced to detailed instructions that follow.

Recommended service should be performed at the appropriate intervals as indicated in the Maintenance Interval Schedule. The actual operating environment of the engine also governs the Maintenance Interval Schedule. Therefore, under severe, dusty, wet, or freezing cold operating conditions, more frequent lubrication, and maintenance than is specified in the Maintenance Interval Schedule may be necessary.

The maintenance schedule items are organized for a preventive maintenance management program. If the preventive maintenance program is followed, a periodic tune-up is not required. The implementation of a preventive maintenance management program should minimize operating costs through cost avoidances resulting from reductions in unscheduled downtime and failures.

Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. Each level and/or individual items in each level should be shifted ahead or back depending upon your specific maintenance practices, operation, and application. Perkins recommends that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. Perkins also recommends that a maintenance record be maintained as part of the permanent record of the engine.

Your authorized Perkins dealer or your Perkins distributor can assist you in adjusting your maintenance schedule to meet the needs of your operating environment.

Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance Manual except for the interval and the maintenance items in that interval. Major repairs are best left to trained personnel or an authorized Perkins distributor or dealer. Your Perkins dealer or your Perkins distributor offers various options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available. Consult with your Perkins dealer or your Perkins distributor for information regarding these options.

Safety Section

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Safety Messages

There may be several specific warning signs on your engine. The exact location and a description of the warning signs are reviewed in this section. Become familiar with all warning signs.

Ensure that all the warning signs are legible. Clean the warning signs or replace the warning signs if the words cannot be read or if the illustrations are not visible. Use a cloth, water, and soap to clean the warning signs. Do not use solvents, gasoline, or other harsh chemicals. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the warning signs.

Replace any warning sign that is damaged or missing. If a warning sign is attached to a part of the engine that is replaced, install a new warning sign on the replacement part. Your Perkins dealer or your distributor can provide new warning signs.

Universal Warning



Do not operate or work on this equipment unless you have read and understand the instructions and warnings in the Operation and Maintenance Manuals. Failure to follow the instructions or heed the warnings could result in serious injury or death.

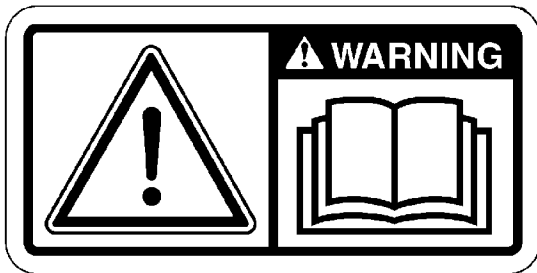


Illustration 1
Typical example

g01154807

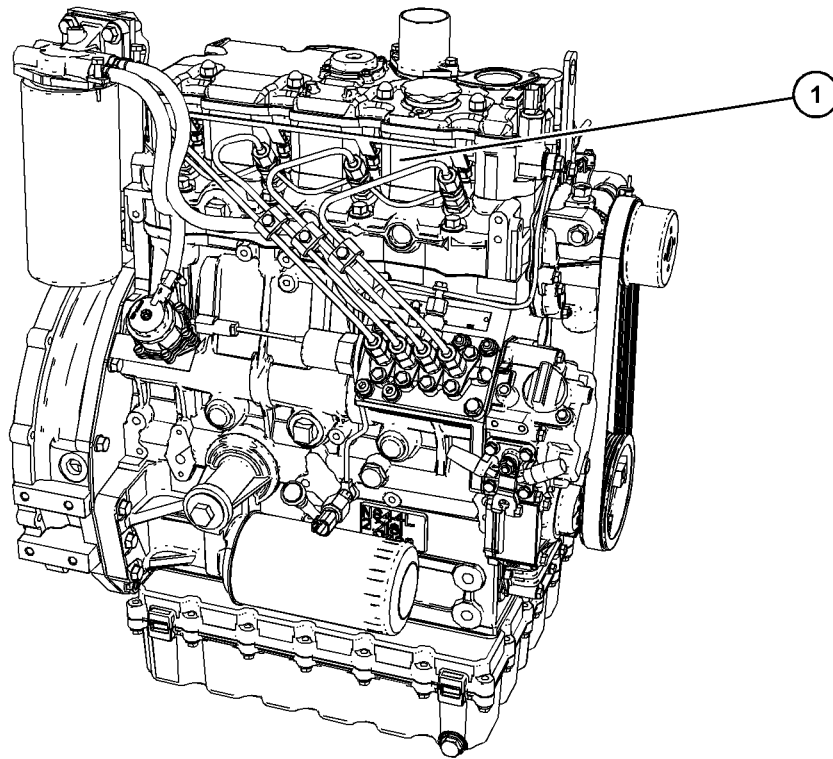


Illustration 2

g06137496

Typical example

The universal warning label (1) is installed on the right side of the valve mechanism cover.

Ether Warning

 **WARNING**

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.



Illustration 3

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Typical example

The ether warning label will be supplied loose. The label should be installed close to the air cleaner intake.

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General Hazard Information

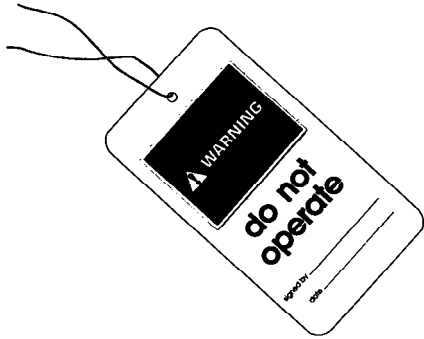


Illustration 4

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Attach a “Do Not Operate” warning tag or a similar warning tag to the start switch or to the controls before you service the equipment or before you repair the equipment.

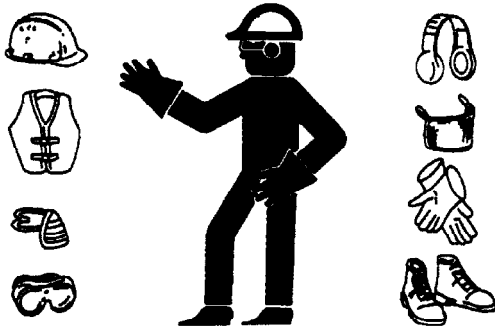


Illustration 5

g00702020

Wear a hard hat, protective glasses, and other protective equipment, as required.

Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.

Make sure that all protective guards and all covers are secured in place on the engine.

Keep the engine free from foreign material. Remove debris, oil, tools, and other items from the deck, from walkways, and from steps.

Never put maintenance fluids into glass containers. Drain all liquids into a suitable container.

Obey all local regulations for the disposal of liquids.

Use all cleaning solutions with care.

Report all necessary repairs.

Do not allow unauthorized personnel on the equipment.

Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads to help prevent sparks. If equipped, allow the diesel exhaust fluid to be purged before disconnecting the battery.

Perform maintenance on the engine with the equipment in the servicing position. Refer to the OEM information for the procedure for placing the equipment in the servicing position.

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

For initial start-up of a new engine or for starting an engine that has been serviced, make provisions to stop the engine if an overspeed occurs. The stopping of the engine may be accomplished by shutting off the fuel supply and/or the air supply to the engine. Ensure that only the fuel supply line is shut off. Ensure that the fuel return line is open.

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

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

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

Pressure Air and Water

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

The direct application of pressurized air or pressurized water to the body could result in personal injury.

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

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

Fluid Penetration

Pressure can be trapped in the hydraulic circuit long after the engine has been stopped. The pressure can cause hydraulic fluid or items such as pipe plugs to escape rapidly if the pressure is not relieved correctly.

Do not remove any hydraulic components or parts until pressure has been relieved or personal injury may occur. Do not disassemble any hydraulic components or parts until pressure has been relieved or personal injury may occur. Refer to the OEM information for any procedures that are required to relieve the hydraulic pressure.

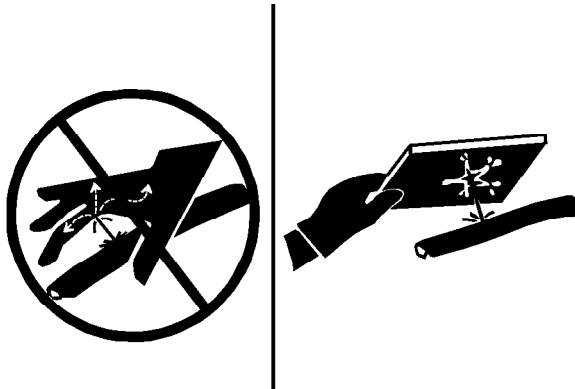


Illustration 6

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

Containing Fluid Spillage

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting, and repair of the engine. Make provision to collect the fluid with a suitable container before any compartment is opened or before any component is disassembled.

- Only use the tools that are suitable for collecting fluids and equipment that is suitable for collecting fluids.
- Only use the tools that are suitable for containing fluids and equipment that is suitable for containing fluids.

Ensure that any spill that may occur are cleaned up.

Obey all local regulations for the disposal of liquids.

Static Electricity Hazard when Fueling with Ultra-low Sulfur Diesel Fuel

The removal of sulfur and other compounds in ultra-low sulfur diesel (ULSD) fuel decreases the conductivity of ULSD and increases the ability of ULSD to store static charge. Refineries may have treated the fuel with a static dissipating additive. Many factors can reduce the effectiveness of the additive over time. Static charges can build up in ULSD fuel while the fuel is flowing through fuel delivery systems. Static electricity discharge when combustible vapors are present could result in a fire or explosion. Ensure that the entire system used to refuel your machine (fuel supply tank, transfer pump, transfer hose, nozzle, and others) is properly grounded and bonded. Consult with your fuel or fuel system supplier to ensure that the delivery system complies with fueling standards for proper grounding and bonding.

WARNING

Avoid static electricity risk when fueling. Ultra-low sulfur diesel fuel (ULSD fuel) poses a greater static ignition hazard than earlier diesel formulations with a higher sulfur contents. Avoid death or serious injury from fire or explosion. Consult with your fuel or fuel system supplier to ensure the delivery system is in compliance with fueling standards for proper grounding and bonding practices.

Inhalation

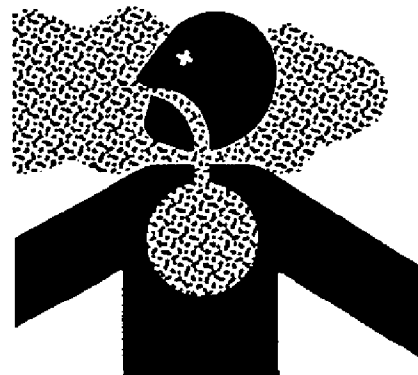


Illustration 7

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Exhaust

Use caution. Exhaust fumes can be hazardous to health. If you operate the equipment in an enclosed area, adequate ventilation is necessary.

Hexavalent Chromium

Perkins equipment and replacement parts comply with applicable regulations and requirements where originally sold. Perkins recommends the use of only genuine Perkins replacement parts.

Hexavalent chromium has occasionally been detected on exhaust and heat shield systems on Perkins engines. Although laboratory testing is the only accurate way to know if hexavalent chromium is, in fact, present, the presence of a yellow deposit in areas of high heat (for example, exhaust system components or exhaust insulation) may be an indication of the presence of hexavalent chromium.

Use caution if you suspect the presence of hexavalent chromium. Avoid skin contact when handling items that you suspect may contain hexavalent chromium, and avoid inhalation of any dust in the suspect area. Inhalation of, or skin contact with, hexavalent chromium dust may be hazardous to your health.

If such yellow deposits are found on the engine, engine component parts, or associated equipment or packages, Perkins recommends following local health and safety regulations and guidelines, utilizing good hygiene, and adhering to safe work practices when handling the equipment or parts. Perkins also recommends the following:

- Wear appropriate Personal Protective Equipment (PPE)
- Wash your hands and face with soap and water prior to eating, drinking, or smoking, and also during rest room breaks, to prevent ingestion of any yellow powder
- Never use compressed air for cleaning areas suspected of containing hexavalent chromium
- Avoid brushing, grinding, or cutting materials suspected of containing hexavalent chromium
- Obey environmental regulations for the disposal of all materials that may contain or have come into contact with hexavalent chromium
- Stay away from areas that might have hexavalent chromium particles in the air.

Asbestos Information

Perkins equipment and replacement parts that are shipped from Perkins engine company limited are asbestos free. Perkins recommends the use of only genuine Perkins replacement parts. Use the following guidelines when you handle any replacement parts that contain asbestos or when you handle asbestos debris.

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

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

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

Dispose of Waste Properly

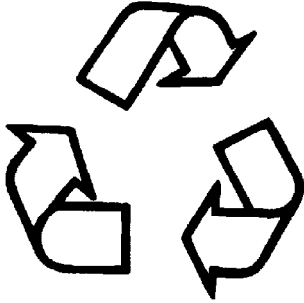


Illustration 8

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Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of in accordance with local regulations.

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

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Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine. Relieve all pressure in the air system, in the hydraulic system, in the lubrication system, in the fuel system, or in the cooling system before any lines, fittings, or related items are disconnected.

Coolant

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

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

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

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

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

Oils

Skin may be irritated following repeated or prolonged exposure to mineral and synthetic base oils. Refer to your suppliers Material Safety Data Sheets for detailed information. Hot oil and lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Appropriate personal protective equipment should be used.

Diesel Fuel

Diesel may be irritating to the eyes, respiratory system, and skin. Prolonged exposure to diesel may cause various skin conditions. Appropriate personal protective equipment should be used. Refer to supplier Material safety Data sheets for detailed information.

Batteries

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

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Fire Prevention and Explosion Prevention



Illustration 9

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

Safety Section
Fire Prevention and Explosion Prevention

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

A flash fire may result if the covers for the engine crankcase are removed within 15 minutes after an emergency shutdown.

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

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

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

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

Do not expose the engine to any flame.

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

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

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

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

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

Inspect all lines and hoses for wear or for deterioration. The hoses must be correctly routed. The lines and hoses must have adequate support and secure clamps. Tighten all connections to the recommended torque. Leaks can cause fires.

Oil filters and fuel filters must be correctly installed. The filter housings must be tightened to the correct torque.



Illustration 10

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

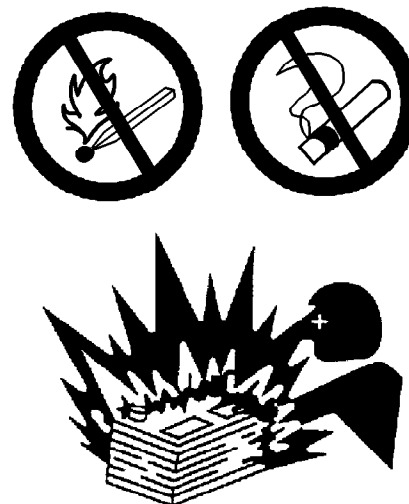


Illustration 11

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

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

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

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

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

Fire Extinguisher

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

Ether

Ether is flammable and poisonous.

Do not smoke while you are replacing an ether cylinder or while you are using an ether spray.

Do not store ether cylinders in living areas or in the engine compartment. Do not store ether cylinders in direct sunlight or in temperatures above 49° C (120° F). Keep ether cylinders away from open flames or sparks.

Lines, Tubes, and Hoses

Do not bend high-pressure lines. Do not strike high-pressure lines. Do not install any lines that are bent or damaged. Do not clip any other items to the high-pressure lines.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult your Perkins dealer or your Perkins distributor for repair or for replacement parts.

Check lines, tubes, and hoses carefully. Do not use your bare hand to check for leaks. Use a board or cardboard to check for leaks. Tighten all connections to the recommended torque.

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

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible parts of the hoses are kinked.
- Outer covers have embedded armoring.

- End fittings are displaced.

Make sure that all clamps, guards, and heat shields are installed correctly. During engine operation, correct installation will help to prevent vibration, rubbing against other parts, and excessive heat.

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Crushing Prevention and Cutting Prevention

Support the component correctly when work beneath the component is performed.

Unless other maintenance instructions are provided, never attempt adjustments while the engine is running.

Stay clear of all rotating parts and of all moving parts. Leave the guards in place until maintenance is performed. After the maintenance is performed, reinstall the guards.

Keep objects away from moving fan blades. The fan blades will throw objects or cut objects.

When objects are struck, wear protective glasses in order to avoid injury to the eyes.

Chips or other debris may fly off objects when objects are struck. Before objects are struck, ensure that no one will be injured by flying debris.

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Mounting and Dismounting

Do not climb on the engine. The engine has not been designed with mounting or dismounting locations.

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

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Before Starting Engine

NOTICE

For initial start-up of a new or rebuilt engine, and for start-up of an engine that has been serviced, make provision to shut the engine off should an overspeed occur. This may be accomplished by shutting off the air and/or fuel supply to the engine.

⚠ WARNING

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

Inspect the engine for potential hazards.

Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" warning tag or similar warning tag attached to the start switch or to the controls.

Before starting the engine, ensure that no one is on, underneath, or close to the engine. Ensure that the area is free of personnel.

If equipped, ensure that the lighting system for the engine is suitable for the conditions. Ensure that all lights work properly, if equipped.

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

Do not bypass the automatic shutoff circuits. Do not disable the automatic shutoff circuits. The circuits are provided in order to help prevent personal injury. The circuits are also provided in order to help prevent engine damage.

See the Service Manual for repairs and for adjustments.

i02157354

Engine Starting

⚠ WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

If a warning tag is attached to the engine start switch or to the controls, DO NOT start the engine or move the controls. Consult with the person that attached the warning tag before the engine is started.

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

Start the engine from the operator's compartment or from the engine start switch.

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

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

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

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

The 400 Series engines are equipped with a glow plug starting aid in each individual cylinder that heats the intake air in order to improve starting.

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Engine Stopping

Stop the engine according to the procedure in the Operation and Maintenance Manual, "Engine Stopping (Operation Section)" in order to avoid overheating of the engine and accelerated wear of the engine components.

Use the Emergency Stop Button (if equipped) ONLY in an emergency situation. Do not use the Emergency Stop Button for normal engine stopping. After an emergency stop, DO NOT start the engine until the problem that caused the emergency stop has been corrected.

Stop the engine if an overspeed condition occurs during the initial start-up of a new engine or an engine that has been overhauled.

To stop an electronically controlled engine, cut the power to the engine and/or shutting off the air supply to the engine.

i06840365

Electrical System

Never disconnect any charging unit circuit or battery circuit cable from the battery when the charging unit is operating. A spark can cause the combustible gases that are produced by some batteries to ignite.

To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative “-” jump start cable should be connected last from the external power source to the negative “-” terminal of the starting motor. If the starting motor is not equipped with a negative “-” terminal, connect the jump start cable to the engine block.

Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before the engine is started. Repair all frayed electrical wires before the engine is started. See the Operation and Maintenance Manual for specific starting instructions.

Grounding Practices

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

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

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

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

All grounds should be tight and free of corrosion. The engine alternator must be grounded to the negative “-” battery terminal with a wire that is adequate to handle the full charging current of the alternator.

Product Information Section

General Information

i06888382

Model View Illustrations

Engine Views

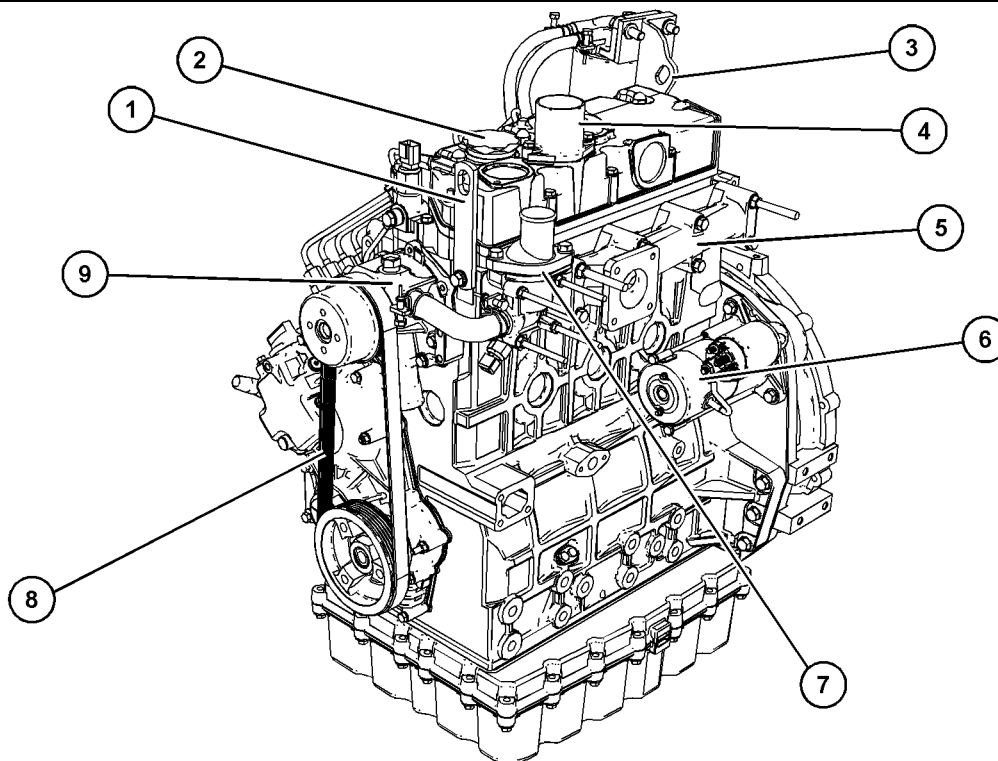


Illustration 12

g06137805

Typical example

- (1) Front lifting eye
- (2) Top oil filler
- (3) Rear lifting eye

- (4) Air intake
- (5) Exhaust manifold
- (6) Starting motor

- (7) Coolant outlet
- (8) Drive belt
- (9) Coolant pump

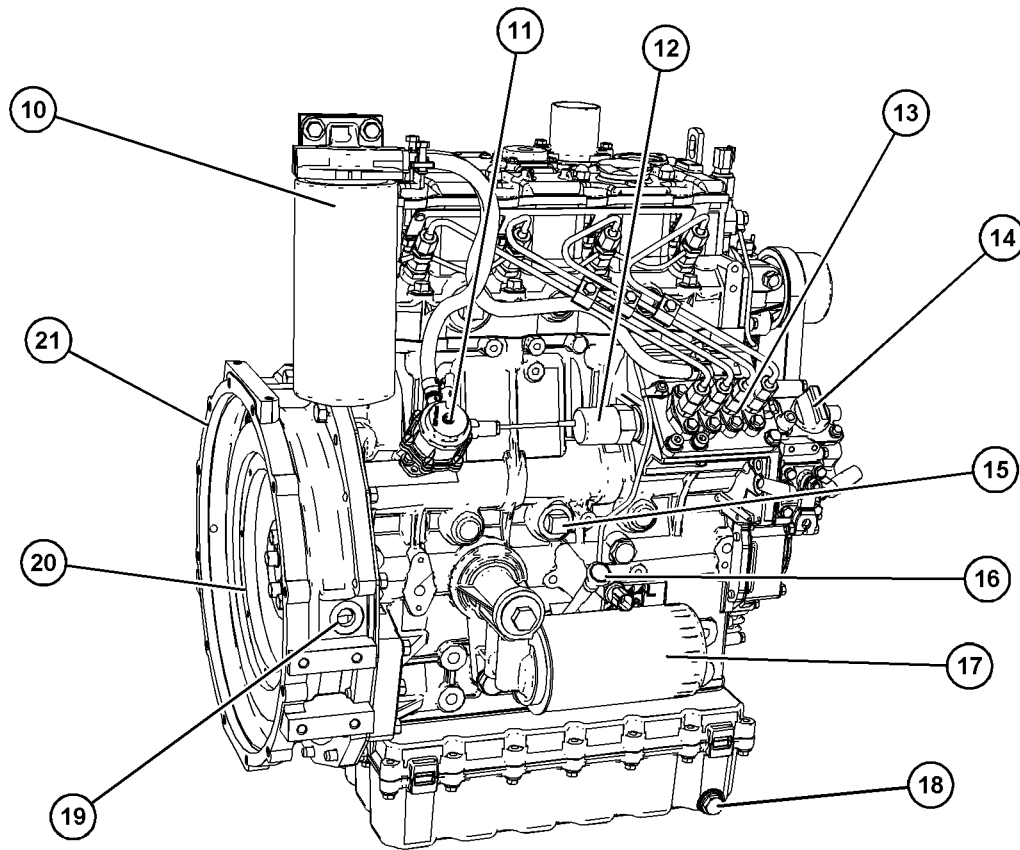


Illustration 13

g06137819

Typical example

- | | | |
|--|--------------------------------|--------------------------------|
| (10) Secondary fuel filter | (14) Oil filler | (19) location for speed sensor |
| (11) Fuel lift pump | (15) Cylinder block drain plug | (20) Flywheel |
| (12) Actuator that is controlled by the
Electronic Control Module (ECM) | (16) Oil gauge (Dipstick) | (21) Flywheel housing |
| (13) Fuel injection pump | (17) Oil filter | |
| | (18) Oil drain plug | |

Off Engine Components

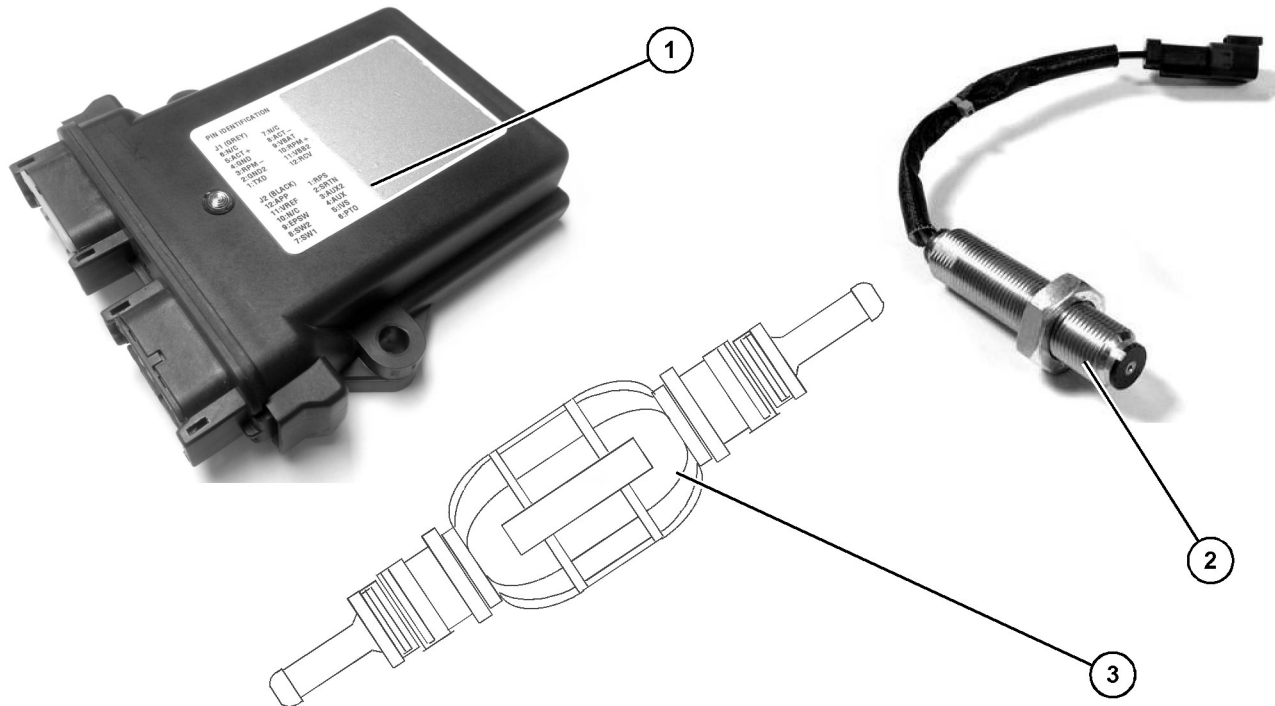


Illustration 14

g06155362

Typical example

(1) Electronic Control Module (ECM)

(2) Speed sensor

(3) Hand fuel priming pump

i09627096

Product Description

This engine sales model 404J-22 with engine build lists of IN84182 and IN84331 is a special design. This design incorporates many unique components to give the engine an extended service capability.

Engine Specifications

The front end of the engine is opposite the flywheel end of the engine. The left and the right side of the engine is determined from the flywheel end. The No. 1 cylinder is the front cylinder.

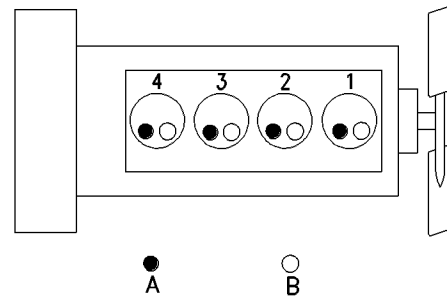


Illustration 15

g00296424

(A) Exhaust valves
(B) Inlet valves

Table 1

404J-22 Engine Specifications for Build Lists of IN84182 and IN84331	
Maximum Operating Speed (rpm)	2600 rpm
Cylinders and Arrangement	In-Line four cylinder
Bore	84.0 mm (3.31 inch)
Stroke	100.0 mm (3.94 inch)
Displacement	2.216 L (135.229 in ³)
Aspiration	NA ⁽¹⁾
Compression Ratio	23.3:1
Firing Order	1-3-4-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.25 mm (0.00984 inch)
Valve Lash Setting (Exhaust)	0.25 mm (0.00984 inch)
Injection	Indirect

(1) Naturally Aspirated

However, failures that result from the installation or use of other manufacturers devices, accessories, or consumables are NOT Perkins defects. Therefore, the defects are NOT covered under the Perkins warranty.

Service Life

The engine 404J-22 with build lists of IN84182 and IN84331 has an extended service period. The following information is important to keep the engine operating correctly. Engine efficiency and maximum utilization of engine performance depend on the adherence to proper operation and maintenance recommendations. In addition, use recommended fuels, coolants, and lubricants. Use the Operation and Maintenance Manual as a guide for required engine maintenance.

Expected engine life is predicted generally by the average power that is demanded. The average power that is demanded is based on fuel consumption of the engine over a time period. Reduced hours of operation at full throttle and/or operating at reduced throttle settings result in a lower average power demand. Reduced hours of operation will increase the length of operating time before an engine overhaul is required.

Aftermarket Products and Perkins Engines

Perkins does not warrant the quality or performance of non-Perkins fluids and filters.

When auxiliary devices, accessories, or consumables (filters, additives, catalysts), which are made by other manufacturers are used on Perkins products, the Perkins warranty is not affected simply because of such use.

Product Identification Information

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Plate Locations and Film Locations

Engine Identification

Perkins engines are identified by a serial number.

A typical example of an engine number is
IN*****U000001D.

I _____ Engine family

N _____ Type of engine

***** _____ The list number of the engine

U _____ Country of manufacture

0 _____ The first digit is a production code.

00001 _____ Engine Serial Number

D _____ Year of Manufacture

Perkins distributors need all these numbers to determine the components that were included with the engine. This information permits accurate identification of replacement part numbers.

Serial Number Plate

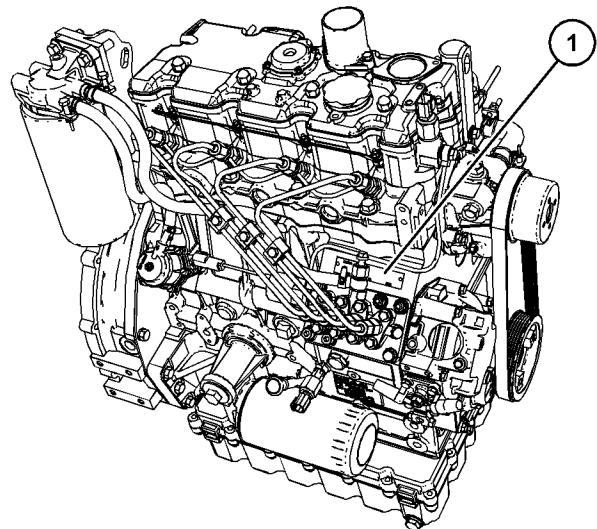


Illustration 16

g06138229

Typical example

(1) Location of serial number plate



Illustration 17

g01094203

Typical serial number plate

The Serial Number Plate is located above the fuel injection pump on the right side of the cylinder block.

The following information is stamped on the Serial Number Plate: Engine serial number, model, and Arrangement number.

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Emissions Certification Film


EMISSION CONTROL INFORMATION	
 PERKINS SMALL ENGINES LTD.	
ENGINE FAMILY	#####
POWER CATEGORY	#####
DISPLACEMENT	##### L
EMISSION-CONTROL SYSTEM	IFI ECM
USEFUL LIFE DEFINED BY	CARB: 5 YEARS OR 3000h
DATE OF MANUFACTURE:	#####
THIS ENGINE CONFORMS TO 2013 U.S. EPA AND CALIFORNIA REGULATIONS FOR LARGE NON-ROAD STATIONARY COMPRESSION-IGNITION ENGINES	
ULTRA LOW SULFUR FUEL ONLY	
EC TYPE- APPROVAL No:	#####
#####	#####

Illustration 18

g06435423

Typical example

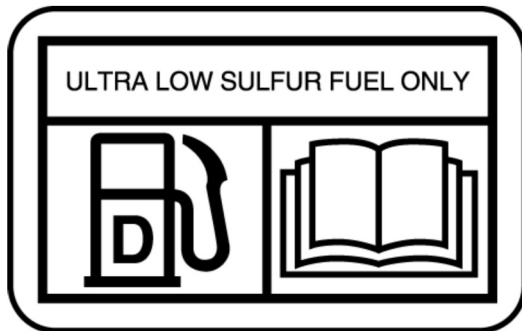


Illustration 19

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Typical example

Illustration 19 is a representation of the label that will be installed next to the fuel filler cap on the fuel tank of the application.

Reference Information

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

Record for Reference

- Engine Model _____
- Engine Serial Number _____
- ECM Serial Number _____
- Actuator/Controller Serial Number _____
- Engine Low Idle rpm _____
- Engine Full Load rpm _____
- Primary Fuel Filter _____
- Secondary Fuel Filter Element _____
- Lubrication Oil Filter Element _____
- Total Lubrication System Capacity _____
- Total Cooling System Capacity _____
- Air Cleaner Element _____
- Alternator Belt _____

Operation Section

Lifting and Storage

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Product Lifting

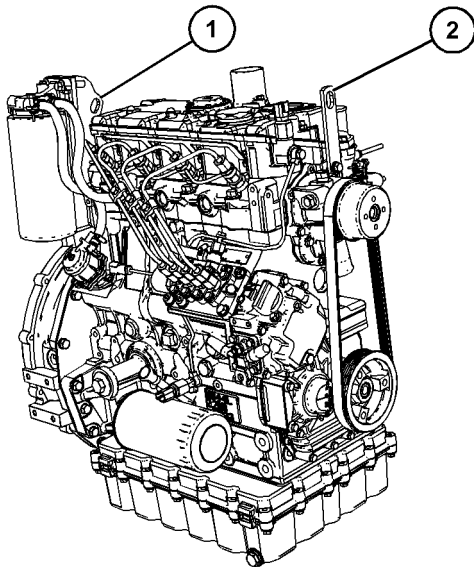


Illustration 20

g06138248

Typical example

- (1) Rear lifting eye
- (2) Front lifting eye

NOTICE

Always inspect lifting eyebolts and all other lifting equipment for damage before performing any lifting. Never bend the eyebolts and the brackets. Never perform product lifting if components are damaged. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

When it is necessary to remove a component at an angle, only use a link bracket that is properly rated for the weight.

Use a hoist to remove heavy components. Use an adjustable lifting beam to lift the engine. All supporting members (chains and cables) should be parallel to each other. The chains and cables should be perpendicular to the top of the object that is being lifted.

Some removals require lifting the fixtures to obtain correct balance and safety.

To remove the engine ONLY, use the lifting eyes that are on the engine.

Lifting eyes are designed and installed for specific engine arrangements. Alterations to the lifting eyes and/or the engine make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that correct lifting devices are provided. Consult your Perkins dealer or your Perkins distributor for information regarding fixtures for correct engine lifting.

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Product Storage

Perkins are not responsible for damage which may occur when an engine is in storage after a period in service.

Your Perkins dealer or your Perkins distributor can assist in preparing the engine for extended storage periods.

Condition for Storage

The engine must be stored in a water proof building. The building must be kept at a constant temperature. Engines that are filled with Perkins ELC will have coolant protection to an ambient temperature of -36°C (-32.8°F). The engine must not be subjected to extreme variations in temperature and humidity.

Storage Period

An engine can be stored for up to 6 months provided all the recommendation are adhered to.

Storage Procedure

Keep a record of the procedure that has been completed on the engine.

Note: Do not store an engine that has biodiesel in the fuel system.

1. Ensure that the engine is clean and dry.
 - a. If the engine has been operated using biodiesel, the system must be drained and new filters installed. The fuel tank will require flushing.
 - b. Fill the fuel system with an ultra low sulfur fuel. For more information on acceptable fuels refer to this Operation and Maintenance Manual, "Fluid recommendations". Operate the engine for 15 minutes in order to remove all biodiesel from the system.

2. Drain any water from the primary filter water separator. Ensure that the fuel tank is full.
3. The engine oil will not need to be drained in order to store the engine. Provided the correct specification of engine oil is used the engine can be stored for up to 6 months. For the correct specification of engine oil refer to this Operation and Maintenance Manual, "Fluid recommendations".
4. Remove the fan belt from the engine.

Sealed Coolant System

Ensure that the cooling system is filled with Perkins ELC, or an antifreeze that meets "ASTM D6210" specification.

Open Cooling System

Ensure that all cooling drain plugs have been opened. Allow the coolant to drain. Install the drain plugs. Place a vapor phase inhibitor into the system. The coolant system must be sealed once the vapor phase inhibitor has been introduced. The effect of the vapor phase inhibitor will be lost if the cooling system is open to the atmosphere.

For maintenance procedures ref to this Operation and Maintenance Manual.

Monthly Checks

The crankshaft must be rotated in order to change the spring loading on the valve train. Rotate the crankshaft more than 180 degrees. Visibly check for damage or corrosion to the engine.

Ensure that the engine is covered completely before storage. Log the procedure in the record for the engine.

Features and Controls

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Gauges and Indicators

Your engine may not have the same gauges or all of the gauges that are described. For more information about the gauge package, see the OEM information.

Gauges provide indications of engine performance. Ensure that the gauges are in good working order. Determine the normal operating range by observing the gauges over a period of time.

Noticeable changes in gauge readings indicate potential gauge or engine problems. Problems may also be indicated by gauge readings that change even if the readings are within specifications. Determine and correct the cause of any significant change in the readings. Consult your Perkins dealer or your Perkins distributor for assistance.

NOTICE

If no oil pressure is indicated, STOP the engine. If maximum coolant temperature is exceeded, STOP the engine. Engine damage can result.



Engine Oil Pressure – The oil pressure should be greatest after a cold engine is started. The typical engine oil pressure with SAE10W30 is 207 to 413 kPa (30 to 60 psi) at rated rpm.

A lower oil pressure is normal at low idle. If the load is stable and the gauge reading changes, perform the following procedure:

1. Remove the load.
2. Reduce engine speed to low idle.
3. Check and maintain the oil level.



Jacket Water Coolant Temperature – Typical temperature range is 71 to 96°C (160 to 205°F). The maximum allowable temperature with the pressurized cooling system at 90 kPa (13 psi) is 125° C (257° F). Higher temperatures may occur under certain conditions. The water temperature reading may vary according to load. The reading should never exceed the boiling point for the pressurized system that is being used.

If the engine is operating above the normal range and steam becomes apparent, perform the following procedure:

1. Reduce the load and the engine rpm.
2. Inspect the cooling system for leaks.

3. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load.



Tachometer – This gauge indicates engine speed (rpm). When the throttle controller is moved to the full throttle position without load, the engine is running at high idle. The engine is running at the full load rpm when the throttle controller is at the full throttle position with maximum rated load.

NOTICE

To help prevent engine damage, never exceed the high idle rpm. Overspeeding can result in serious damage to the engine. The engine can be operated at high idle without damage, but should never be allowed to exceed high idle rpm.



Ammeter – This gauge indicates the amount of charge or discharge in the battery charging circuit. Operation of the indicator should be to the right side of “0” (zero).



Fuel Level – This gauge indicates the fuel level in the fuel tank. The fuel level gauge operates when the “START/STOP” switch is in the “ON” position.



Service Hour Meter – The gauge indicates operating time of the engine.

Indicators and Lamps

The following indicator lamps can be installed, for more information refer to the Original Equipment Manufacturer (OEM)

- Shutdown lamp
- Warning lamp
- Low-pressure oil lamp

A multi function lamp is installed on the electric control module.

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Monitoring System

NOTICE

The Engine Monitoring System is not a guarantee against catastrophic failures. Programmed delays and derate schedules are designed to minimize false alarms and provide time for the operator to stop the engine.

The following parameters are monitored:

- Coolant temperature
- Oil pressure
- Engine speed

The coolant temperature, oil pressure, and the engine speed can trigger an engine shutdown.

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Sensors and Electrical Components

The following sensors or switches are installed on the 404J-22 engine with build lists of IN84182 and IN84331:

- Oil pressure switch
- Coolant temperature sensor
- Speed sensor
- Throttle actuator

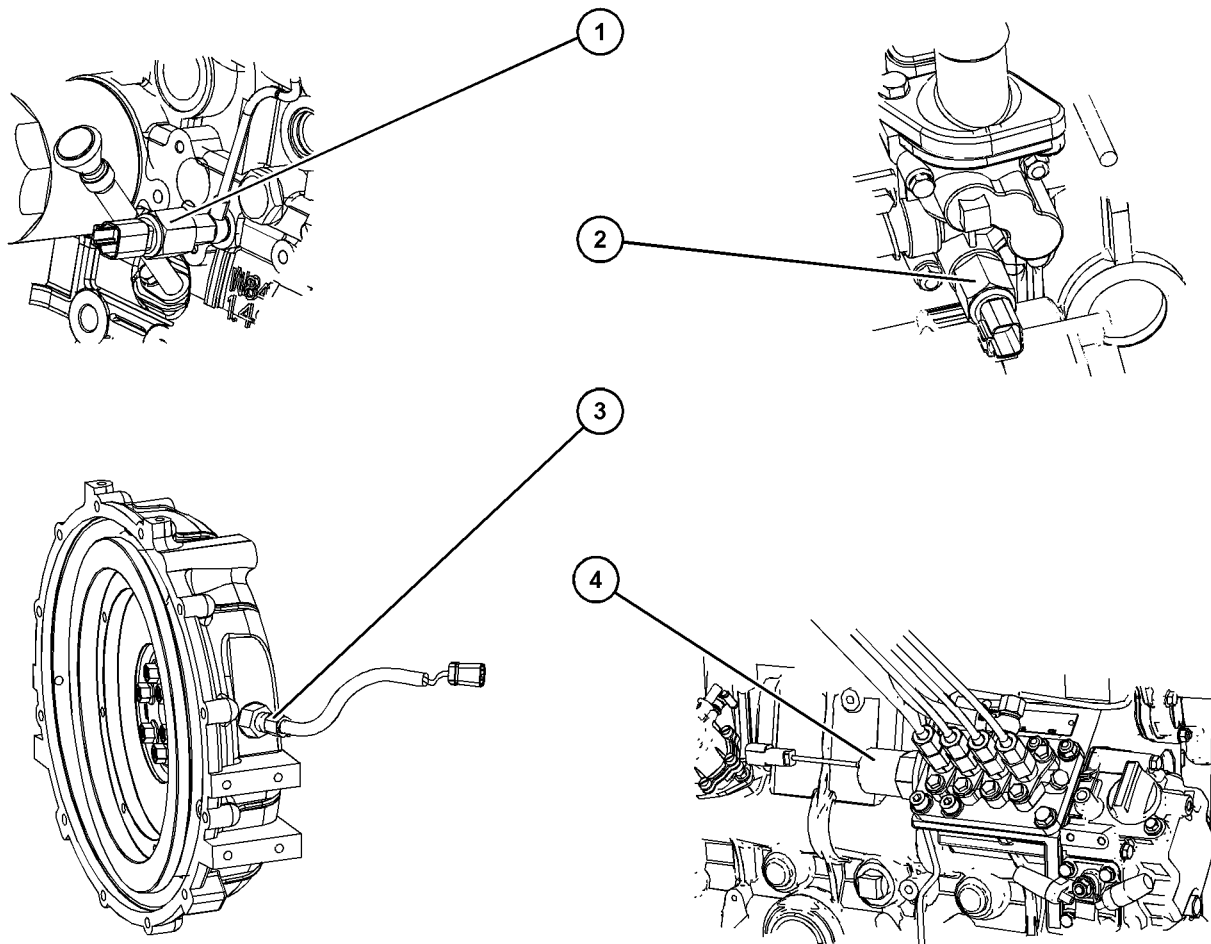


Illustration 21

g06138565

Typical examples

- | | |
|--------------------------------|-----------------------|
| (1) Oil pressure switch | (3) Speed sensor |
| (2) Coolant temperature sensor | (4) Throttle actuator |

Electrical components installed on the 404J-22 engine with build lists of IN84182 and IN84331:

- Starting motor
- Glow plugs
- Electronic control governor (location will depend on the application)

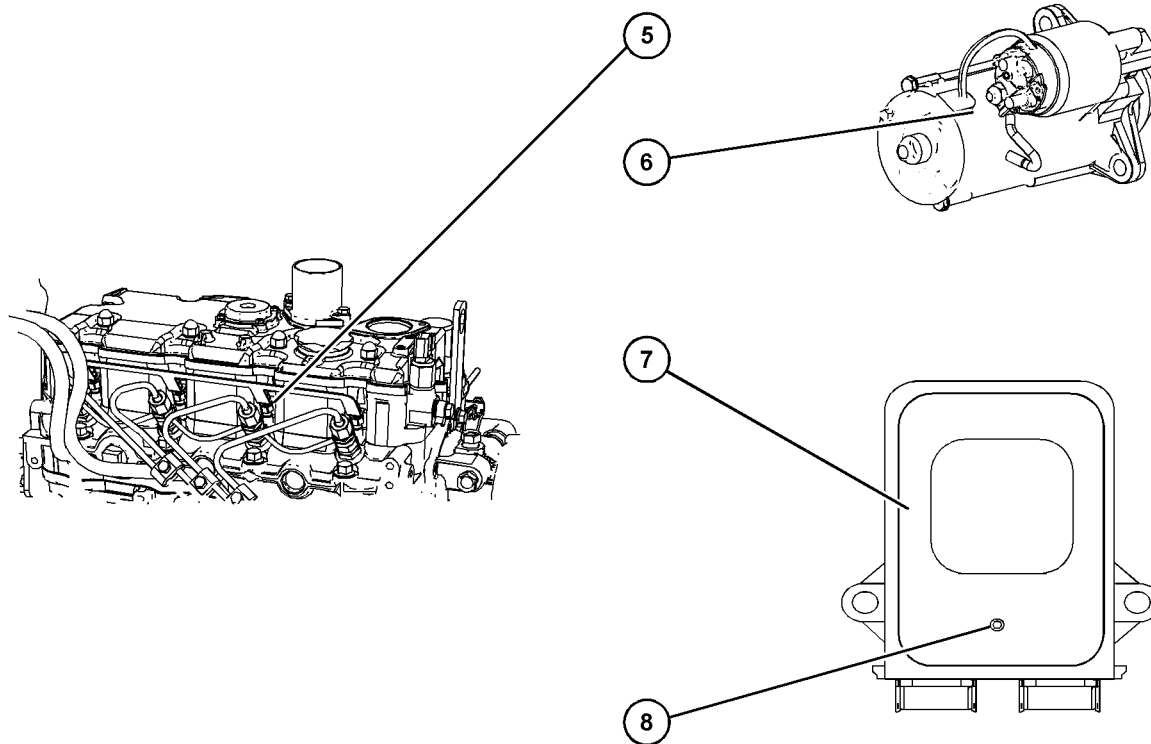


Illustration 22

g06138567

Typical examples

(5) Starting motor
(6) Glow plugs

(7) Electronic control model (Controller)
(8) Multi-function lamp

When the keyswitch is in the OFF position, the multi-function lamp will not be illuminated. With the keyswitch in the ON position the multi-function lamp will flash once. The flash will indicate that the system is powered and ready for operation.

The multi-function lamp can be used as a diagnostic lamp. For information as a diagnostic lamp refer to this Operation and Maintenance Manual, "Diagnostic Lamp".

Engine Starting

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Before Starting Engine

Perform the required daily maintenance and other periodic maintenance before the engine is started. Inspect the engine compartment. This inspection can help prevent major repairs at a later date. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information.

- Ensure that the engine has an adequate fuel supply.
- Open the fuel supply valve (if equipped).

If the engine has not been started for several weeks, fuel may have drained from the fuel system. Air may have entered the filter housing. Also, when fuel filters have been changed, some air pockets will be trapped in the engine. In these instances, prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" for more information on priming the fuel system. Also, check that the fuel specification is correct and that the fuel condition is correct. Refer to the Operation and Maintenance Manual, "Fuel Recommendations".

WARNING

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

- Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" warning tag or similar warning tag attached to the start switch or to the controls.
- Reset all of the shutoffs or alarm components.
- Ensure that any driven equipment has been disengaged. Minimize electrical loads or remove any electrical loads.

Starting the Engine

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

To start the engine, follow the OEM procedure on starting the engine. A typical engine starting procedure has been provided.

A Typical Engine Starting Procedure

Note: Do not adjust the engine speed control during start-up. The electronic control module (ECM) will control the engine speed during start-up.

1. Disengage any equipment that is driven by the engine.
2. Turn the keyswitch to the RUN position. Check the multi-function lamp on the ECM.
3. If the lamp flashes once only, the engine can be started normally. If the lamp flashes again, then a fault has been detected.

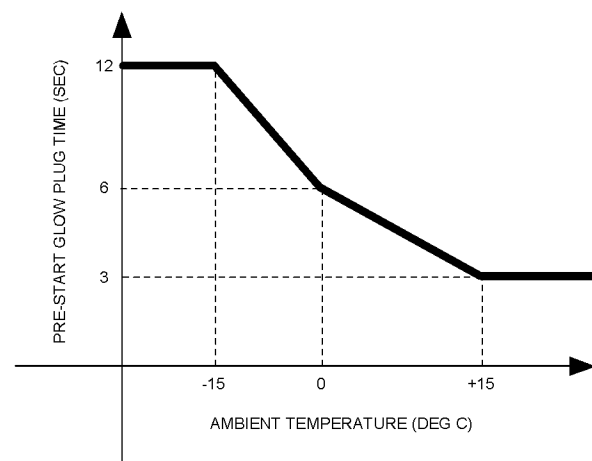


Illustration 23

g06201074

4. During cold weather the keyswitch will need to be in the heat position for a time period to allow the glow plug operation. Some systems will have a wait to start lamp.

5. The wait to start lamp must be extinguished before starting the engine. Refer to the original equipment manufacture for information on how to start an engine in cold weather.

Note: The ambient weather condition will determine the amount of time the glow plugs will require. If the engine is warm, heat from the glow plugs will not be required to start the engine.

6. Turn the engine start switch to the HEAT position. Hold the engine start switch in the HEAT position for time shown in illustration 23 .

NOTICE

Do not engage the starting motor when flywheel is turning. Do not start the engine under load.

If the engine fails to start within 30 seconds, release the starter switch or button and wait two minutes to allow the starting motor to cool before attempting to start the engine again.

7. Turn the keyswitch to operate the starter motor, and allow the engine to crank. After the engine has started, allow the keyswitch to return to the RUN position.

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Starting with Jump Start Cables

WARNING

Improper jump start cable connections can cause an explosion resulting in personal injury.

Prevent sparks near the batteries. Sparks could cause vapors to explode. Do not allow jump start cable ends to contact each other or the engine.

NOTICE

Using a battery source with the same voltage as the electric starting motor. Use ONLY equal voltage for jump starting. The use of higher voltage will damage the electrical system.

Do not reverse the battery cables. The alternator can be damaged. Attach ground cable last and remove first.

Turn all electrical accessories OFF before attaching the jump start cables.

Ensure that the main power switch is in the OFF position before attaching the jump start cables to the engine being started.

1. Turn the start switch on the stalled engine to the OFF position. Turn off all the engines accessories.
2. Connect one positive end of the jump-start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump-start cable to the positive cable terminal of the electrical source.
3. Connect one negative end of the jump-start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump-start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting the combustible gases that are produced by some batteries.

Note: The engine electronic control module must be powered before the starting motor is operated or damage can occur.

4. Start the engine in the normal operating procedure. Refer to this Operation and Maintenance Manual, "Starting the Engine".
5. Immediately after the engine is started, disconnect the jump-start cables in reverse order.

After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be replaced or charged to the proper voltage with a battery charger after the engine is stopped.

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After Starting Engine

Note: In temperatures from 0°C to 60°C (32°F to 140°F), the warm-up time is approximately 3 minutes. In temperatures below 0°C (32°F), extra warm-up time may be required.

When the engine idles during engine warm-up, observe the following conditions:

Constant Speed Engines

Constant speed engines should be allowed to operate at low idle for 3 minutes before used at operational speed. If the low idle option is not available, then operate the engine at operational speed with no load for 2 minutes.

Note: Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

Variable speed Engines

- Check for any fluid or for any air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under load. This action may not be possible in some applications.
- Operate the engine at low idle until all systems achieve operating temperatures. Check all gauges during the warm-up period.

Engine Operation

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Engine Operation

General Engine Operation

Correct operation and maintenance are key factors in obtaining the maximum life and economy of the engine. If the directions in the Operation and Maintenance Manual are followed, costs can be minimized and engine service life can be maximized.

Check that there are no flash codes active. Refer to this Operation and Maintenance Manual, "Diagnostic Flash Code Retrieval" for more information.

The engine can be operated at the rated rpm after the engine reaches operating temperature. The engine will reach normal operating temperature sooner during a low engine speed (rpm) and during a low-power demand. This procedure is more effective than idling the engine at no load. The engine should reach operating temperature in a few minutes.

Gauge readings should be observed and the data should be recorded frequently while the engine is operating. Comparing the data over time will help to determine normal readings for each gauge. Comparing data over time will also help detect abnormal operating developments. Significant changes in the readings should be investigated.

NOTICE

The engine and emissions control system shall be operated, used, and maintained in accordance with the instructions provided. Failure to follow the instructions could result in emissions performance that does not meet the requirements applicable to the category of the engine. No deliberate tampering with, or misuse of the engine emissions control system should take place. Prompt action is critical to rectify any incorrect operation, use, or maintenance of the emissions control system.

Carbon Dioxide (CO₂) Emissions Statement

Emissions regulations require that the value of the CO₂ emissions be reported to the end user. For the variable speed engine, 940.14 g/kWh was determined to be the CO₂ value during the EU type approval process. For the constant speed engine, 888.768 g/kWh was determined to be the CO₂ value during the EU type approval process. This value was recorded in EU type approval certificate. This CO₂ measurement results from testing over a fixed test cycle, under laboratory conditions, with a parent engine representative of the engine family. These values shall not imply or express any guarantee of the performance of a particular engine.

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Fuel Conservation Practices

The efficiency of the engine can affect the fuel economy. Perkins design and technology in manufacturing provides maximum fuel efficiency in all applications. Follow the recommended procedures in order to attain optimum performance for the life of the engine.

- Avoid spilling fuel.

Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.

- Be aware of the properties of the different fuels. Use only the recommended fuels. Refer to the Operations and Maintenance Manual, "Fuel Recommendations" for further information.
- Avoid unnecessary idling.

Shut off the engine rather than idle for long periods of time.

- Observe the service indicator frequently. Keep the air cleaner elements clean.
- Maintain a good electrical system.

One faulty battery cell will overwork the alternator. This fault will consume excess power and excess fuel.

- The belt should be in good condition.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the driven equipment is in good working order.
- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

Cold Weather Operation

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Cold Weather Operation

Perkins Diesel Engines can operate effectively in cold weather. During cold weather, the starting and the operation of the diesel engine is dependent on the following items:

- The type of fuel that is used
- The viscosity of the engine oil
- The operation of the glow plugs
- Battery condition

This section will cover the following information:

- Potential problems that are caused by cold-weather operation
- Suggest steps which can be taken in order to minimize starting problems and operating problems when the ambient air temperature is between 0° to -40 °C (32° to 40 °F).

The operation and maintenance of an engine in freezing temperatures is complex. This complexity is because of the following conditions:

- Weather conditions
- Engine applications

Recommendations from your Perkins dealer or your Perkins distributor are based on past proven practices. The information that is contained in this section provides guidelines for cold-weather operation.

Hints for Cold Weather Operation

- If the engine will start, operate the engine until a minimum operating temperature of 80° C (176° F) is achieved. Achieving operating temperature will help prevent the intake valves and exhaust valves from sticking.
- The cooling system and the lubrication system for the engine do not lose heat immediately upon shutdown. This means that an engine can be shut down for a period and the engine can still have the ability to start readily.

- Install the correct specification of engine lubricant before the beginning of cold weather. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended viscosity of oil.
- Check all rubber parts (hoses, fan drive belts,) weekly.
- Check all electrical wiring and connections for any fraying or damaged insulation.
- Keep all batteries fully charged and warm by ensuring that the engine is allowed to operate at normal operating temperature.
- Fill the fuel tank at the end of each shift.
- Check the air cleaners and the air intake daily. Check the air intake more often when you operate in snow.
- Ensure that the glow plugs are in working order.

WARNING

Personal injury or property damage can result from alcohol or starting fluids.

Alcohol or starting fluids are highly flammable and toxic and if improperly stored could result in injury or property damage.

WARNING

Do not use aerosol types of starting aids such as ether. Such use could result in an explosion and personal injury.

- For jump starting with cables in cold weather, refer to the Operation and Maintenance Manual, "Starting with Jump Start Cables." for instructions.

Viscosity of the Engine Lubrication Oil

Correct engine oil viscosity is essential. Oil viscosity affects lubrication properties and wear protection that the oil provides for the engine. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended viscosity of oil.

Recommendations for the Coolant

Provide cooling system protection for the lowest expected outside temperature. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended coolant mixture.

In cold weather, check the coolant often for the correct glycol concentration in order to ensure adequate freeze protection.

Engine Block Heaters

Engine block heaters (if equipped) heat the engine jacket water that surrounds the combustion chambers. This heat provides the following functions:

- Startability is improved.
- Warm up time is reduced.

An electric block heater can be activated once the engine is stopped. A block heater can be 110 V dc or 240 V dc. The output can be 750/1000W. Consult your Perkins dealer or your Perkins distributor for more information.

Idling the Engine

When idling after the engine is started in cold weather, increase the engine rpm from 1000 to 1200 rpm. This idling will warm up the engine more quickly. Maintaining an elevated low idle speed for extended periods will be easier with the installation of a hand throttle. The engine should not be "raced" in order to speed up the warm-up process.

While the engine is idling, the application of a light load (parasitic load) will assist in achieving the minimum operating temperature. The minimum operating temperature is 80° C (176° F).

Recommendations for Coolant Warm Up

Warm up an engine that has cooled below normal operating temperatures due to inactivity. This warm-up should be performed before the engine is returned to full operation. During operation in very cold temperature conditions, damage to engine valve mechanisms can result from engine operation for short intervals. This damage can happen if the engine is started and the engine is stopped many times without being operated in order to warm up completely.

When the engine is operated below normal operating temperatures, fuel and oil are not completely burned in the combustion chamber. This fuel and oil causes soft carbon deposits to form on the valve stems. Generally, the deposits do not cause problems and the deposits are burned off during operation at normal engine operating temperatures.

When starting and stopping an engine many times without being operated in order to warm up completely, the carbon deposits become thicker. This starting and stopping can cause the following problems:

- Valves become stuck.

- Pushrods may become bent.
- Other damage to valve train components can result.

When an engine is started, the engine must be operated until the coolant temperature is 80° C (176° F) minimum. Carbon deposits on the valve stems will be kept at a minimum and the free operation of the valves and the valve components will be maintained.

The engine must be thoroughly warmed in order to keep other engine parts in better condition. The service life of the engine will be generally extended. Lubrication will be improved. There will be less acid and less sludge in the oil. This condition will provide longer service life for the engine bearings, the piston rings, and other parts. However, limit unnecessary idle time to 10 minutes in order to reduce wear and unnecessary fuel consumption.

The Water Temperature Regulator and Insulated Heater Lines

The engine is equipped with a water temperature regulator. When the engine coolant is below the correct operating temperature, jacket water circulates through the engine cylinder block and into the engine cylinder head. The coolant then returns to the cylinder block via an internal passage that bypasses the valve of the coolant temperature regulator. This return ensures that coolant flows around the engine under cold operating conditions. The water temperature regulator begins to open when the engine jacket water has reached the correct minimum operating temperature. As the jacket water coolant temperature rises above the minimum operating temperature, the water temperature regulator opens further allowing more coolant through the radiator to dissipate excess heat.

The progressive opening of the water temperature regulator operates the progressive closing of the bypass passage between the cylinder block and head. This action ensures maximum coolant flow to the radiator in order to achieve maximum heat dissipation.

Note: Do not restrict the air flow. Restriction of the air flow can damage the fuel system. Perkins discourages the use of all air flow restriction devices such as radiator shutters. Restriction of the air flow can result in the following: high exhaust temperatures, power loss, excessive fan usage and reduction in fuel economy.

A cab heater is beneficial in very cold weather. The feed from the engine and the return lines from the cab should be insulated in order to reduce heat loss to the outside air.

Recommendation for Crankcase Breather Protection

Crankcase ventilation gases contain a large quantity of water vapor. This water vapor can freeze in cold ambient conditions and can plug or damage the crankcase ventilation system. If the engine is operated in temperatures below -25°C (-13°F), measures must be taken to prevent freezing and plugging of the breather system. In extreme weather conditions insulating the breather hose will help to protect the system.

Consult with your Perkins dealer or your Perkins distributor for the recommended breather components for operation from -25°C to -40°C (-13°F to -72°F).

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Fuel and the Effect from Cold Weather

Note: Only use grades of fuel that are recommended by Perkins. Refer to this Operation and Maintenance Manual, “Fluid Recommendations”.

The following fuels can be used in this series of engine.

- Group 1
- Group 2
- Group 3
- Special Fuels

Perkins prefer only Group 1 and Group 2 fuels for use in this series of engines.

Group 1 fuels are the preferred group of fuels for general use by Perkins. Group 1 fuels maximize engine life and engine performance. Group 1 fuels are usually less available than Group 2 fuels. Frequently, Group 1 fuels are not available in colder climates during the winter.

Note: Group 2 fuels must have a maximum wear scar of 650 micrometers (HFRR to ISO 12156-1).

Group 2 fuels are considered acceptable for issues of warranty. This group of fuels may reduce the life of the engine, the engines maximum power, and the engines fuel efficiency.

When Group 2 diesel fuels are used, the following components provide a means of minimizing problems in cold weather:

- Glow plugs

- Engine coolant heaters, which may be an Original Equipment Manufacture (OEM) option
- Fuel heaters, which may be an OEM option
- Fuel line insulation, which may be an OEM option

There are three major differences between Group 1 fuels and Group 2 fuels. Group 1 fuels have the following different characteristics to Group 2 fuels.

- A lower cloud point
- A lower pour point
- A higher energy per unit volume of fuel

Note: Group 3 fuels reduce the life of the engine. The use of Group 3 fuels is not covered by the Perkins warranty.

Group 3 fuels include Low Temperature Fuels and Aviation Kerosene Fuels.

Special fuels include Biofuel.

The cloud point is a temperature that allows wax crystals to form in the fuel. These crystals can cause the fuel filters to plug.

The pour point is the temperature when diesel fuel will thicken. The diesel fuel becomes more resistant to flow through fuel lines, fuel filters, and fuel pumps.

Be aware of these facts when diesel fuel is purchased. Consider the average ambient air temperature for the engines application. Engines that are fueled in one climate may not operate well if the engines are moved to another climate. Problems can result due to changes in temperature.

Before troubleshooting for low power or for poor performance in the winter, check the fuel for waxing.

Low temperature fuels may be available for engine operation at temperatures below 0°C (32°F). These fuels limit the formation of wax in the fuel at low temperatures.

For more information on cold-weather operation, refer to the Operation and Maintenance Manual, “Cold Weather Operation and Fuel Related Components in Cold Weather”.

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Fuel Related Components in Cold Weather

Fuel Tanks

Condensation can form in partially filled fuel tanks. Top off the fuel tanks after you operate the engine.

Fuel tanks should contain some provision for draining water and sediment from the bottom of the tanks. Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Drain the water and sediment from any fuel storage tank at the following intervals: weekly, oil changes and refueling of the fuel tank. This procedure will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

Fuel Filters

After you change the fuel filter or fuel filters, always prime the fuel system to remove air bubbles from the fuel system. Refer to the Operation and Maintenance Manual, Fuel System - Prime for more information on priming the fuel system.

Fuel Heaters

Fuel heaters help to prevent fuel filters from plugging in cold weather due to waxing.

For further information on fuel heaters, consult your Perkins dealer or distributor.

Engine Stopping

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Stopping the Engine

NOTICE

Stopping the engine immediately after it has been working under load, can result in overheating and accelerated wear of the engine components.

Avoid accelerating the engine prior to shutting it down.

Avoiding hot engine shutdowns will maximize turbo-charger shaft and bearing life.

Note: Individual applications will have different control systems. Ensure that the shutoff procedures are understood. Use the following general guidelines to stop the engine.

NOTICE

Before any service or repairs are performed, ensure that the power supply to the engine is disconnected.

To stop the engine, follow the OEM instructions. A typical stopping the engine procedure is provided.

A Typical Stopping the Engine Procedure

1. Remove the load from the engine. Reduce the engine speed (rpm) to low idle. Allow the engine to idle for 5 minutes to cool the engine.
2. Stop the engine after the cool down period according to the shutoff system on the engine. Turn the ignition key switch to the OFF position.

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Emergency Stopping

NOTICE

Emergency shutoff controls are for EMERGENCY use ONLY. DO NOT use emergency shutoff devices or controls for normal stopping procedure.

The OEM may have equipped the application with an emergency stop button. For more information about the emergency stop button, refer to the OEM information.

Ensure that any components for the external system that support the engine operation are secured after the engine is stopped.

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After Stopping Engine

Note: Before you check the engine oil, do not operate the engine for at least 10 minutes in order to allow the engine oil to return to the oil pan.

- Check the crankcase oil level. Maintain the oil level between the “MIN” mark and the “MAX” mark on the engine oil level gauge.
 - If necessary, perform minor adjustments. Repair any leaks and tighten any loose bolts.
 - If the engine is equipped with a service hour meter, note the reading. Perform the maintenance that is in the Operation and Maintenance Manual, “Maintenance Interval Schedule”.
 - Fill the fuel tank in order to help prevent accumulation of moisture in the fuel. Do not overfill the fuel tank.
-

NOTICE

Only use antifreeze/coolant mixtures recommended in this Operation and Maintenance Manual, “Refill Capacities and Recommendations” topic or in this Operation and Maintenance Manual, “Fluid Recommendations” topic. Failure to do so can cause engine damage.

- Allow the engine to cool. Check the coolant level.
- If freezing temperatures are expected, check the coolant for correct antifreeze protection. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the correct coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. This maintenance is outlined in the instructions from the OEM.

Maintenance Section

Refill Capacities

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Refill Capacities and Recommendations

Note: For recommendations for coolant, fuel and oil, refer to this Operation and Maintenance Manual, Fluid Recommendations for more information.

Lubrication System

The engine 404J-22 with build lists IN84182 and IN84331 have a special engine oil capacity for an extended oil service.

Engine oil capacity 14 L (3.69880 US gal).

Cooling System

Engine only cooling capacity 3.6 L (0.95112 US gal).

For the total cooling capacity of the engine and radiator, refer to the OEM for more information.

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Fluid Recommendations

General Coolant Information

NOTICE

Never add coolant to an overheated engine. Engine damage could result. Allow the engine to cool first.

NOTICE

If the engine is to be stored in, or shipped to an area with below freezing temperatures, the cooling system must be either protected to the lowest outside temperature or drained completely to prevent damage.

NOTICE

Frequently check the specific gravity of the coolant for proper freeze protection or for anti-boil protection.

Clean the cooling system for the following reasons:

- Contamination of the cooling system
- Overheating of the engine

- Foaming of the coolant

NOTICE

Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the proper operating temperature. Cooling system problems can develop without water temperature regulators.

Many engine failures are related to the cooling system. The following problems are related to cooling system failures: Overheating, leakage of the water pump and plugged radiators or heat exchangers.

These failures can be avoided with correct cooling system maintenance. Cooling system maintenance is as important as maintenance of the fuel system and the lubrication system. Quality of the coolant is as important as the quality of the fuel and the lubricating oil.

Coolant is normally composed of three elements: Water, additives, and glycol.

Water

Water is used in the cooling system to transfer heat.

Distilled water or deionized water is recommended for use in engine cooling systems.

DO NOT use the following types of water in cooling systems: Hard water, softened water that has been conditioned with salt and sea water.

If distilled water or deionized water is not available, use water with the properties that are listed in Table 2.

Table 2

Acceptable Water	
Property	Maximum Limit
Chloride (Cl)	40 mg/L
Sulfate (SO ₄)	100 mg/L
Total Hardness	170 mg/L
Total Solids	340 mg/L
Acidity	pH of 5.5 to 9.0

For a water analysis, consult one of the following sources:

- Local water utility company
- Agricultural agent
- Independent laboratory

Additives

Additives help to protect the metal surfaces of the cooling system. A lack of coolant additives or insufficient amounts of additives enable the following conditions to occur:

- Corrosion
- Formation of mineral deposits
- Rust
- Scale
- Foaming of the coolant

Many additives are depleted during engine operation. These additives must be replaced periodically.

Additives must be added at the correct concentration. Over concentration of additives can cause the inhibitors to drop out-of-solution. The deposits can enable the following problems to occur:

- Formation of gel compounds
- Reduction of heat transfer
- Leakage of the water pump seal
- Plugging of radiators, coolers, and small passages

Glycol

Glycol in the coolant helps to provide protection against the following conditions:

- Boiling
- Freezing
- Cavitation of the water pump

For optimum performance, Perkins recommends a 1:1 mixture of a water/glycol solution.

Note: Use a mixture that will provide protection against the lowest ambient temperature.

Note: 100 percent pure glycol will freeze at a temperature of -13 °C (8.6 °F).

Most conventional antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. Refer to Table 3 and refer to table 4 .

Table 3

Ethylene Glycol	
Concentration	Freeze Protection
50 Percent	-36 °C (-33 °F)
60 Percent	-51 °C (-60 °F)

NOTICE

Do not use propylene glycol in concentrations that exceed 50 percent glycol because of the reduced heat transfer capability of propylene glycol. Use ethylene glycol in conditions that require additional protection against boiling or freezing.

Table 4

Propylene Glycol	
Concentration	Freeze Protection
50 Percent	-29 °C (-20 °F)

To check the concentration of glycol in the coolant, measure the specific gravity of the coolant.

Coolant Recommendations

- ELC_____Extended Life Coolant
- SCA_____Supplement Coolant Additive
- ASTM_____American Society for Testing and Materials

The following two coolants are used in Perkins diesel engines:

Preferred – Perkins ELC

Acceptable – A commercial heavy-duty antifreeze that meets “ASTM D6210” specifications

NOTICE

The Perkins industrial engines must be operated with a 1:1 mixture of water and glycol.

NOTICE

Do not use a commercial coolant/antifreeze that only meets the ASTM D3306 specification. This type of coolant/antifreeze is made for light automotive applications.

Perkins recommends a 1:1 mixture of water and glycol. This mixture of water and glycol will provide optimum heavy-duty performance as an antifreeze. This ratio may be increased to 1:2 water to glycol if extra freezing protection is required.

Table 5

Coolant Service Life	
Coolant Type	Service Life ⁽¹⁾
Perkins ELC	6,000 Service Hours or Three Years

(continued)

Maintenance Section
Fluid Recommendations

(Table 5, contd)

Commercial Heavy-Duty Anti-freeze that meets "ASTM D6210"	3000 Service Hours or Two Year
Commercial SCA inhibitor and Water	3000 Service Hours or One Year

(1) Use the interval that occurs first. The cooling system must also be flushed out at this time.

ELC

Perkins provides ELC for use in the following applications:

- Heavy-duty spark ignited gas engines
- Heavy-duty diesel engines
- Automotive applications

The anti-corrosion package for ELC is different from the anti-corrosion package for other coolants. ELC is an ethylene glycol base coolant. However, ELC contains organic corrosion inhibitors and antifoam agents with low amounts of nitrite. Perkins ELC has been formulated with the correct amount of these additives to provide superior corrosion protection for all metals in engine cooling systems.

ELC is available in a premixed cooling solution with distilled water. ELC is a 1:1 mixture. The Premixed ELC provides freeze protection to -36°C (-33°F). The Premixed ELC is recommended for the initial fill of the cooling system. The Premixed ELC is also recommended for topping off the cooling system.

Containers of several sizes are available. Consult your Perkins distributor for the part numbers.

ELC Cooling System Maintenance

Correct additions to the Extended Life Coolant

NOTICE

Use only Perkins products for pre-mixed or concentrated coolants.

Mixing Extended Life Coolant with other products reduces the Extended Life Coolant service life. Failure to follow the recommendations can reduce cooling system components life unless appropriate corrective action is performed.

To maintain the correct balance between the antifreeze and the additives, you must maintain the recommended concentration of ELC. Lowering the proportion of antifreeze lowers the proportion of additive. Lowering the ability of the coolant to protect the system will form pitting, from cavitation, from erosion, and from deposits.

NOTICE

Do not use a conventional coolant to top-off a cooling system that is filled with Extended Life Coolant (ELC).

Do not use standard supplemental coolant additive (SCA).

When using Perkins ELC, do not use standard SCA's or SCA filters.

ELC Cooling System Cleaning

Note: If the cooling system is already using ELC, cleaning agents are not required to be used at the specified coolant change interval. Cleaning agents are only required if the system has been contaminated by the addition of some other type of coolant or by cooling system damage.

Clean water is the only cleaning agent that is required when ELC is drained from the cooling system.

Before the cooling system is filled, the heater control (if equipped) must be set to the HOT position. Refer to the OEM to set the heater control. After the cooling system is drained and the cooling system is refilled, operate the engine until the coolant level reaches the normal operating temperature and until the coolant level stabilizes. As needed, add the coolant mixture to fill the system to the specified level.

Changing to Perkins ELC

To change from heavy-duty antifreeze to the Perkins ELC, perform the following steps:

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant into a suitable container.
2. Dispose of the coolant according to local regulations.
3. Fill the cooling system with a 33 percent solution of Perkins ELC and operate the engine, ensure that the thermostat opens. Stop the engine and allow the engine to cool. Drain the coolant.

Note: Use distilled or deionized water in the solution.

4. Again, fill the cooling system with a 33 percent solution of Perkins ELC and operate the engine ensure that the thermostat opens. Stop the engine and allow to cool.
5. Drain the cooling system.

NOTICE

Incorrect or incomplete flushing of the cooling system can result in damage to copper and other metal components.

6. Fill the cooling system with the Perkins Premixed ELC. Operate the engine. Ensure that all coolant valves open then stop the engine. When cool check the coolant level.

ELC Cooling System Contamination

NOTICE

Mixing ELC with other products reduces the effectiveness of the ELC and shortens the ELC service life. Use only Perkins Products for premixed or concentrate coolants. Failure to follow these recommendations can result in shortened cooling system component life.

ELC cooling systems can withstand contamination to a maximum of 10 percent of conventional heavy-duty antifreeze or SCA. If the contamination exceeds 10 percent of the total system capacity, perform ONE of the following procedures:

- Drain the cooling system into a suitable container. Dispose of the coolant according to local regulations. Flush the system with a 5 to 10 percent solution of Perkins ELC. Fill the system with the Perkins ELC.
- Drain a portion of the cooling system into a suitable container according to local regulations. Then, fill the cooling system with premixed ELC. This procedure should lower the contamination to less than 10 percent.
- Maintain the system as a conventional Heavy-Duty Coolant. Treat the system with an SCA. Change the coolant at the interval that is recommended for the conventional Heavy-Duty Coolant.

Commercial Heavy-Duty Antifreeze and SCA

NOTICE

Commercial Heavy-Duty Coolant which contains Amine as part of the corrosion protection system must not be used.

NOTICE

Never operate an engine without water temperature regulators in the cooling system. Water temperature regulators help to maintain the engine coolant at the correct operating temperature. Cooling system problems can develop without water temperature regulators.

Check the antifreeze (glycol concentration) to ensure adequate protection against boiling or freezing. Perkins recommends the use of a refractometer for checking the glycol concentration. A hydrometer should not be used.

Perkins engine cooling systems should be tested at 500-hour intervals for the concentration of SCA.

Additions of SCA are based on the results of the test. An SCA that is liquid may be needed at 500-hour intervals.

Adding the SCA to Heavy-Duty Coolant at the Initial Fill

Use the equation that is in Table 6 to determine the amount of SCA that is required when the cooling system is initially filled.

Table 6

Equation For Adding The SCA To The Heavy-Duty Coolant At The Initial Fill
$V \times 0.07 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 7 is an example for using the equation that is in Table 6 .

Table 7

Example Of The Equation For Adding The SCA To The Heavy-Duty Coolant At The Initial Fill		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of SCA that is Required (X)
15 L (4 US gal)	× 0.07	1.05 L (35.5 oz)

Adding The SCA to The Heavy-Duty Coolant For Maintenance

Heavy-duty antifreeze of all types REQUIRE periodic additions of an SCA.

Test the antifreeze periodically for the concentration of SCA. For the interval, refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section). Cooling System Supplemental Coolant Additive (SCA) Test/Add.

Additions of SCA are based on the results of the test. The size of the cooling system determines the amount of SCA that is needed.

Maintenance Section
Fluid Recommendations

Use the equation that is in Table 8 to determine the amount of SCA that is required, if necessary:

Table 8

Equation For Adding The SCA To The Heavy-Duty Coolant For Maintenance
$V \times 0.023 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 9 is an example for using the equation that is in Table 8 .

Table 9

Example Of The Equation For Adding The SCA To The Heavy-Duty Coolant For Maintenance		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of SCA that is Required (X)
15 L (4 US gal)	$\times 0.023$	0.35 L (11.7 oz)

Cleaning the System of Heavy-Duty Antifreeze

- Clean the cooling system after used coolant is drained or before the cooling system is filled with new coolant.
- Clean the cooling system whenever the coolant is contaminated or whenever the coolant is foaming.

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Fluid Recommendations (General Fuel Information)

• Glossary

- ISO _____International Standards Organization
- ASTM _____American Society for Testing and Materials
- BTL _____Biomass to liquid
- CFPP _____Cold Filter Plugging Point
- CFR _____Co-ordinating Fuel Research
- CTL _____Coal to liquid
- DPF _____Diesel Particulate Filter
- EPA _____Environmental Protection Agency of the United States
- FAME _____Fatty Acid Methyl Esters

- GTL _____Gas to liquid
- HFRR _____High Frequency Reciprocating Rig for Lubricity testing of diesel fuels
- HVO _____Hydrotreated Vegetable Oil
- PPM _____Parts Per Million
- RME _____Rape Methyl Ester
- SME _____Soy Methyl Ester
- ULSD _____Ultra Low Sulfur Diesel
- v/v _____(volume of solute)/(volume of solution)

General Information

NOTICE

Every attempt is made to provide accurate, up-to-date information. By use of this document you agree that Perkins Engines Company Limited is not responsible for errors or omissions.

NOTICE

These recommendations are subject to change without notice. Contact your local Perkins distributor for the most up-to-date recommendations.

Diesel Fuel Requirements

Perkins is not in a position to continuously evaluate and monitor all worldwide distillate diesel fuel specifications that are published by governments and technological societies.

The "Perkins Specification for Distillate Diesel Fuel" provides a known reliable baseline to judge the expected performance of distillate diesel fuels that are derived from conventional sources.

Satisfactory engine performance depends on the use of a good quality fuel. The use of a good quality fuel will give the following results: long engine life and acceptable exhaust emissions levels. The fuel must meet the minimum requirements that are stated in the table 10 .

NOTICE

The footnotes are key part of the Perkins "Specification for Distillate Diesel Fuel" Table. Read ALL of the footnotes.

Table 10

"Perkins Specification for Distillate Diesel Fuel"				
Property	UNITS	Requirements	"ASTM" Test	"ISO/Other" Test
Aromatics	%Volume	35% maximum	"D1319"	"ISO 3837"
Ash	%Weight	0.01% maximum	"D482"	"ISO 6245"
Carbon Residue on 10% Bottoms	%Weight	0.20% maximum	"D524"	"ISO 4262"
Cetane Number ⁽¹⁾	-	40 minimum in North America 45 minimum in European Union	"D613 or D6890"	"ISO 5165"
Cloud Point	°C	The cloud point must not exceed the lowest expected ambient temperature.	"D2500"	"ISO 3015"
Copper Strip Corrosion	-	No. 3 maximum	"D130"	"ISO 2160"
Distillation	°C	50% at 250° C (482° F) minimum 90% at 350° C (662° F) maximum	"D86"	"ISO 3405"
Density at 15 °C (59 °F) ⁽²⁾	kg/M ³	800 minimum and 860 maximum	No equivalent test	"ISO 3675""ISO 12185"
Flash Point	°C	legal limit	"D93"	"ISO 2719"
Thermal Stability	-	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	"D6468"	No equivalent test
Pour Point	°C	6 °C (42.8 °F) minimum below ambient temperature	"D97"	"ISO 3016"
Sulfur ⁽³⁾	%mass	0.0015 % maximum	"D5453"	"ISO 20846"
Kinematic Viscosity ⁽⁴⁾	MM ² /S (cSt)	The viscosity of the fuel that is delivered to the fuel injection pump. 1.4 minimum and 4.5 maximum	"D445"	"ISO 3405"
Water and sediment	% weight	0.05% maximum	"D1796"	"ISO 3734"
Water	% weight	0.02% maximum	"D1744"	No equivalent test
Sediment	% weight	0.05% maximum	"D473"	"ISO 3735"
Gums and Resins ⁽⁵⁾	mg/100mL	10 mg per 100 mL maximum	"D381"	"ISO 6246"
Lubricity corrected wear scar diameter at 60 °C (140 °F). ⁽⁶⁾	mm	0.52 maximum	"D6079"	"ISO 12156-1"
Fuel Cleanliness ⁽⁷⁾	-	"ISO 18/16/13"	"D7619"	"ISO 4406"
Trace Metals ⁽⁸⁾	mg/mg	Max 1 or non-detectable	"D7111"	
Oxidation Stability	g/m ³	Max 25	"D2274"	"ISO 12205"
	Hours ⁽⁹⁾	Min 20		"EN 15751"

(1) A fuel with a higher cetane number than 45 is recommended to operate at a higher altitude in cold weather

(2) Density range allowed includes summer and winter diesel fuel grades.

(continued)

Maintenance Section
General Fuel Information

(Table 10, contd)

- (3) Ultra Low Sulfur Diesel Fuel with sulphur content less than 0.0015 percent 15 PPM (mg/kg) must be used. Use of diesel fuel with higher than 15 PPM sulphur limit in these engines will harm or permanently damage emissions control systems. Also, use of diesel fuel with higher than 15 PPM sulphur limit can shorten service interval.
- (4) The values of the fuel viscosity are the values as the fuel is delivered to the fuel injection pumps. Fuel should also meet the minimum viscosity requirement and the fuel should meet the maximum viscosity requirements at 40 °C (104 °F) of either the "ASTM D445" test method or the "ISO 3104" test method. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain "1.4 cSt" or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters to lower the viscosity to "1.4 cSt" at the fuel injection pump.
- (5) Follow the test conditions and procedures for gasoline (motor).
- (6) The lubricity of a fuel is a concern with low sulfur and ultra low sulfur fuel. Fuel with higher wear scar diameter than 0.52 mm (0.0205 inch) will lead to reduced service life and premature failure of the fuel system. Refer to the lubricity section of this "Operation and Maintenance Manual" Fluid Recommendations for more information.
- (7) Recommended cleanliness level for fuel as dispensed into machine or engine fuel tank is "ISO 18/16/13" or cleaner as per "ISO 4406". Refer to the "Contamination Control Recommendations for Fuels".
- (8) Examples of trace metals include but not limited to Cu, Fe, Mn, Na, P, Pb, Si, and Zn. Use of metal-based additives is not allowed.
- (9) Additional limit for fuel containing FAME. Fuel containing more than 2% v/v FAME must meet both tests.

Note: The owner and the operator of the engine has the responsibility of using the fuel that is prescribed by the EPA and other appropriate regulatory agencies.

NOTICE

Operating with fuels that do not meet the Perkins recommendations can cause the following effects: Starting difficulty, reduced fuel filter service life, poor combustion, deposits in the fuel injectors, significantly reduce service life of the fuel system. Also, the creation of deposits in the combustion chamber and reduced service life of the engine.

NOTICE

The Perkins 400J series of diesel engine must be operated using Ultra Low Sulfur Diesel. The sulphur content of this fuel must be lower than 15 PPM. This fuel complies with the emissions regulations that are prescribed by the Environmental Protection Agency of the United States.

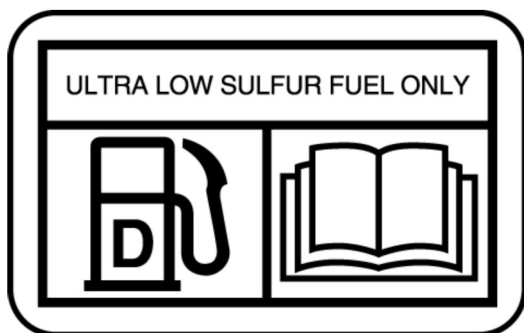


Illustration 24

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Illustration 24 is a representation of the label that will be installed next to the fuel filler cap on the fuel tank of the application.

The fuel specifications that are listed in the table 11 are released as acceptable to use on all 400J series of engine.

Table 11

Acceptable Fuel Specification for the 403J-E17, and 404J-E22 Series of Engines ⁽¹⁾	
Fuel Specification	Comments
EN590	European Automotive Diesel Fuel (DERV)
"ASTM D975 GRADE 1D S15"	"North American Light Distillate Diesel fuel with less than 15 PPM sulfur level"
"ASTM D975 GRADE 2D S15"	"North American Middle Distillate general-purpose Diesel fuel with less than 15 PPM sulfur level"
"JIS K2204"	"Japanese Diesel Fuel" Must meet the requirements that are stated in the lubricity section of this "Operation and Maintenance Manual" Fluid Recommendations.
"BS 2869: 2010 CLASS A2 or EU equivalent"	UK Off-Road Diesel fuel
"CEN TS15940"	"Paraffinic diesel fuel from synthesis or hydrotreatment", "Biomass-to-liquid" (BTL), "Gas-to-liquid" (GTL), called Hydrotreated Vegetable Oil (HVO). Refer to the Renewable and Alternative Fuels section of this "Operation and Maintenance Manual" Fluid Recommendations for more information.
B20 Biodiesel Blend	Refer to the Recommendation for Biodiesel and Using B20 section of this "Operation and Maintenance Manual" Fluid Recommendations for more information.

⁽¹⁾ All the fuels must comply with the specification in the table for the Perkins Specification Distillate Diesel Fuel.

Diesel Fuel Characteristics

Cetane Number

Cetane number is a measure of the ignition quality of diesel fuel. Fuel that has a higher cetane number will give a shorter ignition delay and will produce a better ignition quality. Cetane numbers are derived for fuels against proportions of cetane and heptamethylnonane in the standard CFR engine. Refer to "ISO 5165" for the test method.

In Europe for non-road Stage V emissions regulations require minimum cetane number of 45. In the North America, minimum cetane number requirement is 40.

Cetane number affect engine cold start ability, exhaust emissions, combustion noise, and altitude performance. Fuel with a higher cetane number is desirable and recommended. This is particularly important for operations in cold weather and at high altitude.

Viscosity

Viscosity is the property of a liquid of offering resistance to shear or flow. Viscosity decreases with increasing temperature. This decrease in viscosity follows a logarithmic relationship for normal fossil fuel. The common reference is to kinematic viscosity. Kinematic viscosity is the quotient of the dynamic viscosity that is divided by the density. The determination of kinematic viscosity is normally by readings from gravity flow viscometers at standard temperatures. Refer to "ISO 3104" for the test method.

The viscosity of the fuel is significant because fuel serves as a lubricant for the fuel system components. Fuel must have sufficient viscosity to lubricate the fuel system in both extremely cold temperatures and extremely hot temperatures. If the kinematic viscosity of the fuel is lower than "1.4 cSt" at the fuel injection pump, damage to the fuel injection pump can occur. This damage can be excessive scuffing and seizure. Low viscosity may lead to difficult hot restarting, stalling, and loss of performance. High viscosity may result in seizure of the pump.

Perkins recommends kinematic viscosities of between 1.4 and 4.5 mm²/sec (cSt) that is delivered to the fuel injection pump. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain 1.4 mm²/sec (cSt) or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters to lower the viscosity to 4.5 cSt at the fuel injection pump.

Density

Density is the mass of the fuel per unit volume at a specific temperature. This parameter has a direct influence on engine performance and a direct influence on emissions. This influence determines from a heat output given injected volume of fuel. This parameter is quoted in kg/m³ at 15 °C (59 °F).

Perkins recommends a density of 841 kg/m³ to obtain the correct power output. Lighter fuels are acceptable but these fuels will not produce the rated power.

Sulfur

The level of sulfur is governed by emissions legislations. Regional regulations, national regulations, or international regulations can require a fuel with a specific sulfur limit. The sulfur content of the fuel and the fuel quality must comply with all existing local regulations for emissions.

Perkins 403J, and 404J series diesel engines have been designed to operate only with Ultra Low Sulfur Diesel (ULSD) fuel. By using the test methods "ASTM D5453, or ISO 20846", the content of sulfur in ULSD fuel must be below 15 PPM (mg/kg) or 0.0015% mass.

In the USA, EPA regulations require the use ULSD fuel with less than 0.0015 percent (15 PPM) (mg/kg) sulfur content.

In Europe, sulfur free diesel fuels with sulphur content less than 0.0010 percent (10 PPM) (mg/kg) is required by regulation for use in engines certified to EU nonroad Stage V emissions.

NOTICE

Use of diesel fuel with higher than 15 PPM sulphur limit in these engines will harm or permanently damage emissions control systems and/or shorten service interval.

Lubricity

Lubricity is the capability of the fuel to prevent pump wear. The fluids lubricity describes the ability of the fluid to reduce the friction between surfaces that are under load. This ability reduces the damage that is caused by friction. Fuel injection systems rely on the lubricating properties of the fuel. Until fuel sulfur limits were mandated, the fuels lubricity was generally believed to be a function of fuel viscosity.

The lubricity has particular significance to the current ultra low sulfur fuel, and low aromatic fossil fuels. These fuels are made to meet stringent exhaust emissions.

The lubricity of these fuels must not exceed wear scar diameter of 0.52 mm (0.0205 inch). The fuel lubricity test must be performed on an HFRR, operated at 60 °C (140 °F). Refer to "ISO 12156-1".

NOTICE

The fuels system has been qualified with fuel having lubricity up to 0.52 mm (0.0205 inch) wear scar diameter as tested by "ISO 12156-1". Fuel with higher wear scar diameter than 0.52 mm (0.0205 inch) will lead to reduced service life and premature failure of the fuel system.

Fuel additives can enhance the lubricity of a fuel. Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can make recommendations for additives to use, and for the proper level of treatment.

Distillation

Distillation is an indication of the mixture of different hydrocarbons in the fuel. A high ratio of lightweight hydrocarbons can affect the characteristics of combustion.

Recommendation for Biodiesel and Using B20

Biodiesel is a fuel that can be defined as mono-alkyl esters of fatty acids. Biodiesel is a fuel that can be made from various feedstocks. The most commonly available biodiesel in Europe is Rape Methyl Ester (RME). This biodiesel is derived from rapeseed oil. Soy Methyl Ester (SME) is the most common biodiesel in the United States. This biodiesel is derived from soybean oil. Soybean oil or rapeseed oil are the primary feedstocks. These fuels are together known as Fatty Acid Methyl Esters (FAME).

Raw pressed vegetable oils are NOT acceptable for use as a fuel in any concentration in compression engines. Without esterification, these oils solidify in the crankcase and the fuel tank. These fuels may not be compatible with many of the elastomers that are used in engines that are manufactured today. In original forms, these oils are not suitable for use as a fuel in compression engines. Alternate base stocks for biodiesel may include animal tallow, waste cooking oils, or various other feedstocks. To use any of the products that are listed as fuel, the oil must be esterified.

Fuel made of 100 percent FAME is generally referred to as B100 biodiesel or neat biodiesel.

Biodiesel can be blended with distillate diesel fuel. The blends can be used as fuel. The most commonly available biodiesel blends are B5, which is 5 percent biodiesel and 95 percent distillate diesel fuel. B20, which is 20 percent biodiesel and 80 percent distillate diesel fuel.

Note: The percentages given are volume-based.

The U.S. distillate diesel fuel specification "ASTM D975" includes up to B5 (5 percent) biodiesel.

European distillate diesel fuel specification EN590 includes up to B7 (7 percent) biodiesel.

Note: Engines that are manufactured by Perkins are certified by use of the prescribed Environmental Protection Agency (EPA) and European Certification Agency (EPA) and European Certification Agency (EPA) and European Certification Agency (EPA) fuels. Perkins does not certify engines on any other fuel. The user of the engine has the responsibility of using the correct fuel that is recommended by the manufacturer and allowed by the EPA and other appropriate regulatory agencies.

Specification Requirements

The neat biodiesel must conform to the latest "EN14214 or ASTM D6751" (in the USA). The biodiesel can only be blended in mixture of up to 20% by volume in acceptable mineral diesel fuel meeting latest edition of "EN590 or ASTM D975 S15" designation.

In United States Biodiesel blends of B6 to B20 must meet the requirements listed in the latest edition of "ASTM D7467" (B6 to B20) and must be of an API gravity of 30-45.

In North America biodiesel and biodiesel blends must be purchased from the BQ-9000 accredited producers and BQ-9000 certified distributors.

In other areas of the world, the use of biodiesel that is BQ-9000 accredited and certified, or that is accredited and certified by a comparable biodiesel quality body to meet similar biodiesel quality standards is required.

Engine Service Requirements

Aggressive properties of biodiesel fuel may cause debris in the fuel tank and fuel lines. The aggressive properties of biodiesel will clean the fuel tank and fuel lines. This cleaning of the fuel system can prematurely block the fuel filters. Perkins recommend that after the initial usage of B20 biodiesel blended fuel the fuel filters must be replaced at 50 hours.

Glycerides present in biodiesel fuel will also cause fuel filters to become blocked more quickly. Therefore the regular service interval should be reduced to 250 hours.

When biodiesel fuel is used, crank case oil and aftertreatment systems may be influenced. This influence is due to the chemical composition and characteristics of biodiesel fuel, such as density and volatility, and to chemical contaminants that can be present in this fuel, such as alkali and alkaline metals (sodium, potassium, calcium, and magnesium).

- Crankcase oil fuel dilution can be higher when biodiesel or biodiesel blends are used. This increased level of fuel dilution when using biodiesel or biodiesel blends is related to the typically lower volatility of biodiesel. In-cylinder emissions control strategies utilized in many of the industrial latest engine designs may lead to a higher level of biodiesel concentration in the sump. The long-term effect of biodiesel concentration in crankcase oil is unknown currently.
- Perkins recommend the use of oil analysis to check the quality of the engine oil if biodiesel fuel is used. Ensure that the level of biodiesel in the fuel is noted when the oil sample is taken.

Performance Related Issues

Due to the lower energy content than the standard distillate fuel B20 will cause a power loss in order of 2 to 4 percent. In addition, over time the power may deteriorate further due to deposits in the fuel injectors.

Biodiesel and biodiesel blends are known to cause an increase in fuel system deposits, most significant of which are deposits within the fuel injector. These deposits can cause a loss in power due to restricted or modified fuel injection or cause other functional issues associated with these deposits.

Note: Perkins Fuel Cleaner (part number T400012) is most effective in cleaning and preventing the formation of deposits. Perkins Diesel Fuel Conditioner helps to limit deposit issues by improving the stability of biodiesel and biodiesel blends. For more information refer to Perkins Diesel Fuel Cleaner.

Biodiesel fuel contains metal contaminants (sodium, potassium, calcium, and/or magnesium) that form ash products upon combustion in the diesel engine. The ash can have an impact on the life and performance of aftertreatment emissions control devices and can accumulate in DPF. The ash accumulation may cause the need for more frequent ash service intervals and cause loss of performance.

General Requirements

Biodiesel has poor oxidation stability, which can result in long-term problems in the storage of biodiesel. Biodiesel fuel should be used within 6 months of manufacture. Equipment should not be stored with the B20 biodiesel blends in the fuel system.

Due to poor oxidation stability and other potential issues, it is strongly recommended that engines with limited operational time either not use B20 biodiesel blends or, whilst accepting some risk, limit biodiesel blend to a maximum of B5. Examples of applications that should limit the use of biodiesel are the following: Standby Generator sets and certain emergency vehicles.

For standby generator sets and emergency vehicles that cannot avoid use of biodiesel blends fuel quality in the engine fuel tank must be sampled and checked monthly. Test should include acid number (EN14104), oxidation stability (EN 15751 commonly known as the Rancimat test), and sediment (ISO12937). For standby generator sets oxidation stability of biodiesel blend must be 20 hours or more as per EN 15751. If the test shows that the fuel has degraded, fuel tank must be drained and engine flushed by running with the fresh high-quality diesel fuel.

Perkins strongly recommended that seasonally operated engines have the fuel systems, including fuel tanks, flushed with conventional diesel fuel before prolonged shutdown periods. An example of an application that should seasonally flush the fuel system is a combine harvester.

Microbial contamination and growth can cause corrosion in the fuel system and premature plugging of the fuel filter. Consult your supplier of fuel for assistance in selecting appropriate anti-microbial additive.

Water accelerates microbial contamination and growth. When biodiesel is compared to distillate fuels, water is naturally more likely to exist in the biodiesel. Therefore check frequently and if necessary, drain the water separator.

Materials such as brass, bronze, copper, lead, tin, and zinc accelerate the oxidation process of the biodiesel fuel. The oxidation process can cause the formation of deposits therefore these materials must not be used for fuel tanks and fuel lines.

Renewable and Alternative Fuels

Perkins supports development and use of renewable fuels through sustainability initiatives. In recent years various forms of renewable and alternative (synthetic) diesel fuels have started to emerge.

Synthetic diesel fuels are produced by gasification of various feedstock and then synthesis to liquid to obtain paraffinic diesel fuel. Based on the feedstock used these fuels are commonly referred to as Biomass To Liquid (BTL), Gas To Liquid (GTL) and Coal To Liquid (CTL). Hydrotreating of vegetable oils and animal fats is another emerging process for production of bio based diesel fuel called Hydrotreated Vegetable Oil (HVO).

BTL and HVO fuels are considered to be low carbon fuels as they reduce carbon footprint compared to fossil fuels and are commonly referred to as renewable fuels. These fuels must not be confused with biodiesel FAME which is fundamentally different fuel and is discussed in a separate section in this manual.

These paraffinic diesel fuels have virtually no sulphur or aromatics and have very high cetane numbers which enable very clean burning and efficient engine operation. Chemically these fuels are similar to diesel fuel derived from petroleum.

Paraffinic diesel fuels are considered as acceptable to use as a direct replacement to petroleum diesel or as a blendstock for petroleum diesel fuel in Perkins diesel engines provided they meet latest edition of the paraffinic diesel fuel specification "CENTS 15940". The fuel should also meet requirements described in table 10, Perkins Specification for Distillate Diesel Fuel, EN590, or latest ASTM D975 specification with the exception of density, which is inherently lower for paraffinic fuels. **Due to lower density, some rated power loss might be noticeable.**

Ensure that the fuel has got appropriate cold flow properties (cloud point and CFPP) for the minimum statistical ambient temperature the engine is expected to see in the operation. The fuel must also meet lubricity requirements as specified in the lubricity section of this "Operation and Maintenance Manual" Fluid Recommendations

Fuel for Cold-Weather Operation

The European standard "EN590" contains climate dependant requirements and a range of options. The options can be applied differently in each country. There are five classes that are given to arctic climates and severe winter climates. 0, 1, 2, 3 and 4.

Fuel that complies with "EN590" CLASS 4 can be used at temperatures as low as $-44\text{ }^{\circ}\text{C}$ ($-47.2\text{ }^{\circ}\text{F}$). Refer to "EN590" for a detailed discretion of the physical properties of the fuel.

The diesel fuel "ASTM D975 1-D" used in the United States of America may be used in very cold temperatures that are below $-18\text{ }^{\circ}\text{C}$ ($-0.4\text{ }^{\circ}\text{F}$).

Aftermarket Fuel Additives

NOTICE

Perkins does not warrant the quality or performance of non-Perkins fluids and filters.

When auxiliary devices, accessories, or consumables (filters, additives) which are made by other manufacturers are used on Perkins products, the Perkins warranty is not affected simply because of such use.

However, failures that result from the installation or use of other manufacturers devices, accessories, or consumables are NOT Perkins defects. Therefore, the defects are NOT covered under the Perkins warranty.

Supplemental diesel fuel additives are not generally recommended. This recommendation is due to potential damage to the fuel system or the engine. Your fuel supplier or the fuel manufacturer will add the appropriate supplemental diesel fuel additives.

Perkins recognizes the fact that additives may be required in some special circumstances.

Note: Some anti-corrosion additives can lead to injector fouling, this fouling can cause the injector to operate incorrectly.

Contact your fuel supplier for those circumstances when fuel additives are required. Your fuel supplier can recommend the appropriate fuel additive and the correct level of treatment.

Note: For the best results, your fuel supplier should treat the fuel when additives are required. The treated fuel must meet the requirements that are stated in table 10 .

Perkins Diesel Fuel System Cleaner

Perkins Fuel Cleaner (part number T400012) is the only fuel cleaner that is recommended by Perkins.

If biodiesel or biodiesel blends of fuel are to be used, Perkins require the use of Perkins fuel cleaner. The use of the fuel is to remove deposits within the fuel system that is created with the use of biodiesel. For more information on the use of biodiesel and biodiesel blends refer to Recommendation for Biodiesel and Using B20.

Perkins fuel cleaner will remove deposits that can form in the fuel system with the use of biodiesel and biodiesel blends. These deposits can create a loss of power and engine performance.

Once the fuel cleaner has been added to the fuel, the deposits within the fuel system are removed after 30 hours of engine operation. For maximum results, continue to use the fuel cleaner for up to 80 hours. Perkins fuel cleaner can be used on an on-going basis with no adverse impact on engine or fuel system durability.

Detailed instructions on the rate at which the fuel cleaner is to be used are on the container.

Note: Perkins fuel cleaner is compatible with existing and U.S. EPA Tier 4 nonroad certified diesel engine emission control catalysts and particulate filters. Perkins fuel system cleaner contains less than 15 ppm of sulfur and is acceptable for use with ULSD fuel.

Contamination Control Recommendations for Fuels

Fuels of "ISO 18/16/13" cleanliness level or cleaner as dispensed into the engine or application fuel tank should be used. This action will reduce risk of power loss, fuel system failures, and related down time of engines. This cleanliness level is important for new fuel system designs such as common rail injection systems and unit injectors. These fuels systems utilize higher fuel injection pressures and have tight clearances between moving parts to meet required stringent emissions regulations. Peak injection pressures in current fuel injection systems may exceed 2000 bar (29000 psi). Clearances in these systems are less than 5 µm. As a result, particle contaminants as small as 4 µm can cause scoring and scratching of internal pump and injector surfaces and of injector nozzles.

Water in the fuel causes cavitation, corrosion of fuel system parts, and provides an environment where microbial growth in the fuel can flourish. Other sources of fuel contamination are soaps, gels, or other compounds that may result from undesirable chemical interactions in the fuels, particularly in ULSD. Gels and other compounds can also form in biodiesel fuel at low temperatures or if biodiesel is stored for extended periods. The best indication of microbial contamination, fuel additives, or cold temperature gel is rapid filter plugging of bulk fuel filters or application fuel filters.

To reduce downtime due to contamination, follow these fuel maintenance guidelines.

- Use high-quality fuels per recommended and required specifications
- Fill fuel tanks with fuels of "ISO 18/16/13" cleanliness level or cleaner, in particular for engines with common rail and unit injection systems. When you refuel the tank, filter the fuel through a 4 µm absolute filter (Beta 4 = 75 up to 200) to reach the recommended cleanliness level. This filtration should be installed at the device that dispenses the fuel to the fuel tank. In addition, filtration at the dispensing point should remove water to ensure that fuel is dispensed at 500 ppm water or less.

- Perkins recommends the use of bulk fuel filter / coalescer units which clean the fuel of both particulate contamination and water in a single pass.
- Ensure that you use Perkins Advanced Efficiency Fuel Filters. Change your fuel filters per recommended service requirements or as needed.
- Drain your water separators daily.
- Drain your fuel tanks of sediment and water per the Operation and Maintenance Manual instructions.
- Install and maintain a properly designed bulk filter / coalescer filtration system. Continuous bulk filtration systems may be required to ensure that dispensed fuel meets the cleanliness target. Consult your Perkins distributor for availability of bulk filtration products.
- Centrifugal filters may need to be used as a pre-filter with fuel that is severely contaminated with gross amounts of water and/or large particulate contaminants. Centrifugal filters can effectively remove large contaminants. Centrifugal filters may not be able to remove the small abrasive particles required to achieve the recommended "ISO" cleanliness level. Bulk filter / coalescers are necessary as a final filter to achieve the recommended cleanliness level.
- Install desiccant type breathers of 4 µm or less absolute efficiency with the ability to remove water on bulk storage tanks.
- Follow proper practices of fuel transportation. Filtration from the storage tank to the application promotes the delivery of clean fuel. Fuel filtration can be installed at each transport stage to keep the fuel clean.
- Cover, protect, and ensure cleanliness of all connection hoses, fittings, and dispensing nozzles.

Consult your local Perkins distributor for additional information on Perkins designed and produced filtration products.

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Fluid Recommendations (General Lubricant Information)

Because of government regulations regarding the certification of exhaust emissions from the engine, the lubricant recommendations must be followed.

- API American Petroleum Institute

The Engine Oil Licensing and Certification System by the American Petroleum Institute (API) is recognized by Perkins. For detailed information about this system, see the latest edition of the "API publication No. 1509". Engine oils that bear the API symbol are authorized by API

Perkins Recommendations

This Perkins engine model 404J-22 with the engine build list of IN84182 and IN84331 is a special design. Only operate this engine using synthetic engine oil that is recommended by Perkins.

Table 12

Recommended Synthetic Engine Oils			
Brand	Type	Specification	Grade
Shell	Rimula R6 LM	API CI-4	10W-40
Mobil	Delvac 1	API CI-4 Plus	5W-40
Chevron	Delo 400 LE Synthetic	API CJ-4	5W-40
Aral	Mega Turboral LA	API CJ-4	10W-40

Maintenance Recommendations

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System Pressure Release

Coolant System

WARNING

Pressurized system: Hot coolant can cause serious burn. To open cap, stop engine, wait until radiator is cool. Then loosen cap slowly to relieve the pressure.

Ensure that the power supply is isolated before any service or repair is performed.

To relieve the pressure from the coolant system, turn off the engine. Allow the cooling system pressure cap to cool. Remove the cooling system pressure cap slowly in order to relieve pressure.

Fuel System

To relieve the pressure from the fuel system, turn off the engine.

Engine Oil

To relieve pressure from the lubricating system, turn off the engine.

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Welding on Engines with Electronic Controls

Correct welding procedures are necessary to avoid damage to the following components:

- Electronic Control Module (ECM) for the governor
- Sensors
- Associated components

Components for the driven equipment should also be considered. When possible, remove the component that requires welding. When welding on an engine that is equipped with an ECM and removal of the component is not possible, the following procedure must be followed. This procedure minimizes the risk to the electronic components.

1. Stop the engine. Remove the electrical power from the ECM.
2. Ensure that the fuel supply to the engine is turned off.
3. Disconnect the negative battery cable from the battery. If a battery disconnect switch is installed, open the switch.
4. Disconnect all electronic components from the wiring harnesses. Include the following components:
 - Electronic components for the driven equipment
 - ECM
 - Switches
 - Sensors
 - Relays

NOTICE

Do not use electrical components (ECM, switches, or sensors) or electronic component grounding points for grounding the welder.

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Severe Service Application

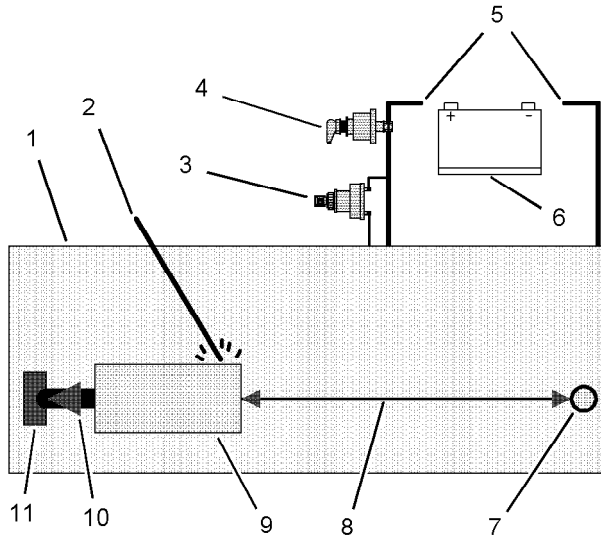


Illustration 25

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Use the example above. The current flow from the welder to the ground clamp of the welder will not damage any associated components.

- (1) Engine
- (2) Welding electrode
- (3) Keyswitch in the OFF position
- (4) Battery disconnect switch in the open position
- (5) Disconnected battery cables
- (6) Battery
- (7) Electrical/Electronic component
- (8) Minimum distance between the component that is being welded and any electrical/electronic component
- (9) The component that is being welded
- (10) Current path of the welder
- (11) Ground clamp for the welder

5. When possible, connect the ground clamp for the welding equipment directly to the engine component that will be welded. Place the clamp as close as possible to the weld. Close positioning reduces the risk of welding current damage to the engine bearings, to the electrical components, and to other components.
6. Protect the wiring harnesses from welding debris and/or from welding spatter.
7. Use standard welding procedures to weld the materials together.

Severe service is the application of an engine that exceeds the current published standards for that engine. Perkins maintains standards for the following engine parameters:

- Performance such as power range, speed range, and fuel consumption
- Fuel quality
- Operational Altitude
- Maintenance intervals
- Oil selection and maintenance
- Coolant type and maintenance
- Environmental qualities
- Installation
- The temperature of the fluid in the engine

Refer to the standards for the engine or consult your Perkins dealer or your Perkins distributor to determine if the engine is operating within the defined parameters.

Severe service operation can accelerate component wear. Engines that operate under severe conditions may need more frequent maintenance intervals to ensure maximum reliability and retention of full service life.

Due to individual applications, it is not possible to identify all the factors which can contribute to severe service operation. Consult your Perkins dealer or your Perkins distributor for the unique maintenance that is necessary for the engine.

The operating environment, incorrect operating procedures, and incorrect maintenance procedures can be factors which contribute to a severe service application.

Environmental Factors

Ambient temperatures – The engine may be exposed to extended operation in cold environments or hot environments. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in cold temperatures. Hot intake air reduces engine performance.

Quality of the air – The engine may be exposed to extended operation in an environment that is dirty or dusty, unless the equipment is cleaned regularly. Mud, dirt, and dust can encase components.

Maintenance can be difficult. The buildup can contain corrosive chemicals.

Buildup – Compounds, elements, corrosive chemicals, and salt can damage some components.

Altitude – Problems can arise when the engine is operated at altitudes that are higher than the intended settings for that application. Necessary adjustments should be made.

Incorrect Operating Procedures

- Frequent hot shutdowns
- Operating at excessive loads
- Operating at excessive speeds
- Operating outside the intended application

Incorrect Maintenance Procedures

- Extending the maintenance intervals
- Failure to use recommended fuel, lubricants, and coolant/antifreeze

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Maintenance Interval Schedule

When Required

- " Battery - Replace" 56
- " Battery or Battery Cable - Disconnect" 56
- " Engine - Clean" 61
- " Engine Air Cleaner Element - Replace" 61
- " Fuel System - Prime" 64

Daily

- " Coolant Level - Check" 60
- " Engine Oil Level - Check" 62
- "Walk-Around Inspection" 68

Every 50 Service Hours or Weekly

- " Fuel Tank Water and Sediment - Drain" 66

Every 3000 Service Hours

- " Engine Crankcase Breather - Replace" 61
- " Engine Oil and Filter - Change" 63
- " Engine Valve Lash - Check" 64
- " Fuel System Secondary Filter - Replace" 65
- " Radiator - Clean" 67
- " Coolant Temperature Regulator - Replace" 60

Every 6000 Service Hours

- " Belts - Replace" 56
- " Coolant Extender (ELC) - Add" 60
- "Fuel Injection Pump - Check" 64
- "Fuel Transfer Pump - Replace" 67

- "Water Pump - Replace" 68

Every 9000 Service Hours

- "Starting Motor - Replace" 68

Every 12 000 Service Hours or 6 Years

- " Coolant (ELC) - Change" 58

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Battery - Replace

WARNING

Batteries give off combustible gases which can explode. A spark can cause the combustible gases to ignite. This can result in severe personal injury or death.

Ensure proper ventilation for batteries that are in an enclosure. Follow the proper procedures in order to help prevent electrical arcs and/or sparks near batteries. Do not smoke when batteries are serviced.

WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Switch the engine to the OFF position. Remove all electrical loads.
2. Turn off any battery chargers. Disconnect any battery chargers.
3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the NEGATIVE “-” terminal on the starting motor. Disconnect the cable from the NEGATIVE “-” battery terminal.
4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the POSITIVE “+” terminal on the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

Note: Always recycle a battery. Never discard a battery. Dispose of used batteries to an appropriate recycling facility.

5. Remove the used battery.
6. Install the new battery.

Note: Before the cables are connected, ensure that the engine start switch is OFF.

7. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.
8. Connect the NEGATIVE “-” cable to the NEGATIVE “-” battery terminal.

Battery or Battery Cable - Disconnect

WARNING

The battery cables or the batteries should not be removed with the battery cover in place. The battery cover should be removed before any servicing is attempted.

Removing the battery cables or the batteries with the cover in place may cause a battery explosion resulting in personal injury.

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
2. Disconnect the negative battery terminal. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, two negative connection must be disconnected.
3. Remove the positive connection.
4. Clean all disconnected connection and battery terminals.
5. Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit correctly. Coat the clamps and the terminals with a suitable silicone lubricant or petroleum jelly.
6. Tape the cable connections in order to help prevent accidental starting.
7. Proceed with necessary system repairs.
8. In order to connect the battery, connect the positive connection before the negative connector.

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Belts - Replace

Note: The water pump requires replacement at the same time as the special elastic drive belt.

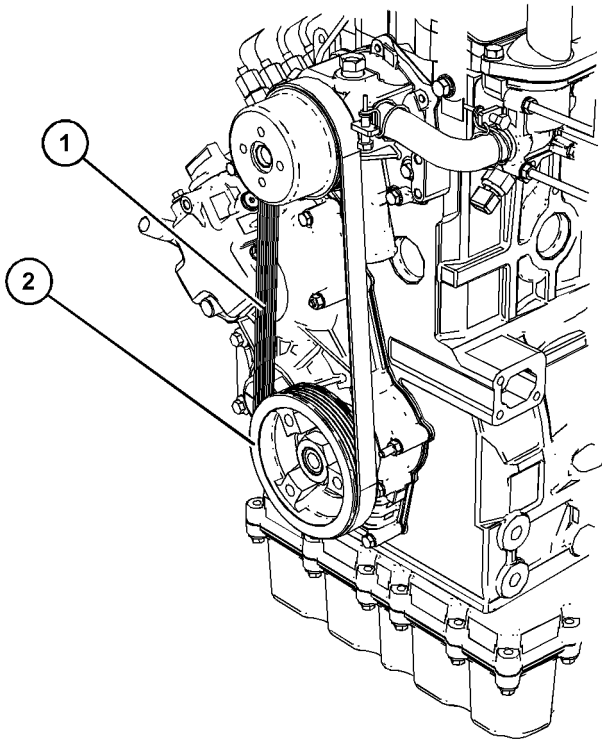


Illustration 26

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Typical example

1. The belt (1) can be cut to remove the belt from the engine.
2. Ensure that both pulleys are clean and free from damage.

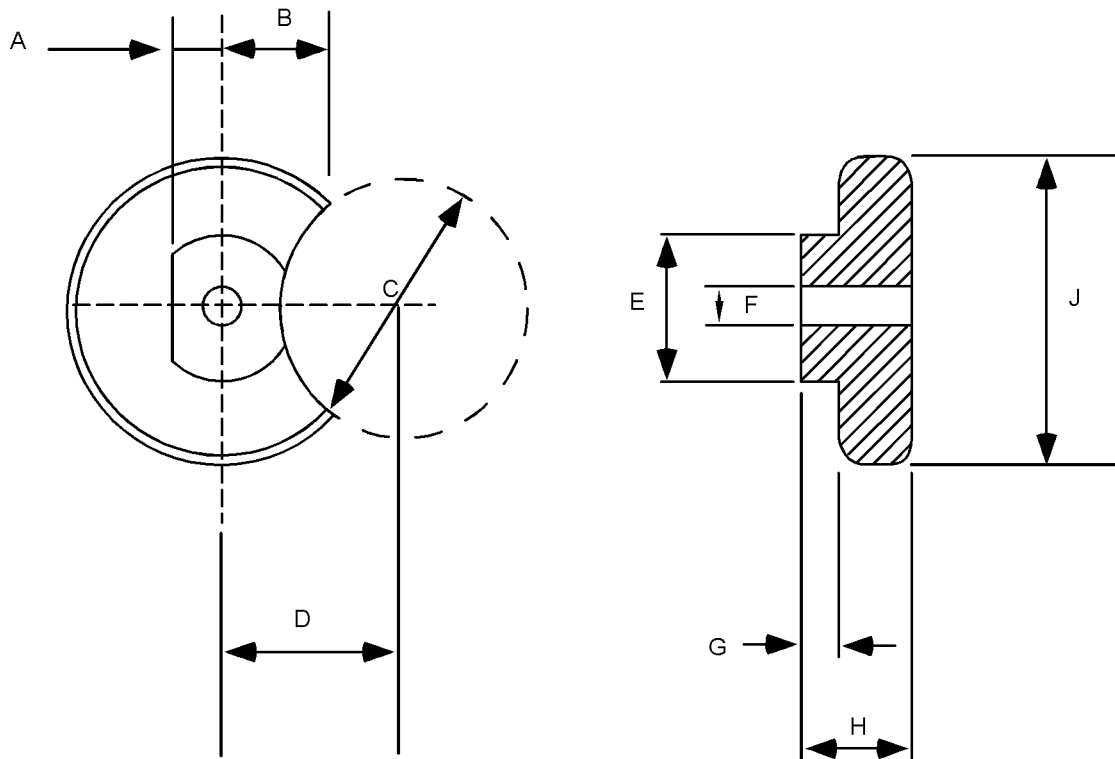


Illustration 27

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Belt tool

(A) 10.5 mm
(B) 23 mm
(C) 50 mm Diameter

(D) 37 mm
(E) 30 mm Diameter
(F) 11 mm Diameter

(G) 6 mm
(H) 18 mm
(J) 65 mm Diameter

3. Install belt tool to the bottom pulley (2). For belt tool details, refer to illustration 27. With the belt tool installed to the bottom pulley (2), rotate pulley to install the belt.

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Coolant (ELC) - Change**NOTICE**

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

Dispose of all fluids according to Local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Clean the cooling system and flush the cooling system before the recommended maintenance interval if the following conditions exist:

- The engine overheats frequently.
- Foaming is observed.
- The oil has entered the cooling system and the coolant is contaminated.
- The fuel has entered the cooling system and the coolant is contaminated.

Note: When the cooling system is cleaned, only clean water is needed when the ELC is drained and replaced.

Note: Inspect the water pump and the water temperature regulator after the cooling system has been drained. This inspection is a good opportunity to replace the water pump, the water temperature regulator, and the hoses, if necessary.

Drain

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap.

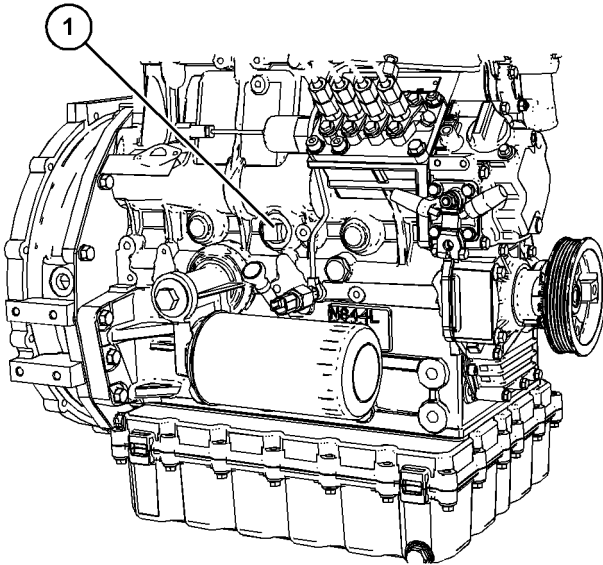


Illustration 28

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Typical example

2. Open the drain cock or remove the drain plug (1) on the engine. Open the drain cock or remove the drain plug on the radiator.

Allow the coolant to drain.

NOTICE

Dispose of used engine coolant or recycle. Various methods have been proposed to reclaim used coolant for reuse in engine cooling systems. The full distillation procedure is the only method acceptable by Perkins to reclaim the coolant.

For information regarding the disposal and the recycling of used coolant, consult your Perkins dealer or your Perkins distributor.

Flush

1. Flush the cooling system with clean water to remove any debris.
2. Close the drain cock or install the drain plug in the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE

Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water. Install the cooling system filler cap.
4. Start and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly to relieve any pressure. Remove the cooling system filler cap. Open the drain cock or remove the drain plug on the engine. Open the drain cock or remove the drain plug on the radiator. Allow the water to drain. Flush the cooling system with clean water.

Fill

1. Close the drain cock or install the drain plug on the engine. Close the drain cock or install the drain plug on the radiator.

NOTICE

Do not fill the cooling system faster than 5 L (1.3 US gal) per minute to avoid air locks.

Cooling system air locks may result in engine damage.

2. Fill the cooling system with Extended Life Coolant (ELC). Refer to the Operation and Maintenance Manual, "Fluid Recommendations" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.
3. Start and run the engine at low idle. Increase the engine rpm to high idle. Run the engine at high idle for 1 minute to purge the air from the cavities of the engine block. Stop the engine.

4. Check the coolant level. Maintain the coolant level within 13 mm (0.5 inch) below the bottom of the pipe for filling. Maintain the coolant level in the expansion bottle (if equipped) at the correct level.
5. Clean the cooling system filler cap. Inspect the gasket that is on the cooling system filler cap. If the gasket that is on the cooling system filler cap is damaged, discard the old cooling system filler cap and install a new cooling system filler cap. If the gasket that is on the cooling system filler cap is not damaged, use a suitable pressurizing pump to pressure test the cooling system filler cap. The correct pressure for the cooling system filler cap is stamped on the face of the cooling system filler cap. If the cooling system filler cap does not retain the correct pressure, install a new cooling system filler cap.
6. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i06854232

Coolant Extender (ELC) - Add

For Perkins ELC to achieve 12000 hours an extender must be added at 6000 hours. For a suitable extender, contact your Perkins dealer or Perkins distributor.

i06851202

Coolant Level - Check

WARNING

Pressurized System: Hot coolant can cause serious burns. To open the cooling system filler cap, stop the engine and wait until the cooling system components are cool. Loosen the cooling system pressure cap slowly in order to relieve the pressure.

Check the coolant level when the engine is stopped and cool.

Refer to the OEM information for the correct procedures.

i06857448

Coolant Temperature Regulator - Replace

Replace the water temperature regulator before the water temperature regulator fails. This is a recommended preventive maintenance practice. Replacing the water temperature regulator reduces the chances for unscheduled downtime.

A water temperature regulator that fails in a partially opened position can cause overheating or overcooling of the engine.

A water temperature regulator that fails in the closed position can cause excessive overheating. Excessive overheating could result in cracking of the cylinder head or piston seizure problems.

A water temperature regulator that fails in the open position will cause the engine operating temperature to be too low during partial load operation. Low engine operating temperatures during partial loads could cause an excessive carbon buildup inside the cylinders. This excessive carbon buildup could result in an accelerated wear of the piston rings and wear of the cylinder liner.

NOTICE

Failure to replace your water temperature regulator on a regularly scheduled basis could cause severe engine damage.

Perkins engines incorporate a shunt design cooling system and require operating the engine with a water temperature regulator installed.

If the water temperature regulator is installed incorrectly, the engine may overheat, causing cylinder head damage. Ensure that the new water temperature regulator is installed in the original position. Ensure that the water temperature regulator vent hole is open.

Do not use liquid gasket material on the gasket or cylinder head surface.

Refer to the Disassembly and Assembly Manual, "Water Temperature Regulator - Remove and Install" for the replacement procedure of the water temperature regulator, or consult your Perkins dealer or your Perkins distributor.

Note: If only the water temperature regulators are replaced, drain the coolant from the cooling system to a level that is below the water temperature regulator housing.

i07376803

i06851726

Engine - Clean

WARNING

Personal injury or death can result from high voltage.

Moisture can create paths of electrical conductivity.

Make sure that the electrical system is OFF. Lock out the starting controls and tag the controls "DO NOT OPERATE" .

NOTICE

Accumulated grease and oil on an engine is a fire hazard. Keep the engine clean. Remove debris and fluid spills whenever a significant quantity accumulates on the engine.

Periodic cleaning of the engine is recommended. Steam cleaning the engine will remove accumulated oil and grease. A clean engine provides the following benefits:

- Easy detection of fluid leaks
- Maximum heat transfer characteristics
- Ease of maintenance

Note: Caution must be used to prevent electrical components from being damaged by excessive water when the engine is cleaned. Do not direct the nozzle of the cleaner at any electrical connectors or the junction of cables into the rear of the connectors. Avoid electrical components such as the alternator, the starter, and the ECM. Protect the fuel injection pump from fluids when washing the engine.

Ensure that care is taken that the safety labels, emission label, and any information labels are not removed during engine cleaning.

Engine Air Cleaner Element - Replace

NOTICE

Never run the engine without an air cleaner element installed. Never run the engine with a damaged air cleaner element. Do not use air cleaner elements with damaged pleats, gaskets or seals. Dirt entering the engine causes premature wear and damage to engine components. Air cleaner elements help to prevent airborne debris from entering the air inlet.

NOTICE

Never service the air cleaner element with the engine running since this will allow dirt to enter the engine.

The type of air filter element installed on the application is unknown to Perkins. Refer to the OEM for the hours when the air filter element should be changed. Refer to OEM for instructions on changing the air filter element or elements.

i06852386

Engine Crankcase Breather - Replace

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i07376805

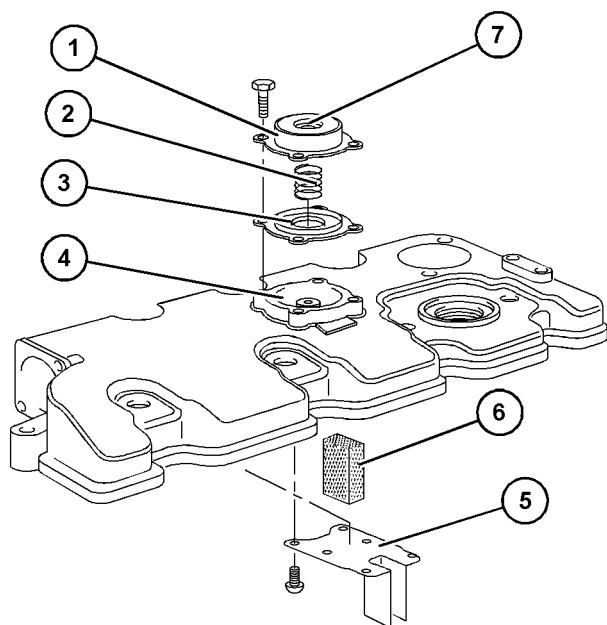


Illustration 29

g06142266

Typical example

- (1) Breather cover
- (2) Spring
- (3) Diaphragm and plate
- (4) Cavity
- (5) Baffle plate
- (6) Gauze
- (7) Vent hole

1. Remove the breather cover (2) diaphragm and plate (3) and remove the spring (2).
2. Remove baffle pate (5) and remove gauze (6). Discard diaphragm and plate (3) and gauze (6). Check the condition of spring (2) and baffle pate (5) and replace, if necessary.
3. Clean the vent hole (6) and the cavity (5) in the valve mechanism cover. Ensure that all components are clean and free from dirt.
4. For information on removing and Installing the breather assembly, refer to Disassembly and Assembly, Crankcase Breather - Remove and Install on naturally aspirated engines.

Engine Oil Level - Check**WARNING**

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

NOTICE

Perform this maintenance with the engine stopped.

Note: Ensure that the application is on a level surface.

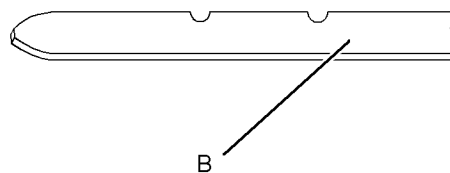
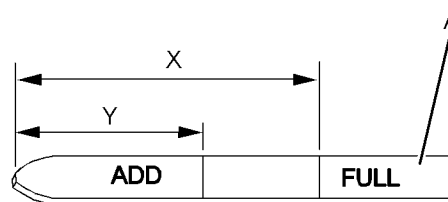


Illustration 30

g03317856

(Y) "ADD" mark. (X) "FULL" mark.

- (A) Original oil level gauge
(B) Alternative oil level gauge

Note: Oil gauge (A) or oil gauge (B) may be installed in the engine.

1. Maintain the oil level between "ADD" mark (Y) and "FULL" mark (X) on oil level gauge (1). Do not fill the crankcase above "FULL" mark (X).

NOTICE

Operating your engine when the oil level is above the "FULL" mark could cause your crankshaft to dip into the oil. The air bubbles created from the crankshaft dipping into the oil reduces the oil's lubricating characteristics and could result in the loss of power or engine failure.

- Remove the oil filler cap and add oil, if necessary. Clean the oil filler cap. Install the oil filler cap.

i06853843

Engine Oil and Filter - Change

WARNING

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Do not drain the oil when the engine is cold. As the oil cools, suspended waste particles settle on the bottom of the oil pan. The waste particles are not removed with the draining cold oil. Drain the crankcase with the engine stopped. Drain the crankcase with the oil warm. This draining method allows the waste particles that are suspended in the oil to be drained correctly.

Failure to follow this recommended procedure will cause the waste particles to be recirculated through the engine lubrication system with the new oil.

Drain the Engine Oil

After the engine has been run at the normal operating temperature, stop the engine. Use the following method to drain the engine crankcase oil:

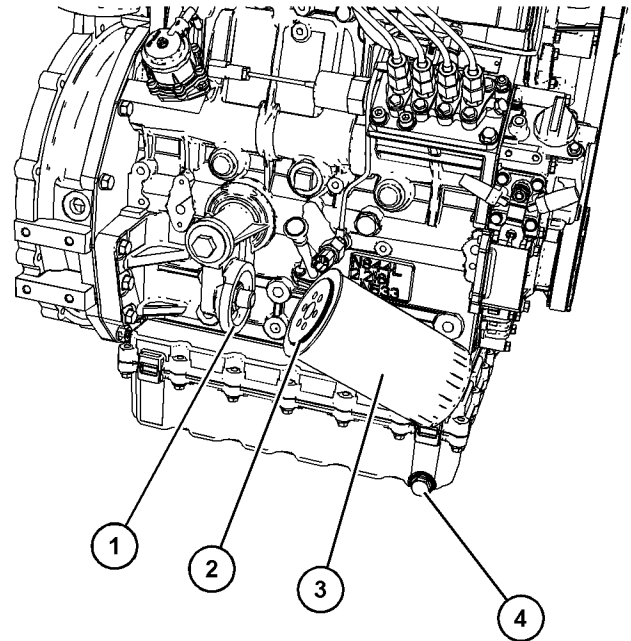


Illustration 31

g06142731

Typical example

- Place a suitable container below the drain plug (4). Remove the drain plug (4) and allow the oil to drain.
- Check the seal on drain plug and if necessary replace seal (not shown). Install the drain plug (4) and tighten to a torque of 34 N·m (301. lb in).

Replace the Oil Filter

- Place a suitable container below the oil filter (3). Using a suitable tool, remove the oil filter (3) and discard the old filter.
- Ensure the mating surface of the oil filter base (1) is clean and free from dirt. Lubricate the O ring seal (2) on the new oil filter (3) with clean engine oil.
- Spin on the new oil filter (3), when the O ring seal (2) contacts the oil filter base (1). Rotate the oil filter $\frac{3}{4}$ of a full turn.

Fill the Engine Crankcase

1. Remove the oil filler cap. Refer to this Operation and Maintenance Manual, Fluid Recommendation for more information on lubricant specifications. Fill the crankcase with the correct amount of oil. Refer to this Operation and Maintenance Manual, Refill Capacities for more information. Install filler cap.
2. Start the engine and operate engine without load for 2 minutes. Perform this procedure to ensure that the lubrication system has oil and that the oil filter is filled. Inspect the oil filter for oil leaks.
3. Stop the engine and check the engine oil level. Maintain the correct oil level, for more information refer to this Operation and Maintenance Manual, Engine Oil Level Check.

Remove all containers and dispose of all fluids according to local regulations and mandates.

i06890795

Engine Valve Lash - Check

This maintenance is recommended by Perkins as part of a lubrication and preventive maintenance schedule to help provide maximum engine life. The maintenance for the valve lash is important to keep the engine compliant.

NOTICE

Only qualified service personnel should perform this maintenance. Refer to the Service Manual or your authorized Perkins dealer or your Perkins distributor for the complete valve lash adjustment procedure.

Operation of Perkins engines with incorrect valve lash can reduce engine efficiency, and also reduce engine component life.

WARNING

Ensure that the engine cannot be started while this maintenance is being performed. To help prevent possible injury, do not use the starting motor to turn the flywheel.

Hot engine components can cause burns. Allow additional time for the engine to cool before measuring/adjusting valve lash clearance.

Ensure that the engine is stopped before measuring the valve lash. The engine valve lash can be inspected and adjusted when the temperature of the engine is hot or cold.

- The engine valve lash setting 0.25 mm (0.00984 inch) for inlet and exhaust valves.

i06857095

Fuel Injection Pump - Check

Remove the fuel injection pump, refer to Disassembly and Assembly, Fuel Injection pump - Remove.

The following components will need to be removed before the fuel injection pump can be removed from the engine

- Fuel leak-off
- Fuel supply line
- Fuel injection lines
- The actuator for the E governor
- The linkage connection to throttle control

Note: The shims for the fuel injection pump must be measured and new shims installed. These shims are also a gasket seal for the fuel injection pump.

1. Check that the cam-rollers on the bottom of the fuel injection pump are free from wear or damage. If necessary, replace fuel injection pump.
2. Check the lobes on the camshaft that operate the fuel injection pump are free from wear or damage. If necessary, replace the camshaft. Refer to Disassembly and Assembly, Camshaft - Remove

Note: Once the front cover of the engine has been removed, the engines exhaust emissions will have to be checked to comply with emissions regulations. Ensure that the governor settings are recorded, refer to Systems Operation Testing and Adjusting, Governor - Adjust for more information.

i06889648

Fuel System - Prime

Ensure that all adjustments and repairs are performed by authorized personnel that have had the correct training.

NOTICE

Do not crank the engine continuously for more than 30 seconds. Allow the starting motor to cool for two minutes before cranking the engine again.

If air enters the fuel system, the air must be purged from the fuel system before the engine can be started. Air can enter the fuel system when the following events occur:

- The fuel tank is empty or the fuel tank has been partially drained.
- The low-pressure fuel lines are disconnected.
- A leak exists in the low-pressure fuel system.
- The fuel filter has been replaced.

Use the following procedures as a general guide to remove air from the fuel system. For more information, refer to the OEM information on priming the fuel system.

1. Ensure that the fuel system is in working order. Check that the fuel supply valve (if equipped) is in the "ON" position.

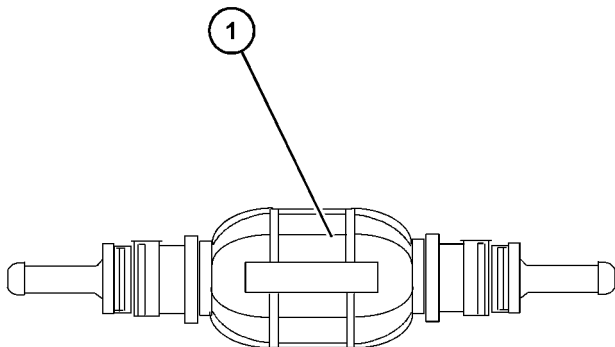


Illustration 32

g06156006

Typical example

() Hand priming pump

2. If equipped, refer to the OEM for priming the primary fuel filter.

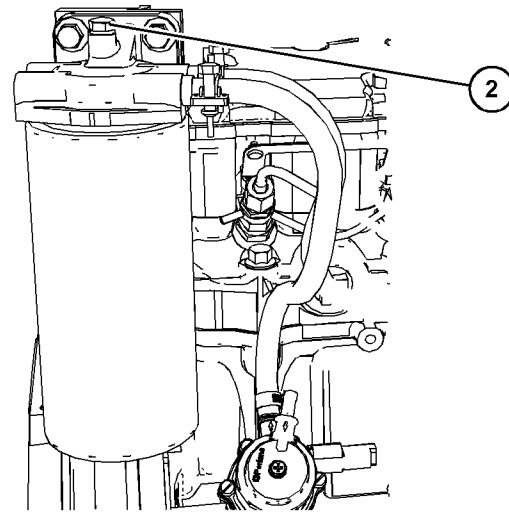


Illustration 33

g06156301

Typical example

3. Loosen vent screw (2) and operate fuel priming pump (1). When fuel free from air comes for the vent, close the vent screw (2). Tighten vent screw (2) to a torque of 8 N·m (70 lb in).
4. Operate the hand fuel priming pump (1). As the fuel system is primed, the pressure will increase within the fuel system and this increase in pressure can be felt during priming.
5. After approximately 2 minutes the fuel system will be primed and the engine should be able to start.
6. Operate the engine starter and crank the engine. After the engine has started, operate the engine without load for a minimum of 3 minutes. Ensure that the fuel system is free from leaks.

i06853962

Fuel System Secondary Filter - Replace

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE

Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Remove and Install the Fuel Filter

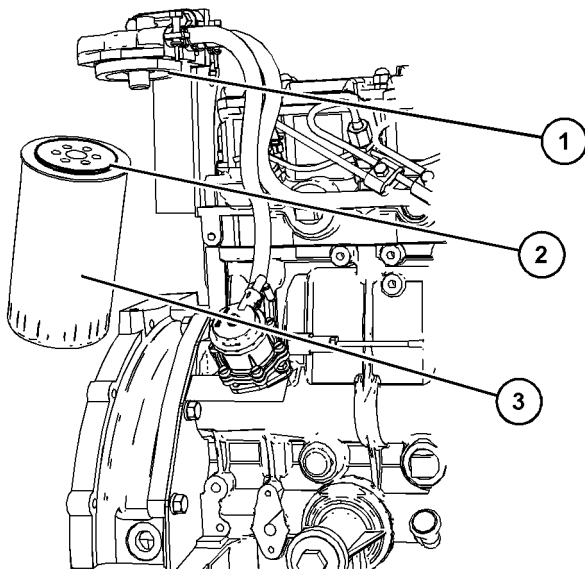


Illustration 34

g06142872

Typical example

1. If equipped, close the fuel supply valve and clean the fuel filter assembly before removal.
2. Place a suitable container below the fuel filter. Using a suitable tool, remove the fuel filter element (3) and discard the fuel filter element.
3. Ensure that the sealing surface (1) on the filter base is clean and free from dirt. Lubricate the O ring seal with clean diesel fuel and spin on the new fuel filter element (3).
4. When the O ring seal (2) contacts the sealing surface (1), rotate the fuel filter element (3) $\frac{3}{4}$ of a turn by hand only.

5. If equipped, open the fuel supply valve. Remove container and dispose of the fluids according to local regulations and mandates.
6. The fuel system will need to be primed after the new fuel filter is installed. Refer to Operation and Maintenance Manual, "Fuel System - Prime".

i06851844

Fuel Tank Water and Sediment - Drain

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

Fuel quality is critical to the performance and to the service life of the engine. Water in the fuel can cause excessive wear to the fuel system.

Water can be introduced into the fuel tank when the fuel tank is being filled.

Condensation occurs during the heating and cooling of fuel. The condensation occurs as the fuel passes through the fuel system and the fuel returns to the fuel tank. This causes water to accumulate in fuel tanks. Draining the fuel tank regularly and obtaining fuel from reliable sources can help to eliminate water in the fuel.

Drain the Water and the Sediment

Fuel tanks should contain some provision for draining water and draining sediment from the bottom of the fuel tanks.

Open the drain valve on the bottom of the fuel tank in order to drain the water and the sediment. Close the drain valve.

Check the fuel daily. Allow five minutes after the fuel tank has been filled before draining water and sediment from the fuel tank.

Fill the fuel tank after operating the engine in order to drive out moist air. This will help prevent condensation. Do not fill the tank to the top. The fuel expands as the fuel gets warm. The tank may overflow.

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe. Some fuel tanks use supply lines that take fuel directly from the bottom of the tank. If the engine is equipped with this system, regular maintenance of the fuel system filter is important.

Fuel Storage Tanks

Drain the water and the sediment from the fuel storage tank at the following intervals:

- Weekly
- Service intervals
- Refill of the tank

This will help prevent water or sediment from being pumped from the storage tank into the engine fuel tank.

If a bulk storage tank has been refilled or moved recently, allow adequate time for the sediment to settle before filling the engine fuel tank. Internal baffles in the bulk storage tank will also help trap sediment. Filtering fuel that is pumped from the storage tank helps to ensure the quality of the fuel. When possible, water separators should be used.

i06857107

i06854219

Fuel Transfer Pump - Replace

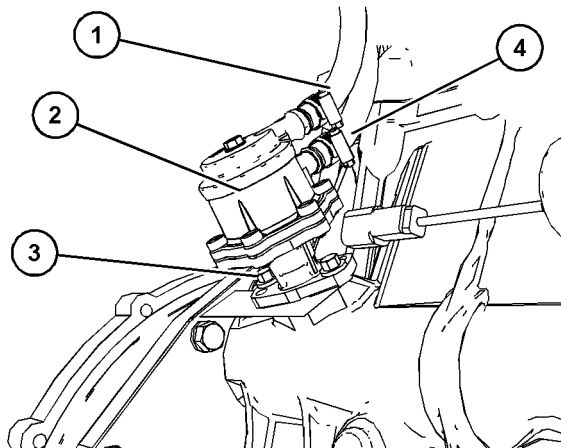


Illustration 35

g06143269

Typical example

1. If equipped, turn the fuel supply valve to the OFF position. Remove the fuel line (1) and remove the fuel line (4).
2. Remove bolts (3) and remove fuel transfer pump (2).
3. Ensure that the camshaft lobe for the fuel transfer pump is at minimum lift before the fuel transfer pump is installed. Ensure that a new O ring seal (not shown) is installed onto the fuel transfer pump.
4. Ensure correct orientation of the new fuel transfer pump. Install the new fuel transfer pump (2) and install bolts (3).
5. Tighten bolts (3) to a torque of 6 N·m (53 lb in).
6. Install the fuel lines (1) and fuel line (4), tighten clips securely.
7. Ensure that the fuel supply valve if equipped is turned to the ON position and there are no fuel leaks.

Prime the fuel system, refer to this Operation and Maintenance Manual, Fuel System Prime.

Radiator - Clean

The radiator is not usually supplied by Perkins. The following text describes a typical cleaning procedure for the radiator. Refer to the OEM information for further information on cleaning the radiator.

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

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

⚠ WARNING

Personal injury can result from air pressure.

Personal injury can result without following proper procedure. When using pressure air, wear a protective face shield and protective clothing.

Maximum air pressure at the nozzle must be less than 205 kPa (30 psi) for cleaning purposes.

Maintenance Section

Starting Motor - Replace

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction to the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the radiator fins. Slowly move the air nozzle in a direction that is parallel with the radiator tube assembly. This will remove debris that is between the tubes.

Pressurized water may also be used for cleaning. The maximum water pressure for cleaning purposes must be less than 275 kPa (40 psi). Use pressurized water in order to soften mud. Clean the core from both sides.

Use a degreaser and steam for removal of oil and grease. Clean both sides of the core. Wash the core with detergent and hot water. Thoroughly rinse the core with clean water.

If the radiator is blocked internally, refer to the OEM Manual for information regarding flushing the cooling system.

After cleaning the radiator, start the engine. Allow the engine to operate at low idle speed for three to five minutes. Accelerate the engine to high idle. This will help in the removal of debris and the drying of the core. Slowly reduce the engine speed to low idle and then stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb". Inspect these items for good condition: Welds, mounting brackets, air lines, connections, clamps and seals. Make repairs, if necessary.

i06857464

Starting Motor - Replace

Replace the starter motor, refer to "Disassembly and Assembly" Electric starting Motor - Remove and Install for more information.

i06851666

Walk-Around Inspection

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

With the engine stopped inspect the engine for the following conditions:

- Inspect all safety guards for damage
- Inspect the engine for oil leaks
- Inspect the engine for coolant leaks

- Inspect the engine fuel system for leaks
- Inspect the drive belt for damage or contamination
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires

The daily walk around inspection is an ideal opportunity to if equipped, drain the water from the primary fuel filter.

When appropriate, start the engine and check for easy of starting, color of exhaust smoke and engine noise or vibrations. Also, check the engine gauges for correct operation. Refer to the OEM for more information on gauges that are installed.

i06859427

Water Pump - Replace

Remove belt guard refer to OEM. Remove the water pump, refer to Disassembly and Assembly, Water Pump - Remove and Install.

Warranty Section

Warranty Information

i06858487

Emissions Warranty Information

This engine may be certified to comply with exhaust emission standards and gaseous emission standards that are prescribed by the law at the time of manufacture. This engine may be covered by an Emissions Warranty.

For a full warranty statement contact your Perkins dealer or your Perkins distributor. For customers that have a valid user name and password, for perkins.com. Login then go to TIPSS, and the warranty information can be accessed.

Reference Information Section

Reference Materials

i05204675

Maintenance Log

Table 13

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Serial Number		Arrangement Number		
Service Hours	Quantity Of Fuel	Service Item	Date	Authorization

(continued)

(Table 13, contd)

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Product and Dealer Information

Note: For product identification plate locations, see the section "Product Identification Information" in the Operation and Maintenance Manual.

Delivery Date: _____

Product Information

Model: _____

Product Identification Number: _____

Engine Serial Number: _____

Transmission Serial Number: _____

Generator Serial Number: _____

Attachment Serial Numbers: _____

Attachment Information: _____

Customer Equipment Number: _____

Dealer Equipment Number: _____

Dealer Information

Name: _____ Branch: _____

Address: _____

Dealer Contact

Phone Number

Hours

Sales: _____

Parts: _____

Service: _____

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