

Operation and Maintenance Manual

400C 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, including human factors that can affect safety. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper 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 verify that you are authorized to perform this work, and 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.

A non-exhaustive list of operations that may cause product damage are identified by "NOTICE" labels on the product and in this publication.

Caterpillar 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 Caterpillar 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. Cat dealers have the most current information available.

NOTICE

When replacement parts are required for this product Caterpillar recommends using original Caterpillar® replacement parts.

Other parts may not meet certain original equipment specifications.

When replacement parts are installed, the machine owner/user should ensure that the machine remains in compliance with all applicable requirements.

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

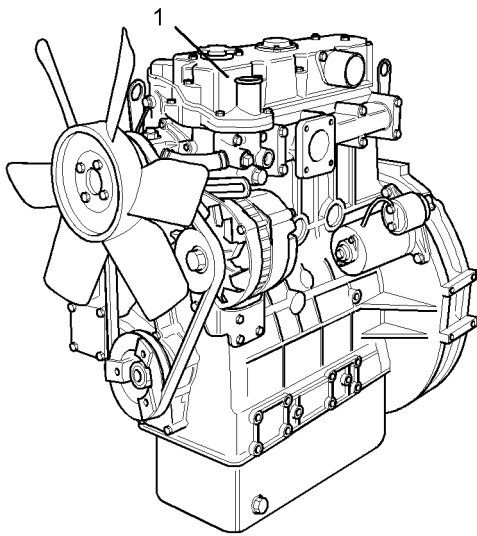


Illustration 1
Typical example

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There may be several specific safety messages on an engine. The exact location of the hazards and the description of the hazards 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 pictures are not visible. When the warning signs are cleaned, use a cloth, water, and soap. Do not use solvent, gasoline, or other harsh chemicals to clean the warning signs. Solvents, gasoline, or harsh chemicals could loosen the adhesive that secures the warning signs. The warning signs that are loosened could drop off the engine.

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

Do not work on the engine and do not operate the engine unless the instructions and warnings in the Operation and Maintenance Manual are understood. Correct care is your responsibility. Failure to follow the instructions or failure to heed the warnings could result in injury or in death.

The warning labels that may be found on the engine are illustrated and described.

Ether (1)

The warning label for ether is on the front, left side of the valve mechanism cover for all engine models in the series.



Illustration 2

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Do not spray starting aids such as ether into the air inlet. Such use could result in an explosion and personal injury.

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General Hazard Information

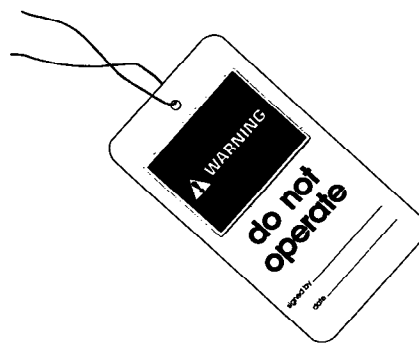


Illustration 3

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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.

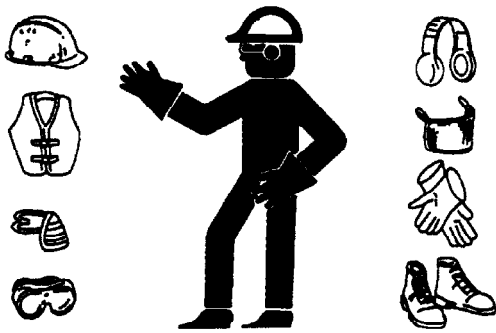


Illustration 4

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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 located 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.

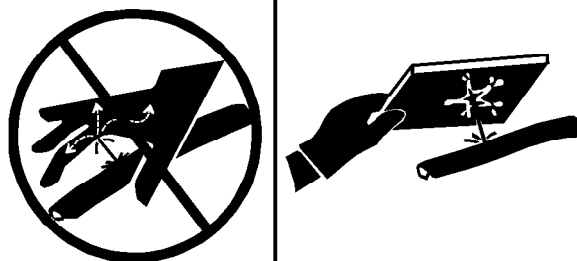


Illustration 5

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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.

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 fuel (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

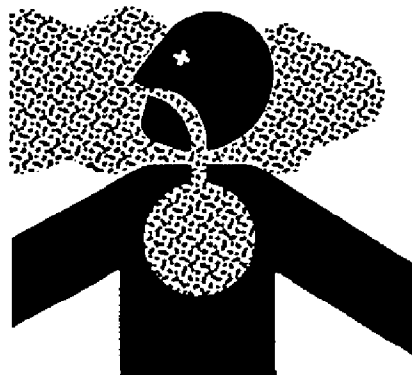


Illustration 6

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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

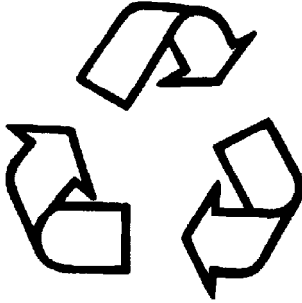


Illustration 7

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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. Operating engines exhaust gases could burn, do not come in contact with hot gases. 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 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 8

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

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

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 9

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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 10

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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.

Safety Section

Crushing Prevention and Cutting Prevention

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.

i02143194

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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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.

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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.

i02590389

Engine Stopping

To avoid overheating of the engine and accelerated wear of the engine components, stop the engine according to this Operation and Maintenance Manual, "Engine Stopping" topic (Operation Section).

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.

On the initial start-up of a new engine or an engine that has been serviced, make provisions to stop the engine if an overspeed condition occurs. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

If equipped, in order to stop an electronically controlled engine, cut the power to the engine.

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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

Model Views

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Model View Illustrations

The following model views show typical features of the 400 series engines. Due to individual applications, your engine may appear different from the illustrations.

Note: Individual components are detailed on the 404C-22T turbocharged engine only.

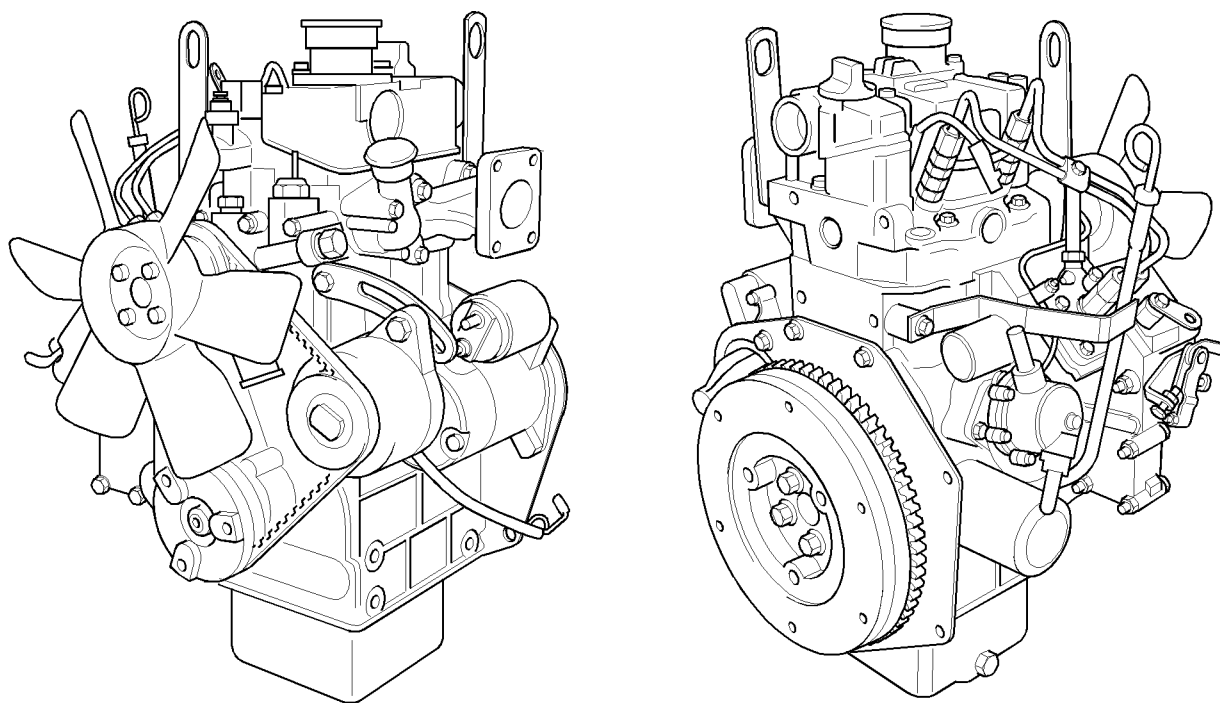


Illustration 11

Typical view of the 402C-05 engine

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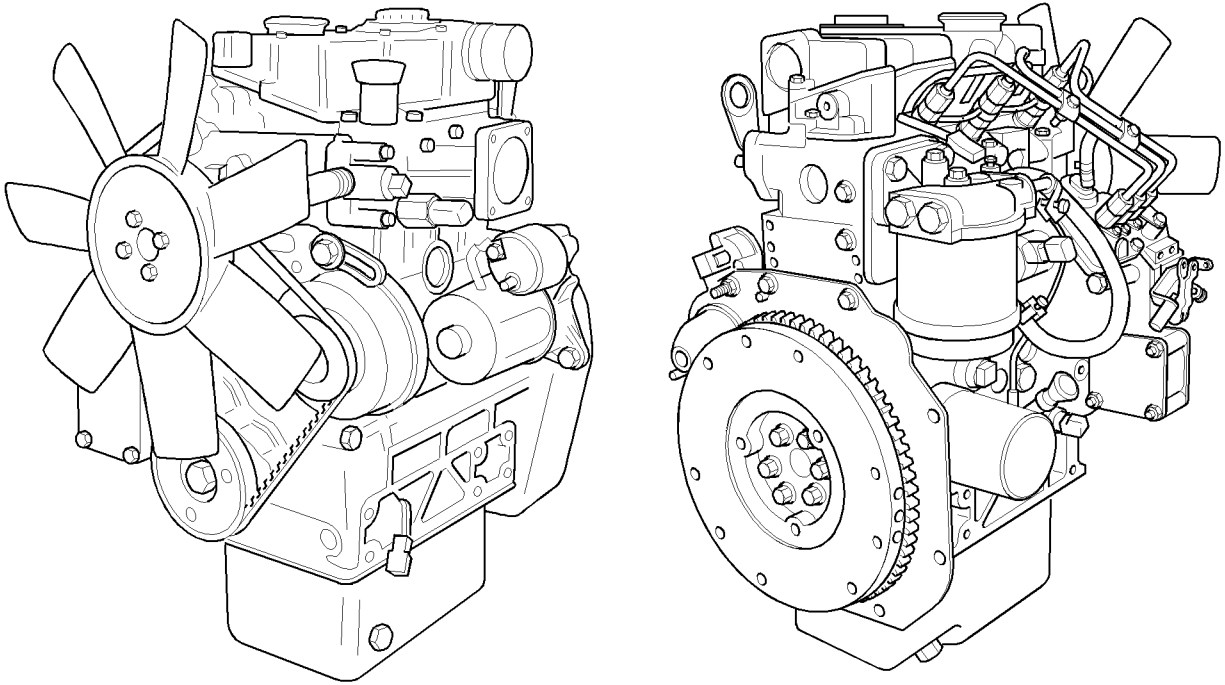


Illustration 12

Typical view of the 403C-11 engine

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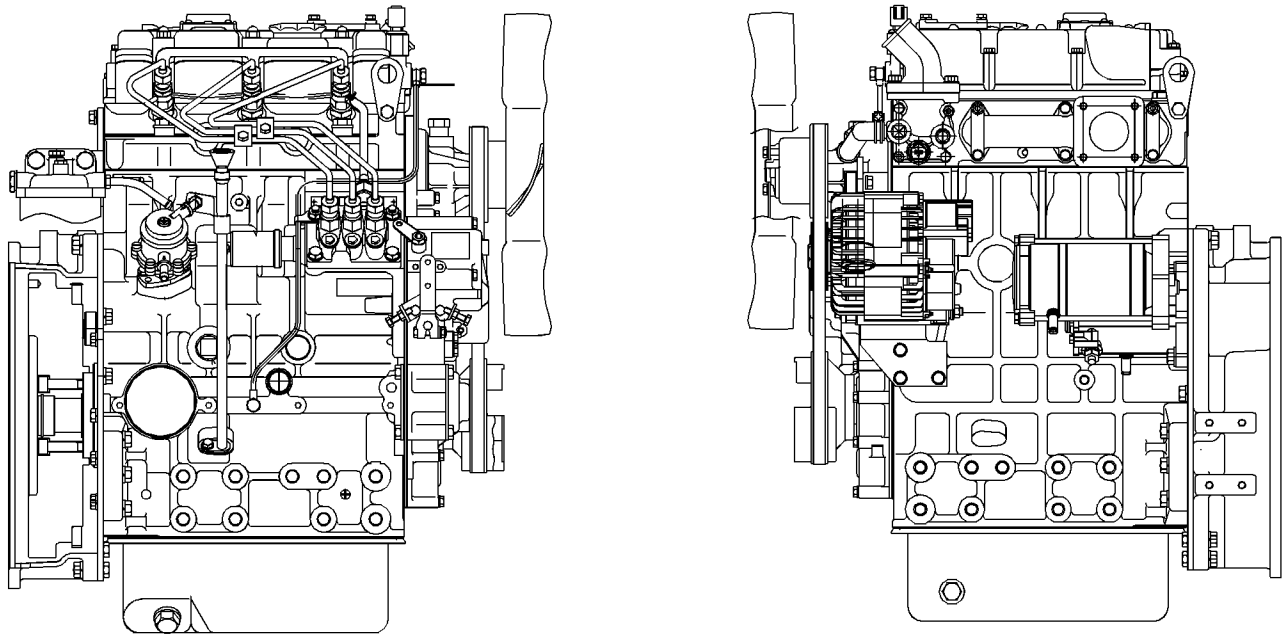


Illustration 13

g01402021

Typical view of the 403C-17 engine

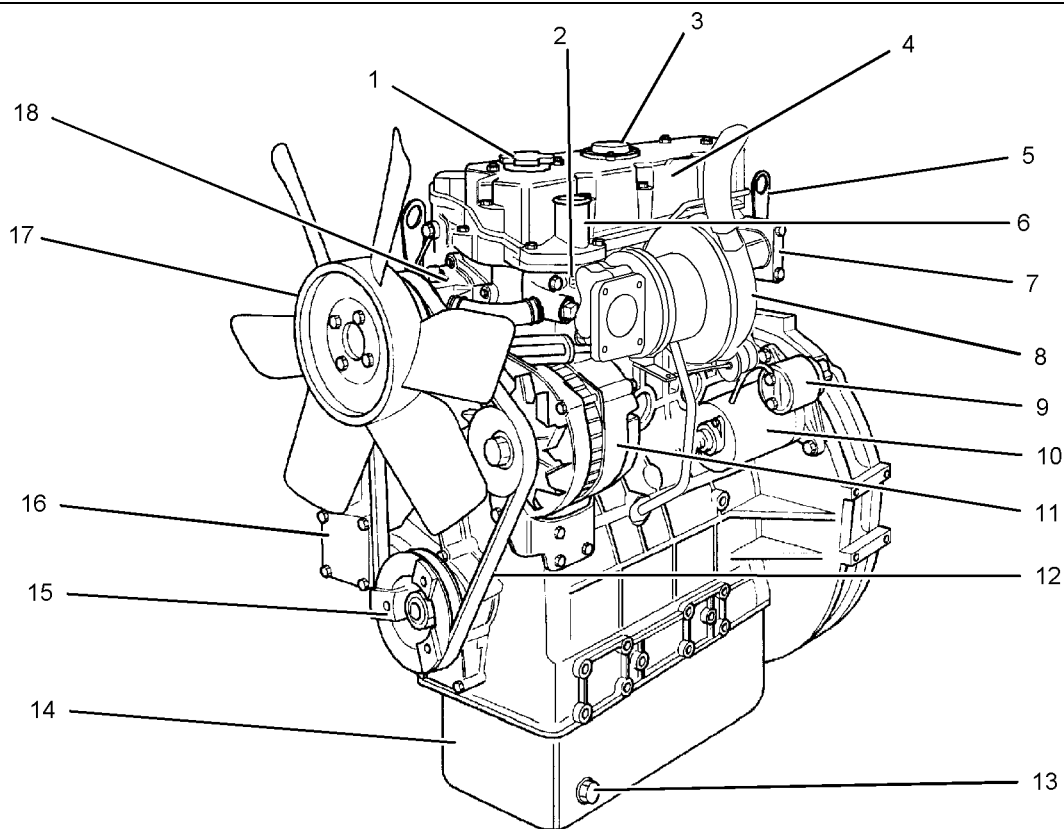


Illustration 14

g01097209

Front and left side view of the 404C-22T Engine

- | | | |
|---|------------------------------|--|
| (1) Engine oil filler cap | (7) Exhaust manifold | (13) Engine oil drain plug |
| (2) Coolant temperature switch | (8) Turbocharger | (14) Engine oil pan |
| (3) Crankcase breather | (9) Starting motor solenoid | (15) Crankshaft pulley |
| (4) Valve mechanism cover | (10) Electric starting motor | (16) Cover plate for the accessory drive |
| (5) Lifting eye | (11) Alternator | (17) Cooling fan |
| (6) Water temperature regulator housing | (12) Fan drive belt | (18) Water pump |

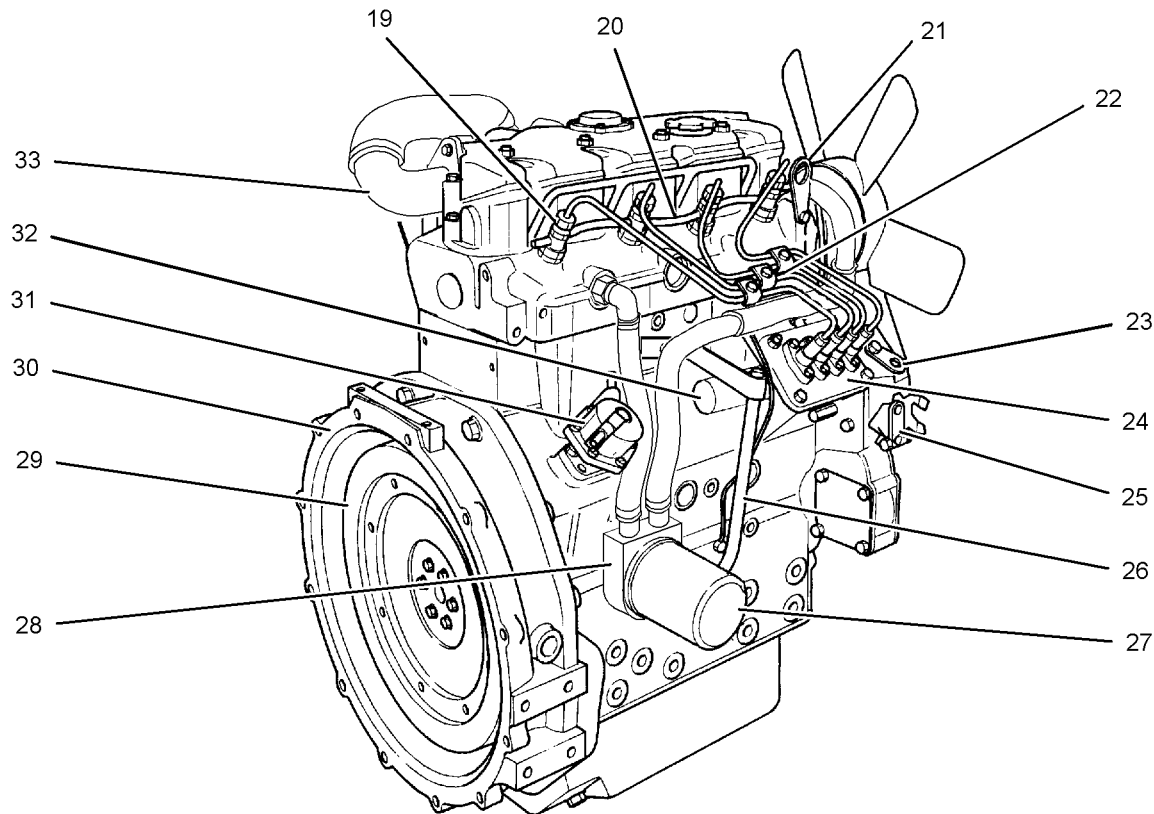


Illustration 15

g01097214

Rear and right side view of the 404C-22T Engine

- | | | |
|------------------------------|-----------------------------|----------------------------|
| (19) Fuel injector | (24) Fuel injection pump | (29) Flywheel |
| (20) Fuel return line | (25) Fuel control lever | (30) Flywheel housing |
| (21) Lifting eye | (26) Engine oil level gauge | (31) Fuel transfer pump |
| (22) Fuel injection lines | (27) Engine oil filter | (32) Fuel shutoff solenoid |
| (23) Mechanical fuel shutoff | (28) Engine oil cooler | (33) Air inlet elbow |

i02801121

Engine Description

The 400 series engines are diesel engines that are controlled with a mechanically actuated fuel injection pump. The engine cylinders are arranged in-line.

The cylinder head assembly has one inlet valve and one exhaust valve for each cylinder. Each cylinder valve has a single valve spring.

The pistons have two compression rings and an oil control ring. It is important to ensure the correct piston height so that the piston does not contact the cylinder head. The correct piston height also ensures efficient combustion of fuel that is necessary in order to conform to requirements for emissions.

The crankshaft for a two cylinder engine has two main bearing journals. The crankshaft for a three cylinder engine has four main bearing journals. The crankshaft for a four cylinder engine has five main bearing journals. End play is controlled by the thrust washers that are located on the rear main bearing.

The timing gears are stamped with timing marks in order to ensure the correct assembly of the gears. When the No. 1 piston is at top center compression stroke, the teeth that are stamped on the crankshaft gear and the camshaft gear will be in alignment with the idler gear.

The crankshaft gear turns the idler gear which then turns the camshaft gear and the gear for the engine oil pump.

The fuel injection pump is mounted in the cylinder block. The fuel injection pump is operated by lobes on the camshaft. The fuel transfer pump is located on the right hand side of the cylinder block. The fuel transfer pump is also operated by lobes on the camshaft.

The fuel injection pump conforms to requirements for emissions. Adjustments to the fuel injection pump timing and high idle should only be made by trained personnel. The fuel injection pumps have mechanical governors that control the engine rpm.

A gerotor oil pump is located in the center of the idler gear. The engine oil pump sends lubricating oil to the main oil gallery through a pressure relief valve and an engine oil filter. The rocker arms receive pressurized oil through an externally located oil line that runs from the main oil gallery to the cylinder head.

Coolant from the bottom of the radiator passes through the belt driven centrifugal water pump. The coolant is cooled by the radiator and the temperature is regulated by a water temperature regulator.

Engine efficiency, efficiency of emission controls, and engine performance depend on adherence to correct operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended fuels, lubrication oils, and coolants. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information on maintenance items.

Engine Specifications

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

402C-05 Engine

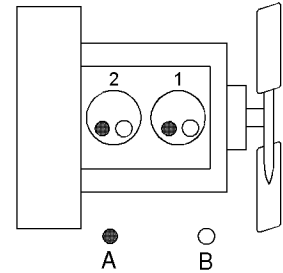


Illustration 16
(A) Exhaust valves
(B) Inlet valves

Table 1

402C-05 Engine Specifications	
Maximum Operating Speed (rpm)	3600 rpm
Cylinders and Arrangement	In-Line two cylinder
Bore	67 mm (2.64 inch)
Stroke	72 mm (2.83 inch)
Displacement	0.507 L (30.939 in³)
Aspiration	NA ⁽¹⁾
Compression Ratio	23.5:1
Firing Order	1-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)

⁽¹⁾ Naturally Aspirated

403C-07 Engine

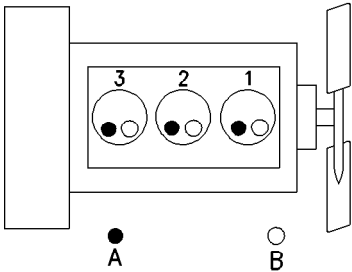


Illustration 17

g00852304

(A) Exhaust valves
(B) Inlet valves

Table 2

403C-07 Engine Specifications	
Maximum Operating Speed (rpm)	3600 rpm
Cylinders and Arrangement	In-Line three cylinder
Bore	67 mm (2.64 inch)
Stroke	72 mm (2.83 inch)
Displacement	0.762 L (46.500 in³)
Aspiration	NA ⁽¹⁾
Compression Ratio	23.5:1
Firing Order	1-2-3
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)

⁽¹⁾ Naturally Aspirated

403C-11 Engine

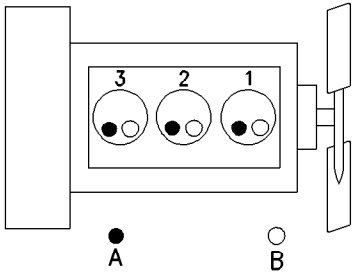


Illustration 18

g00852304

(A) Exhaust valves
(B) Inlet valves

Table 3

403C-11 Engine Specifications	
Maximum Operating Speed (rpm)	3600 rpm
Cylinders and Arrangement	In-Line three cylinder
Bore	77 mm (3.03 inch)
Stroke	81 mm (3.19 inch)
Displacement	1.131 L (69.018 in³)
Aspiration	NA ⁽¹⁾
Compression Ratio	23:1
Firing Order	1-2-3
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)

⁽¹⁾ Naturally Aspirated

403C-15 Engine

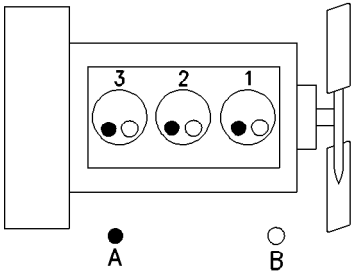


Illustration 19
(A) Exhaust valves
(B) Inlet valves

Table 4

403C-15 Engine Specifications	
Maximum Operating Speed (rpm)	3000 rpm
Cylinders and Arrangement	In-Line three cylinder
Bore	84 mm (3.31 inch)
Stroke	90 mm (3.54 inch)
Displacement	1.496 L (91.291 in³)
Aspiration	NA ⁽¹⁾
Compression Ratio	22.5:1
Firing Order	1-2-3
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)

⁽¹⁾ Naturally Aspirated

403C-17 Engine

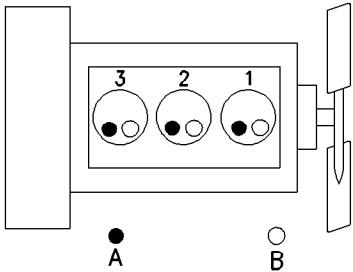


Illustration 20
(A) Exhaust valves
(B) Inlet valves

Table 5

403C-17 Engine Specifications	
Maximum Operating Speed (rpm)	2600 rpm
Cylinders and Arrangement	In-Line three cylinder
Bore	84 mm (3.31 inch)
Stroke	100 mm (3.94 inch)
Displacement	1.66 L (101.3 in³)
Aspiration	NA ⁽¹⁾
Compression Ratio	22.5:1
Firing Order	1-2-3
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)

⁽¹⁾ Naturally Aspirated

404C-15 Engine

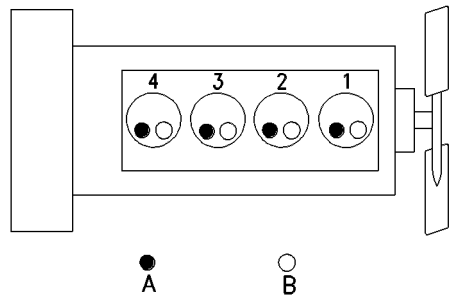


Illustration 21
(A) Exhaust valves
(B) Inlet valves

Table 6

404C-15 Engine Specifications	
Maximum Operating Speed (rpm)	3000 rpm
Cylinders and Arrangement	In-Line four cylinder
Bore	77 mm (3.03 inch)
Stroke	81 mm (3.19 inch)
Displacement	1.508 L (92.024 in³)
Aspiration	NA ⁽¹⁾
Compression Ratio	23.5:1
Firing Order	1-3-4-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)

⁽¹⁾ Naturally Aspirated

404C-22 Engine

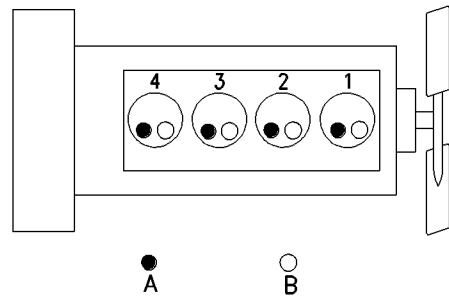


Illustration 22
(A) Exhaust valves
(B) Inlet valves

Table 7

404C-22 Engine Specifications	
Maximum Operating Speed (rpm)	3000 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 in³)
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)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)

⁽¹⁾ Naturally Aspirated

404C-22T Engine

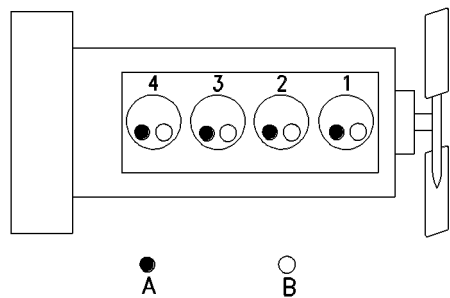


Illustration 23 g00296424
(A) Exhaust valves
(B) Inlet valves

Table 8

404C-22T Engine Specifications	
Maximum Operating Speed (rpm)	3000 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 in³)
Aspiration	T ⁽¹⁾
Compression Ratio	23.3:1
Firing Order	1-3-4-2
Rotation that is viewed from the flywheel	Counterclockwise
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)

⁽¹⁾ Turbocharged

Product Identification Information

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

i02216958

i02164876

Engine Identification

Perkins engines are identified by a serial number. This number is shown on a serial number plate that is mounted above the fuel injection pump on the right hand side of the engine block.

An example of an engine number is HHU000001J.

HH _____ Type of engine

U _____ Built in the United Kingdom

Engines that are built in Japan will have a (J).

Engines that are built in North America will have a (N).

000001 _____ Engine Serial Number

J _____ Year of Manufacture

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

i02157258

Serial Number Plate



Illustration 24

g01094203

Typical serial number plate

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

Reference Numbers

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

Record for Reference

Engine Model _____

Engine Serial number _____

Engine Low Idle rpm _____

Engine Full Load rpm _____

Primary Fuel Filter _____

Water Separator Element _____

Secondary Fuel Filter Element _____

Lubrication Oil Filter Element _____

Auxiliary Oil Filter Element _____

Total Lubrication System Capacity _____

Total Cooling System Capacity _____

Air Cleaner Element _____


Fan Drive Belt _____

Alternator Belt _____

i07790641

Emissions Certification Film

A typical example is shown.

EMISSION CONTROL INFORMATION		
 PERKINS SMALL ENGINES LTD.		
ENGINE FAMILY:		
ENGINE TYPE:	DISPL:	
ADVERTISED POWER:	kW at	rpm
DIESEL FUEL ONLY		
INLET/EXH. VALVE CLEARANCE: 0.2mm COLD		
LOW IDLE:	rpm	
THIS ENGINE CONFORMS TO U.S. EPA AND CALIFORNIA REGULATIONS FOR NON - ROAD COMPRESSION - IGNITION ENGINES		
EC NRMM No.:		

Operation Section

Lifting and Storage

i08066305

Engine Lifting

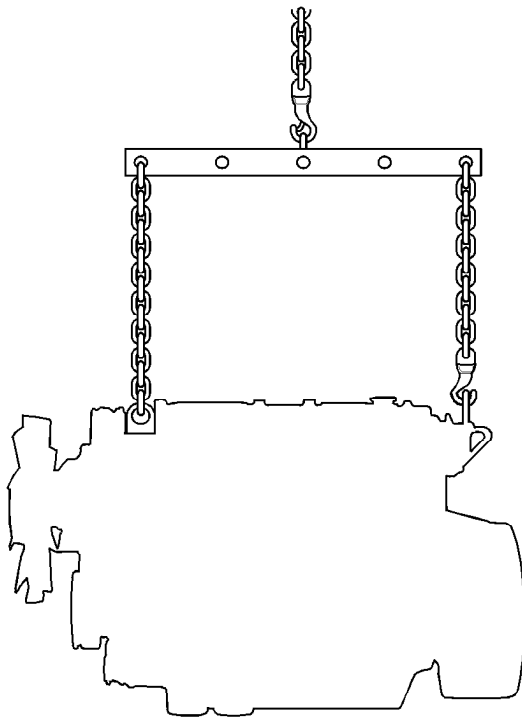


Illustration 26

g01097527

NOTICE

Never bend the eyebolts and the brackets. 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.

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 the components are damaged.

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.

Engine Only

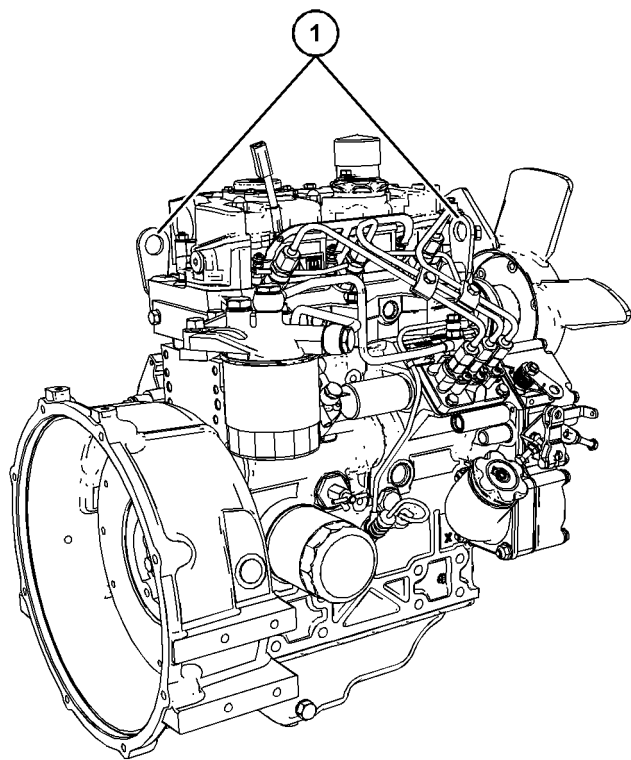


Illustration 27

g06531058

Typical example of Industrial Engine

(1) Front and rear lifting eyes

Engines with Factory Installed Radiators

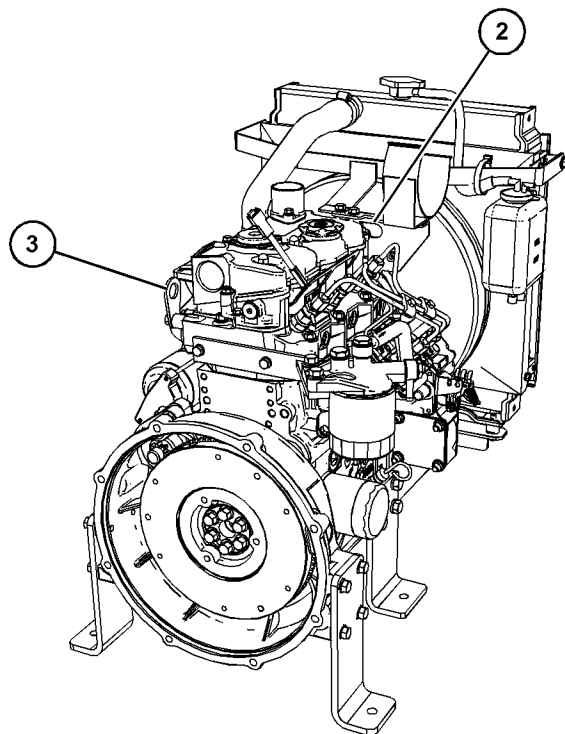


Illustration 28

g06531094

Typical example Industrial Open Power Unit (IOPU)

(2) Front lifting eye

(3) Rear lifting eye

i02134814

Engine Storage

If the engine will not be started for several weeks, the lubricating oil will drain from the cylinder walls and from the piston rings. Rust can form on the cylinder walls. Rust on the cylinder walls will cause increased engine wear and a reduction in engine service life.

Lubrication System

To help prevent excessive engine wear, use the following guidelines:

Complete all of the lubrication recommendations that are listed in this Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section).

If an engine is out of operation and if use of the engine is not planned, special precautions should be made. If the engine will be stored for more than one month, a complete protection procedure is recommended.

Use the following guidelines :

- Completely clean the outside of the engine.
- Drain the fuel system completely and refill the system with preservative fuel. 1772204 POWERPART Lay-Up 1 can be mixed with the normal fuel in order to change the fuel into preservative fuel.
- If preservative fuel is not available, the fuel system can be filled with normal fuel. This fuel must be discarded at the end of the storage period together with the fuel filter elements.
- Operate the engine until the engine reaches normal operating temperature. Stop any leaks from fuel, lubricating oil or air systems. Stop the engine and drain the lubricating oil from the oil pan.
- Renew the canister(s) of the lubricating oil filter.
- Fill the oil pan to the Full Mark on the engine oil level gauge with new, clean lubricating oil. Add 1762811 POWERPART Lay-Up 2 to the oil in order to protect the engine against corrosion. If 1762811 POWERPART Lay-Up 2 is not available, use a preservative of the correct specification instead of the lubricating oil. If a preservative is used, this must be drained completely at the end of the storage period and the oil pan must be refilled to the correct level with normal lubricating oil.

Cooling System

To help prevent excessive engine wear, use the following guidelines:

NOTICE

Do not drain the coolant while the engine is still hot and the system is under pressure because dangerous hot coolant can be discharged.

If freezing temperatures are expected, check the cooling system for adequate protection against freezing. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" (Maintenance Section).

NOTICE

To prevent frost damage, ensure that all the coolant is removed from the engine. This is important if the system is drained after it has been flushed with water, or if an antifreeze solution too weak to protect the system from frost has been used.

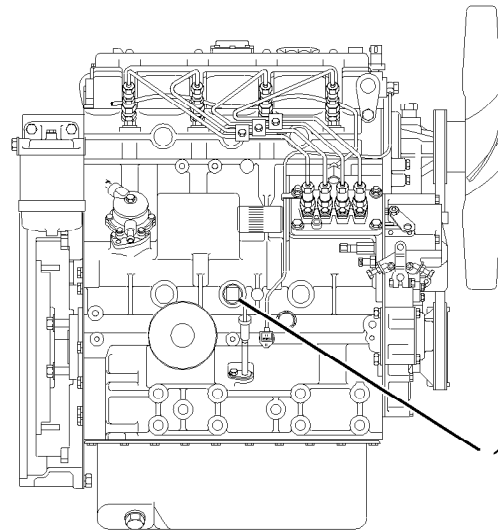


Illustration 29

g01087295

Typical example

1. Ensure that the vehicle is on level ground.
 2. Remove the filler cap of the cooling system.
 3. Remove the drain plug (1) from the side of the cylinder block in order to drain the engine. Ensure that the drain hole is not restricted.
 4. Open the tap or remove the drain plug at the bottom of the radiator in order to drain the radiator. If the radiator does not have a tap or a drain plug, disconnect the hose at the bottom of the radiator.
 5. Flush the cooling system with clean water.
 6. Fit the drain plugs and the filler cap. Close the tap or connect the radiator hose.
 7. Fill the cooling system with an approved antifreeze mixture because this gives protection against corrosion.
- Note:** Certain corrosion inhibitors could cause damage to some engine components. Contact the Service Department of Perkins for advice.
8. Operate the engine for a short period in order to circulate the lubricating oil and the coolant in the engine.

9. Disconnect the battery. Put the battery into safe storage in a fully charged condition. Before the battery is put into storage, protect the terminals against corrosion. 1734115 POWERPART Lay-Up 3 can be used on the terminals.
10. Clean the crankcase breather if one is installed. Seal the end of the pipe.
11. Remove the fuel injectors and spray 1762811 POWERPART Lay-Up 2 for one or two seconds into each cylinder bore with the piston at BDC.
12. Slowly rotate the crankshaft for one complete revolution and then replace the fuel injectors.

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

Induction System

- Remove the air filter assembly. If necessary, remove the pipes that are installed between the air filter assembly and the turbocharger. Spray 1762811 POWERPART Lay-Up 2 into the turbocharger. The duration of the spray is printed on the container. Seal the turbocharger with waterproof tape.

Exhaust System

- Remove the exhaust pipe. Spray 1762811 POWERPART Lay-Up 2 into the turbocharger. The duration of the spray is printed on the container. Seal the turbocharger with waterproof tape.

General Items

- If the lubricating oil filler is installed on the valve mechanism cover, remove the filler cap. If the lubricating oil filler cap is not installed on the valve mechanism cover, remove the valve mechanism cover. Spray 1762811 POWERPART Lay-Up 2 around the rocker shaft assembly. Replace the filler cap or the valve mechanism cover.
- Seal the vent of the fuel tank or the fuel filler cap with waterproof tape.
- Remove the alternator drive belts and put the drive belts into storage.
- In order to prevent corrosion, spray the engine with 1734115 POWERPART Lay-Up 3. Do not spray the area inside the alternator.

When the engine protection has been completed in accordance with these instructions, this ensures that no corrosion will occur. Perkins are not responsible for damage which may occur when an engine is in storage after a period in service.

Gauges and Indicators

i02216960

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 110°C (230°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 control lever 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 control lever 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.

Features and Controls

i00705809

Fuel Shutoff

The fuel shutoff solenoid is located on the governor or the fuel shutoff solenoid is located on the fuel injection pump. When the fuel shutoff solenoid is activated, the solenoid moves the fuel rack "OFF". The fuel shutoff solenoid moves the fuel rack directly or the fuel shutoff solenoid moves the fuel rack through the governor.

Engine Starting

i02194223

Before Starting Engine

Before the engine is started, perform the required daily maintenance and any other periodic maintenance that is due. Refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information.

- For the maximum service life of the engine, make a thorough inspection within the engine compartment before the engine is started. Look for the following items: oil leaks, coolant leaks, loose bolts and excessive dirt and/or grease. Remove any excess dirt and/or grease buildup. Repair any faults that were identified during the inspection.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the alternator and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn wires or frayed wires.
- Check the fuel supply. Drain water from the water separator (if equipped). Open the fuel supply valve (if equipped).

NOTICE

All valves in the fuel return line must be open before and during engine operation to help prevent high fuel pressure. High fuel pressure may cause filter housing failure or other damage.

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.

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.
- Ensure that the areas around the rotating parts are clear.
- All of the guards must be put in place. Check for damaged guards or for missing guards. Repair any damaged guards. Replace damaged guards and/or missing guards.
- Disconnect any battery chargers that are not protected against the high current drain that is created when the electric starting motor is engaged. Check electrical cables and check the battery for poor connections and for corrosion.
- Reset all of the shutoffs or alarm components (if equipped).
- Check the engine lubrication oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the engine oil level gauge.
- Check the coolant level. Observe the coolant level in the header tank (if equipped). Maintain the coolant level to the "FULL" mark on the header tank.
- If the engine is not equipped with a header tank maintain the coolant level within 13 mm (0.5 inch) of the bottom of the filler pipe. If the engine is equipped with a sight glass, maintain the coolant level in the sight glass.
- Observe the air cleaner service indicator (if equipped). Service the air cleaner when the yellow diaphragm enters the red zone, or when the red piston locks in the visible position.
- Ensure that any equipment that is driven by the engine has been disengaged from the engine. Minimize electrical loads or remove any electrical loads.

i02811447

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.

Refer to the OEM manual for your type of controls. Use the following procedure to start the engine.

Operation Section
Starting with Jump Start Cables

1. Before the engine is started, move the throttle lever to the 30 PERCENT OPEN position.

NOTICE

Do not operate the glow plugs for more than 30 seconds at one time. Damage to the glow plugs could occur.

2. Turn the engine start switch to the HEAT position. Hold the engine start switch in the HEAT position for 6 seconds until the glow plug indicator light illuminates. This will activate the glow plugs and aid in the starting of the engine.

NOTICE

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

3. While the glow plug indicator light is illuminated, turn the engine start switch to the START position and crank the engine.
4. When the engine starts, release the engine start switch.
5. Slowly move the throttle lever to the low idle position and allow the engine to idle. Refer to the Operation and Maintenance Manual, "After Starting Engine" topic.

Note: If the glow plug indicator light illuminates rapidly for 2 to 3 seconds, or if the glow plug indicator light fails to illuminate, a malfunction exists in the cold start system. Do not use ether or other starting fluids to start the engine.

6. If the engine does not start, release the engine start switch and allow the electric starting motor to cool. Then, repeat steps 2 through step 5.
7. Turn the engine start switch to the OFF position in order to stop the engine.

i02177935

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.

Note: If it is possible, first diagnose the reason for the starting failure. Make any necessary repairs. If the engine will not start only due to the condition of the battery, either charge the battery, or start the engine with jump start cables. The condition of the battery can be rechecked after the engine has been switched OFF.

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.

When using an external electrical source to start the engine, turn the generator set control switch to the "OFF" position. 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 to the OFF position. Turn off all the engine's 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.
4. Start the engine.
5. Immediately after the stalled 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 correct voltage with a battery charger after the engine is stopped. Many batteries which are considered unusable are still rechargeable. Refer to Operation and Maintenance Manual, "Battery - Replace" and Testing and Adjusting Manual, "Battery - Test".

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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 warm-up, observe the following conditions:

- 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.

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.

Engine Operation

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Engine Operation

Proper 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.

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.

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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.
- Avoid unnecessary idling.

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

- Observe the air cleaner service indicator frequently. Keep the air cleaner elements clean.
- Maintain the electrical systems.

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

- Ensure that the drive belts are correctly adjusted. The drive belts 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.

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.

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. If necessary, refer to the instructions that are provided by the OEM.
-

NOTICE

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

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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 Original Equipment Manufacturer (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.

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 the Refill Capacities and Recommendations topic that is in this Operation and Maintenance Manual. 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.

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
- Optional Cold starting aid
- Battery condition
- Ambient air temperature and altitude
- Parasitic load of the application
- Application hydraulic and transmission oil viscosities

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 81 °C (177.8 °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 of time, and the engine can still be able to start readily.
- Install the correct specification of engine lubricant before the beginning of cold weather.
- 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.
- 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. Refer to Testing and Adjusting Manual, "Glow Plug - Test".

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 the amount of torque that is needed to crank 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. An effective block heater is typically a 1250/1500 W unit. 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 increase in RPM 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 82 °C (179.6 °F).

Recommendations for Coolant Warm Up

Warm up an engine that has cooled below normal operating temperatures due to inactivity. The 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 action 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 the engine is started and the engine is stopped many times without being operated in order to warm up completely, the carbon deposits become thicker. This action can cause the following problems:

- Free operation of the valves is prevented.
- Valves become stuck.
- Pushrods may become bent.
- Other damage to valve train components can result.

For this reason, when the engine is started, the engine must be operated until the coolant temperature is 71 °C (160 °F) minimum. Carbon deposits on the valve stems will be kept at a minimum. The free operation of the valves and the valve components will be maintained.

In addition, the engine must be thoroughly warmed in order to keep other engine parts in better condition and 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 lubrication 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 system 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 system ensures maximum coolant flow to the radiator in order to achieve maximum heat dissipation.

Note: 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.

Insulating the Air Inlet and Engine Compartment

When temperatures below -18°C (-0°F) will be frequently encountered, an air cleaner inlet that is located in the engine compartment may be specified. An air cleaner that is located in the engine compartment may also minimize the entry of snow into the air cleaner. Also, heat that is rejected by the engine helps to warm the intake air.

Additional heat can be retained around the engine by insulating the engine compartment.

Properties of the diesel fuel can have a significant effect on the engine cold start capability. Critical to the low temperature properties of diesel fuel is the acceptability for the minimum ambient temperature the engine is expected to see in operation. Following properties are used to define fuels low temperature capability:

- Cloud point
- Pour point
- Cold Filter Plugging Point (CFPP)

The cloud point of the fuel is the temperature at which waxes naturally found in diesel fuel begins to form crystals. The cloud point of the fuel must be below lowest ambient temperature to prevent filters from plugging.

CFPP is a temperature at which a particular fuel will pass through a standardized filtration device. The CFPP gives an estimate of the lower operability temperature of fuel.

Pour point is the last temperature before the fuel flow stops and waxing of the fuel will start.

Be aware of these properties 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 shipped to colder 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.

The following components can provide a means of minimizing fuel waxing problems in cold weather:

- Fuel heaters, which may be an OEM option
- Fuel line insulation, which may be an OEM option

Winter and arctic grades of diesel fuel are available in the countries and territories with severe winters. For more information refer to the Operation and Maintenance Manual, "Cold Weather Operation"

Another important fuel property which can affect cold start and operation of diesel engine is cetane number. For more information refer to the Operation and Maintenance Manual, "Fluid Recommendations".

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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".

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

Fuel Filters

It is possible that a primary fuel filter is installed between the fuel tank and the engine fuel inlet. After you change the fuel filter, always prime the fuel system in order to remove air bubbles from the fuel system. Refer to the Operation and Maintenance Manual in the Maintenance Section for more information on priming the fuel system.

The micron rating and the location of a primary fuel filter is important in cold weather operation. The primary fuel filter and the fuel supply line are the most common components that are affected by cold fuel.

Fuel Heaters

Note: The OEM may equip the application with fuel heaters. If this is the case, disconnect an electric type of fuel heater in warm weather in order to prevent overheating of the fuel. If the type of fuel heater is a heat exchanger, the OEM should have included a bypass for warm weather. Ensure that the bypass is operational during warm weather in order to prevent overheating of the fuel.

For more information about fuel heaters (if equipped), refer to the OEM information.

Maintenance Section

Refill Capacities

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Refill Capacities

Lubrication System

The refill capacities for the engine crankcase reflect the approximate capacity of the crankcase or sump plus standard oil filters. Auxiliary oil filter systems will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter. Refer to the Operation and Maintenance Manual, "Maintenance Section" for more information on Lubricant Specifications.

402C-05 Engine

Table 9

402C-05 Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	1.61 L (1.7 qt)	2.01 L (2.1 qt)
Total Lubrication System ⁽²⁾		

- (1) These values are the approximate capacities for the crankcase oil sump which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
- (2) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity of factory installed oil filters and other filters added to the lubrication system. Enter the value for the capacity of the Total Lubrication System in this row.

403C-07 Engine

Table 10

403C-07 Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	2.35 L (2.5 qt)	3.05 L (3.2 qt)
Total Lubrication System ⁽²⁾		

(Table 10, contd)

- (1) These values are the approximate capacities for the crankcase oil sump which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
- (2) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity of factory installed oil filters and other filters added to the lubrication system. Enter the value for the capacity of the Total Lubrication System in this row.

403C-11 Engine

Table 11

403C-11 Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	3.4 L (3.6 qt)	4.9 L (5.2 qt)
Total Lubrication System ⁽²⁾		

- (1) These values are the approximate capacities for the crankcase oil sump which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
- (2) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity of factory installed oil filters and other filters added to the lubrication system. Enter the value for the capacity of the Total Lubrication System in this row.

403C-15 and 403C-17 Engine

Table 12

403C-15 and 403C-17 Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	4.5 L (4.8 qt)	6 L (6.3 qt)
Total Lubrication System ⁽²⁾		

- (1) These values are the approximate capacities for the crankcase oil sump which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
- (2) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity of factory installed oil filters and other filters added to the lubrication system. Enter the value for the capacity of the Total Lubrication System in this row.

(continued)

404C-15 Engine

Table 13

404C-15 Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	4.1 L (4.3 qt)	6.5 L (6.9 qt)
Total Lubrication System ⁽²⁾		

- (1) These values are the approximate capacities for the crankcase oil sump which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
- (2) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity of factory installed oil filters and other filters added to the lubrication system. Enter the value for the capacity of the Total Lubrication System in this row.

404C-22 and 404C-22T Engine

Table 14

404C-22 and 404C-22T Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	8.9 L (9.4 qt)	10.6 L (11.2 qt)
Total Lubrication System ⁽²⁾		

- (1) More than one style of sump may be used on these engines. Use these values to estimate the refill capacity. Use the engine oil level gauge to fill the engine to the correct oil level. Record the result in this table. These values are the approximate capacities for the Crankcase Oil Sump which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.
- (2) The Total Lubrication System includes the capacity for the Crankcase Oil Sump plus the capacity of factory installed oil filters and other filters added to the lubrication system. Enter the value for the capacity of the Total Lubrication System in this row.

Cooling System

To maintain the cooling system, the Total Cooling System capacity must be known. The approximate capacity is for the engine cooling system. External System capacities will vary among applications. Refer to the OEM specifications for the External System capacity. This capacity information will be needed in order to determine the amount of coolant/antifreeze that is required for the Total Cooling System.

402C-05 Engine

Table 15

402C-05 Engine Refill Capacities		
Compartment or System	Liters	Quarts
Engine Only	1.1	1.2
External System Per OEM ⁽¹⁾		
Total Cooling System ⁽²⁾		

- (1) The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.
- (2) The Total Cooling System capacity includes the capacity of the Engine plus the External System. Enter the value for the capacity of the Total Cooling System in this row.

403C-07 Engine

Table 16

403C-07 Engine Refill Capacities		
Compartment or System	Liters	Quarts
Engine Only	1.2	1.3
External System Per OEM ⁽¹⁾		
Total Cooling System ⁽²⁾		

- (1) The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.
- (2) The Total Cooling System capacity includes the capacity of the Engine plus the External System. Enter the value for the capacity of the Total Cooling System in this row.

403C-11 Engine

Table 17

403C-11 Engine Refill Capacities		
Compartment or System	Liters	Quarts
Engine Only	1.9	2.0
External System Per OEM ⁽¹⁾		
Total Cooling System ⁽²⁾		

- (1) The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.
- (2) The Total Cooling System capacity includes the capacity of the Engine plus the External System. Enter the value for the capacity of the Total Cooling System in this row.

403C-15 Engine

Table 18

403C-15 Engine Refill Capacities		
Compartment or System	Liters	Quarts
Engine Only	2.6	2.7
External System Per OEM ⁽¹⁾		
Total Cooling System ⁽²⁾		

- (1) The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.
- (2) The Total Cooling System capacity includes the capacity of the Engine plus the External System. Enter the value for the capacity of the Total Cooling System in this row.

403C-17 Engine

Table 19

403C-17 Engine Refill Capacities		
Compartment or System	Liters	Quarts
Engine Only	2.8	2.9
External System Per OEM ⁽¹⁾		
Total Cooling System ⁽²⁾		

- (1) The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.
- (2) The Total Cooling System capacity includes the capacity of the Engine plus the External System. Enter the value for the capacity of the Total Cooling System in this row.

404C-15 Engine

Table 20

404C-15 Engine Refill Capacities		
Compartment or System	Liters	Quarts
Engine Only	2.4	2.5
External System Per OEM ⁽¹⁾		
Total Cooling System ⁽²⁾		

- (1) The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.
- (2) The Total Cooling System capacity includes the capacity of the Engine plus the External System. Enter the value for the capacity of the Total Cooling System in this row.

404C-22 and 404C-22T Engine

Table 21

404C-22 and 404C-22T Engine Refill Capacities		
Compartment or System	Liters	Quarts
Engine Only	3.6	3.8
External System Per OEM ⁽¹⁾		
Total Cooling System ⁽²⁾		

- (1) The External System includes a radiator or an expansion tank with the following components: heat exchanger and piping. Refer to the OEM specifications. Enter the value for the capacity of the External System in this row.
- (2) The Total Cooling System capacity includes the capacity for the Engine plus the External System. Enter the value for the capacity of the Total Cooling System in this row.

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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.

Engine Manufacturers Association (EMA) Oils

The "Engine Manufacturers Association Recommended Guideline on Diesel Engine Oil" is recognized by Perkins. For detailed information about this guideline, see the latest edition of EMA publication, "EMA DHD -1".

API Oils

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.

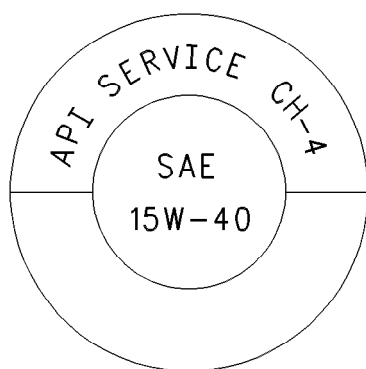


Illustration 30

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Typical API symbol

Diesel engine oils CC, CD, CD-2, and CE have not been API authorized classifications since January 1, 1996. Table 22 summarizes the status of the classifications.

Table 22

API Classifications	
Current	Obsolete
CF-4, CG-4, CH-4	CE
CF	CC, CD
CF-2 ⁽¹⁾	CD-2 ⁽¹⁾

⁽¹⁾ The classifications CD-2 and American Petroleum Institute CF-2 are for two-cycle diesel engines. Perkins does not sell engines that utilize CD-2 and API CF-2 oils.

Terminology

Certain abbreviations follow the nomenclature of "SAE J754". Some classifications follow "SAE J183" abbreviations, and some classifications follow the "EMA Recommended Guideline on Diesel Engine Oil". In addition to Perkins definitions, there are other definitions that will be of assistance in purchasing lubricants. Recommended oil viscosities can be found in this publication, "Fluid Recommendations/Engine Oil" topic (Maintenance Section).

Engine Oil

Commercial Oils

The performance of commercial diesel engine oils is based on American Petroleum Institute (API) classifications. These API classifications are developed to provide commercial lubricants for a broad range of diesel engines that operate at various conditions.

Only use commercial oils that meet the following classifications:

- EMA DHD-1 multigrade oil (preferred oil)

- API CH-4 multigrade oil (preferred oil)
- ACEAE5

To make the correct choice of a commercial oil, refer to the following explanations:

EMA DHD-1 – The Engine Manufacturers Association (EMA) has developed lubricant recommendations as an alternative to the API oil classification system. DHD-1 is a Recommended Guideline that defines a level of oil performance for these types of diesel engines: high speed, four stroke cycle, heavy-duty and light duty. DHD-1 oils may be used in Perkins engines when the following oils are recommended: API CH-4, API CG-4, and API CF-4. DHD-1 oils are intended to provide superior performance in comparison to API CG-4 and API CF-4.

DHD-1 oils will meet the needs of high-performance Perkins diesel engines that are operating in many applications. The tests and the test limits that are used to define DHD-1 are similar to the new API CH-4 classification. Therefore, these oils will also meet the requirements for diesel engines that require low emissions. DHD-1 oils are designed to control the harmful effects of soot with improved wear resistance and improved resistance to plugging of the oil filter. These oils will also provide superior piston deposit control for engines with either two-piece steel pistons or aluminum pistons.

All DHD-1 oils must complete a full test program with the base stock and with the viscosity grade of the finished commercial oil. The use of "API Base Oil Interchange Guidelines" are not appropriate for DHD-1 oils. This feature reduces the variation in performance that can occur when base stocks are changed in commercial oil formulations.

DHD-1 oils are recommended for use in extended oil change interval programs that optimize the life of the oil. These oil change interval programs are based on oil analysis. DHD-1 oils are recommended for conditions that demand a premium oil. Your Perkins dealer or your Perkins distributor has the specific guidelines for optimizing oil change intervals.

API CH-4 – API CH-4 oils were developed to meet the requirements of the new high-performance diesel engines. Also, the oil was designed to meet the requirements of the low emissions diesel engines. API CH-4 oils are also acceptable for use in older diesel engines and in diesel engines that use high sulfur diesel fuel. API CH-4 oils may be used in Perkins engines that use API CG-4 and API CF-4 oils. API CH-4 oils will generally exceed the performance of API CG-4 oils in the following criteria: deposits on pistons, control of oil consumption, wear of piston rings, valve train wear, viscosity control, and corrosion.

Three new engine tests were developed for the API CH-4 oil. The first test specifically evaluates deposits on pistons for engines with the two-piece steel piston. This test (piston deposit) also measures the control of oil consumption. A second test is conducted with moderate oil soot. The second test measures the following criteria: wear of piston rings, wear of cylinder liners and resistance to corrosion. A third new test measures the following characteristics with high levels of soot in the oil: wear of the valve train, resistance of the oil in plugging the oil filter and control of sludge.

In addition to the new tests, API CH-4 oils have tougher limits for viscosity control in applications that generate high soot. The oils also have improved oxidation resistance. API CH-4 oils must pass an additional test (piston deposit) for engines that use aluminum pistons (single piece). Oil performance is also established for engines that operate in areas with high sulfur diesel fuel.

All these improvements allow the API CH-4 oil to achieve optimum oil change intervals. API CH-4 oils are recommended for use in extended oil change intervals. API CH-4 oils are recommended for conditions that demand a premium oil. Your Perkins dealer or your Perkins distributor has specific guidelines for optimizing oil change intervals.

Some commercial oils that meet the API classifications may require reduced oil change intervals. To determine the oil change interval, closely monitor the condition of the oil and perform a wear metal analysis.

NOTICE

Failure to follow these oil recommendations can cause shortened engine service life due to deposits and/or excessive wear.

Total Base Number (TBN) and Fuel Sulfur Levels for Diesel Engines

The Total Base Number (TBN) for an oil depends on the fuel sulfur level. For engines that use distillate fuel, the minimum TBN of the new oil must be 10 times the fuel sulfur level. The TBN is defined by "ASTM D2896". The minimum TBN of the oil is 5 regardless of fuel sulfur level. Illustration 31 demonstrates the TBN.

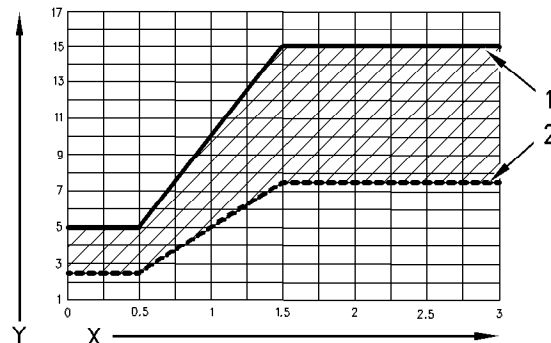


Illustration 31

g00799818

(Y) TBN by "ASTM D2896"

(X) Percentage of fuel sulfur by weight

(1) TBN of new oil

(2) Change the oil when the TBN deteriorates to 50 percent of the original TBN.

Use the following guidelines for fuel sulfur levels that exceed 1.5 percent:

- Choose an oil with the highest TBN that meets one of these classifications: EMA DHD-1 and API CH-4.
- Reduce the oil change interval. Base the oil change interval on the oil analysis. Ensure that the oil analysis includes the condition of the oil and a wear metal analysis.

Excessive piston deposits can be produced by an oil with a high TBN. These deposits can lead to a loss of control of the oil consumption and to the polishing of the cylinder bore.

NOTICE

Operating diesel engines with fuel sulphur levels over 0.5 percent will require shortened oil change intervals to help maintain adequate wear protection.

Table 23

Percentage of Sulfur in the fuel	Oil change interval
Lower than 0.5	Normal
0.5 to 1.0	0.75 of normal
Greater than 1.0	0.50 of normal

Lubricant Viscosity Recommendations

The correct SAE viscosity grade of oil is determined by the minimum ambient temperature during cold engine start-up, and the maximum ambient temperature during engine operation.

Refer to Table 24 (minimum temperature) to determine the required oil viscosity for starting a cold engine.

Refer to Table 24 (maximum temperature) to select the oil viscosity for engine operation at the highest ambient temperature that is anticipated.

Generally, use the highest oil viscosity that is available to meet the requirement for the temperature at start-up.

Table 24

Engine Oil Viscosity		
EMA LRG-1 API CH-4 Viscosity Grade	Ambient Temperature	
	Minimum	Maximum
SAE 0W20	-40 °C (-40 °F)	10 °C (50 °F)
SAE 0W30	-40 °C (-40 °F)	30 °C (86 °F)
SAE 0W40	-40 °C (-40 °F)	40 °C (104 °F)
SAE 5W30	-30 °C (-22 °F)	30 °C (86 °F)
SAE 5W40	-30 °C (-22 °F)	40 °C (104 °F)
SAE 10W30	-20 °C (-4 °F)	40 °C (104 °F)
SAE 15W40	-10 °C (14 °F)	50 °C (122 °F)

Synthetic Base Stock Oils

Synthetic base oils are acceptable for use in these engines if these oils meet the performance requirements that are specified for the engine.

Synthetic base oils generally perform better than conventional oils in the following two areas:

- Synthetic base oils have improved flow at low temperatures especially in arctic conditions.
- Synthetic base oils have improved oxidation stability especially at high operating temperatures.

Some synthetic base oils have performance characteristics that enhance the service life of the oil. Perkins does not recommend the automatic extending of the oil change intervals for any type of oil.

Re-refined Base Stock Oils

Re-refined base stock oils are acceptable for use in Perkins engines if these oils meet the performance requirements that are specified by Perkins. Re-refined base stock oils can be used exclusively in finished oil or in a combination with new base stock oils. The US military specifications and the specifications of other heavy equipment manufacturers also allow the use of re-refined base stock oils that meet the same criteria.

The process that is used to make re-refined base stock oil should adequately remove all wear metals that are in the used oil and all the additives that are in the used oil. The process that is used to make re-refined base stock oil generally involves the process of vacuum distillation and hydrotreating the used oil. Filtering is adequate for the production of high quality, re-refined base stock oil.

Lubricants for Cold Weather

When an engine is started and an engine is operated in ambient temperatures below -20 °C (-4 °F), use multigrade oils that are capable of flowing in low temperatures.

These oils have lubricant viscosity grades of SAE 0W or SAE 5W.

When an engine is started and operated in ambient temperatures below -30 °C (-22 °F), use a synthetic base stock multigrade oil with an 0W viscosity grade or with a 5W viscosity grade. Use an oil with a pour point that is lower than -50 °C (-58 °F).

The number of acceptable lubricants is limited in cold-weather conditions. Perkins recommends the following lubricants for use in cold-weather conditions:

First Choice – Use oil with an EMA DHD-1 Recommended Guideline. Use a CH-4 oil that has an API license. The oil should be either SAE 0W20, SAE 0W30, SAE 0W40, SAE 5W30, or SAE 5W40 lubricant viscosity grade.

Second Choice – Use an oil that has a CH-4 additive package. Although the oil has not been tested for the requirements of the API license, the oil must be either SAE 0W20, SAE 0W30, SAE 0W40, SAE 5W30, or SAE 5W40.

NOTICE

Shortened engine service life could result if second choice oils are used.

Aftermarket Oil Additives

Perkins does not recommend the use of aftermarket additives in oil. It is not necessary to use aftermarket additives to achieve the engine's maximum service life or rated performance. Fully formulated, finished oils consist of base oils and of commercial additive packages. These additive packages are blended into the base oils at precise percentages to help provide finished oils with performance characteristics that meet industry standards.

There are no industry standard tests that evaluate the performance or the compatibility of aftermarket additives in finished oil. Aftermarket additives may not be compatible with the finished oil's additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil. This could produce sludge in the crankcase. Perkins discourages the use of aftermarket additives in finished oils.

To achieve the best performance from a Perkins engine, conform to the following guidelines:

- Select the correct oil, or a commercial oil that meets the "EMA Recommended Guideline on Diesel Engine Oil" or the recommended API classification.
- See the appropriate "Lubricant Viscosities" table to find the correct oil viscosity grade for your engine.
- At the specified interval, service the engine. Use new oil and install a new oil filter.
- Perform maintenance at the intervals that are specified in the Operation and Maintenance Manual, "Maintenance Interval Schedule".

S·O·S Oil analysis

Some engines may be equipped with an oil sampling valve. If S·O·S oil analysis is required the oil sampling valve is used to obtain samples of the engine oil. The S·O·S oil analysis will complement the preventive maintenance program.

The S·O·S oil analysis is a diagnostic tool that is used to determine oil performance and component wear rates. Contamination can be identified and measured by using the S·O·S oil analysis. The S·O·S oil analysis includes the following tests:

- The Wear Rate Analysis monitors the wear of the engine's metals. The amount of wear metal and type of wear metal that is in the oil is analyzed. The increase in the rate of engine wear metal in the oil is as important as the quantity of engine wear metal in the oil.
- Tests are conducted to detect contamination of the oil by water, glycol, or fuel.

- The Oil Condition Analysis determines the loss of the oil's lubricating properties. An infrared analysis is used to compare the properties of new oil to the properties of the used oil sample. This analysis allows technicians to determine the amount of deterioration of the oil during use. This analysis also allows technicians to verify the performance of the oil according to the specification during the entire oil change interval.

Fuel Specifications

Fuel Recommendations

To get the correct power and performance from the engine, use a fuel of the correct quality. The recommended fuel specification for Perkins engines is shown below:

- Cetane number_____45 minimum
- Viscosity_____2,0 to 4.5 cSt at 40 °C (104 °F)
- Density_____0.835 to 0.855 Kg/liter
- Sulfur_____0.2% of mass, maximum
- Distillation_____85% at 350 °C (662 °F)
- Lubricity_____460 micrometers maximum wear scar on "ISO 12156 - 1"

Cetane number

This indicates the properties of ignition of the fuel. Fuel with a low cetane number can be the root cause of problems during cold start. This will affect combustion.

Viscosity

This is the resistance to flow of a fluid. If this resistance is outside the limits, the engine and the engine starting performance in particular can be affected.

Sulfur

High sulfur content of the fuel is not normally found in Europe, North America, or Australasia. This can cause engine wear. When only high sulfur fuels are available, it will be necessary that high alkaline lubricating oil is used in the engine or that the lubricating oil change interval is reduced.

Distillation

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

Lubricity

This is the capability of the fuel to prevent pump wear.

Diesel engines have the ability to burn a wide variety of fuels. These fuels are divided into four general groups:

- Group 1 (preferred fuels)
- Group 2 (permissible fuels)
- Group 3 (aviation kerosene fuels)
- Other fuels

Group 1 (preferred fuels): Specification

“DERV to EN590”

Note: Only use Arctic fuels when the temperature is below 0 °C (32 °F). Do not use Arctic fuels when the ambient temperature is above 0 °C (32 °F). To ensure that the time period between cranking the engine and first fire is kept to a minimum, only use fuel of the correct viscosity and at the correct temperature.

Gas oil to “BS2869 Class A2”

“ASTM D975 - 91 Class 2D” This can only be used if the fuel has the correct specification of lubricity.

“JIS K2204 (1992) Grades 1, 2, 3 and Special Grade 3” This can only be used if the fuel has the correct specification of lubricity.

Note: If low sulfur or low sulfur aromatic fuels are used, then fuel additives can be used to increase lubricity.

Group 2 (permissible fuels): Specification

These fuel specifications are considered acceptable for issues of warranty. However, these fuels may reduce the life of the engine, the engine's maximum power and the engine's fuel efficiency.

“ASTM D975 - 91 Class 1D”

“JP7, Mil T38219”

“NATO F63”

NOTICE

These fuels should have a wear scar value of 650 micrometers maximum
*HFRR to ISO 12156 - 1.

Group 3 (aviation kerosene fuels): Specification

Performance of the engine may be reduced if these fuels are used. To enable group 3 (aviation kerosene fuels) to be used, 5% spindle oil must be added. The fuel injection pump will not be covered by a warranty, even when additives are included.

“JP5 MIL T5624 (Avcat FSII, NATO F44”

“JP8 T83133 (Avtur FSII, NATO F34”

“Jet A”

“Jet A1, NATO F35, XF63”

Low temperature fuels

Special fuels for use in cold weather may be available for engine operation at temperatures below 0 °C (32 °F). These fuels limit the formation of wax in the fuel oil at low temperatures. If wax forms in the fuel oil, this could stop the flow of fuel oil through the filter.

Note: These fuels that lack lubricity may cause the following problems:

- Low engine power
- Difficult starting in hot conditions or in cold conditions
- White smoke
- Deterioration of emissions and misfire at certain operating conditions

Biofuel: Specification

Biofuel: A 5% mix of RME to EN14214 in conventional fuel is permitted.

NOTICE

Water emulsion fuels: These fuels are not permitted

Refer to the following fuel specifications for North America.

The preferred fuels provide maximum engine service life and performance. The preferred fuels are distillate fuels. These fuels are commonly called diesel fuel or gas oil.

The permissible fuels are crude oils or blended fuels. Use of these fuels can result in higher maintenance costs and in reduced engine service life.

Diesel fuels that meet the specifications in Table 25 will help to provide maximum engine service life and performance. In North America, diesel fuel that is identified as No. 2-D in “ASTM D975” generally meets the specifications. Table 25 is for diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

Table 25

Perkins Specifications for Distillate Diesel Fuel		
Specifications	Requirements	ASTM Test
Aromatics	35% maximum	“D1319”
Ash	0.02% maximum (weight)	“D482”

(continued)

Maintenance Section Fluid Recommendations

(Table 25, contd)

Carbon Residue on 10% Bottoms	0.35% maximum (weight)	"D524"
Cetane Number	40 minimum (DI engines)	"D613"
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	-
Copper Strip Corrosion	No. 3 maximum	"D130"
Distillation	10% at 282 °C (540 °F) maximum	"D86"
	90% at 360 °C (680 °F) maximum	
Flash Point	legal limit	"D93"
API Gravity	30 minimum	"D287"
	45 maximum	
Pour Point	6 °C (10 °F) minimum below ambient temperature	"D97"
Sulfur ⁽¹⁾	0.2% maximum	"D3605" or "D1552"
Kinematic Viscosity ⁽²⁾	2.0 cSt minimum and 4.5 cSt maximum at 40 °C (104 °F)	"D445"
Water and Sediment	0.1% maximum	"D1796"
Water	0.1% maximum	"D1744"
Sediment	0.05% maximum (weight)	"D473"
Gum and Resins ⁽³⁾	10 mg per 100 mL maximum	"D381"
Lubricity ⁽⁴⁾	0.38 mm (0.015 inch) maximum at 25 °C (77 °F)	"D6079"

(1) Perkins fuel systems and engine components can operate on high sulfur fuels. Fuel sulfur levels affect exhaust emissions. High sulfur fuels also increase the potential for corrosion of internal components. Fuel sulfur levels above 0.5 percent may significantly shorten the oil change interval. For additional information, see this publication, "Fluid Recommendations/Engine Oil" topic (Maintenance Section).

(2) The values of the fuel viscosity are the values as the fuel is delivered to the fuel injection pumps. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain a 1.4 cSt viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters to bring down the viscosity to a 20 cSt viscosity.

(3) Follow the test conditions and procedures for gasoline (motor).

(Table 25, contd)

(4) The lubricity of a fuel is a concern with low sulfur fuel. To determine the lubricity of the fuel, use either the "ASTM D6078 Scuffing Load Wear Test (SBOCLE)" or the "ASTM D6079 High Frequency Reciprocating Rig (HFRR)" test. If the lubricity of a fuel does not meet the minimum requirements, consult your fuel supplier. Do not treat the fuel without consulting the fuel supplier. Some additives are not compatible. These additives can cause problems in the fuel system.

NOTICE

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

NOTICE

Heavy Fuel Oil (HFO), Residual fuel, or Blended fuel must NOT be used in Perkins diesel engines. Severe component wear and component failures will result if HFO type fuels are used in engines that are configured to use distillate fuel.

In extreme cold ambient conditions, you may use the distillate fuels that are specified in Table 26. However, the fuel that is selected must meet the requirements that are specified in Table 25. These fuels are intended to be used in operating temperatures that are down to -54 °C (-65 °F).

Table 26

Distillate Fuels ⁽¹⁾	
Specification	Grade
"MIL-T-5624R"	JP-5
"ASTM D1655"	Jet-A-1
"MIL-T-83133D"	JP-8

(1) The fuels that are listed in this Table may not meet the requirements that are specified in the "Perkins Specifications for Distillate Diesel Fuel" Table. Consult the supplier for the recommended additives to maintain the correct fuel lubricity.

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in Table 26 must be at least 40. If the viscosity is below 1.4 cSt at 38 °C (100 °F), use the fuel only in temperatures below 0 °C (32 °F). Do not use any fuels with a viscosity of less than 1.2 cSt at 38 °C (100 °F). Fuel cooling may be required to maintain the minimum viscosity of 1.4 cSt at the fuel injection pump.

(continued)

There are many other diesel fuel specifications that are published by governments and by technological societies. Usually, those specifications do not review all the requirements that are addressed in this specification. To ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all the properties that are listed in Table 25 .

Cooling System Specifications

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 27 .

Table 27

Perkins Minimum Acceptable Water Requirements	
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. Overconcentration 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

Maintenance Section

Fluid Recommendations

- 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 -23°C (-9°F).

Most conventional coolants 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. See Tables 28 and 29.

Table 28

Ethylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	-36°C (-33°F)	106°C (223°F)
60 Percent	-51°C (-60°F)	111°C (232°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 29

Propylene Glycol		
Concentration	Freeze Protection	Anti-Boil Protection
50 Percent	-29°C (-20°F)	106°C (223°F)

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

Coolant Recommendations

The following two coolants are used in Perkins diesel engines:

Preferred – Perkins Extended Life Coolant (ELC)

Acceptable – A commercial heavy-duty coolant that meets “ASTM D4985” specifications

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 a coolant. This ratio may be increased to 1:2 water to glycol if extra freezing protection is required.

Note: A commercial heavy-duty coolant that meets “ASTM D4985” specifications MAY require a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

In stationary engine applications and marine engine applications that do not require anti-boil protection or freeze protection, a mixture of SCA and water is acceptable. Perkins recommends a six percent to eight percent concentration of SCA in those cooling systems. Distilled water or deionized water is preferred. Water which has the recommended properties may be used.

Engines that are operating in an ambient temperature above 43°C (109.4°F) must use SCA and water. Engines that operate in an ambient temperature above 43°C (109.4°F) and below 0°C (32°F) due to seasonal variations consult your Perkins dealer or your Perkins distributor for the correct level of protection.

Table 30

Coolant Service Life	
Coolant Type	Service Life
Perkins ELC	6,000 Service Hours or Three Years
Commercial Heavy-Duty Coolant that meets “ASTM D4985”	3000 Service Hours or Two Years

Extended Life Coolant (ELC)

Perkins provides Extended Life Coolant (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 extends the service life of the coolant to 6000 service hours or three years. ELC does not require a frequent addition of a Supplemental Coolant Additive (SCA). An Extender is the only additional maintenance that is needed at 3000 service hours or one half of the ELC service life.

ELC is available in a 1:1 premixed cooling solution with distilled water. 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.

ELC Concentrate is also available. ELC Concentrate can be used to lower the freezing point to -51°C (-60°F) for arctic conditions.

Containers of several sizes are available. Consult your Perkins dealer or 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.

Use only Perkins Extender with Extended Life Coolant.

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 Extended Life Coolant (ELC). Lowering the proportion of antifreeze lowers the proportion of additive. This will lower the ability of the coolant to protect the system from 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). Only use ELC Extender in cooling systems that are filled with ELC.

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.

After the cooling system is drained and after the cooling system is refilled, operate the engine while the cooling system filler cap is removed. 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 coolant 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. Flush the system with clean water to remove any debris.
4. Use Perkins cleaner to clean the system. Follow the instruction on the label.
5. Drain the cleaner into a suitable container. Flush the cooling system with clean water.

6. Fill the cooling system with clean water and operate the engine until the engine is warmed to 49° to 66°C (120° to 150°F).

NOTICE

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

To avoid damage to the cooling system, ensure that the cooling system is completely flushed with clean water. Continue to flush the system until all the signs of the cleaning agent are gone.

7. Drain the cooling system into a suitable container and flush the cooling system with clean water.

Note: The cooling system cleaner must be thoroughly flushed from the cooling system. Cooling system cleaner that is left in the system will contaminate the coolant. The cleaner may also corrode the cooling system.

8. Repeat Steps 6 and 7 until the system is completely clean.
9. Fill the cooling system with the Perkins Premixed ELC.

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. Use only Perkins ELC extender with Perkins ELC. Failure to follow these recommendations can result in shortened cooling system component life.

ELC cooling systems can withstand contamination to a maximum of ten percent of conventional heavy-duty coolant or SCA. If the contamination exceeds ten 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 clean water. 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 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 Coolant 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 coolant (glycol concentration) to ensure adequate protection against boiling or freezing. Perkins recommends the use of a refractometer for checking the glycol concentration.

Perkins engine cooling systems should be tested at 500-hour intervals for the concentration of Supplemental Coolant Additive (SCA).

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

Refer to Table 31 for part numbers and for quantities of SCA.

Table 31

Perkins Liquid SCA	
Part Number	Quantity
21825735	.

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

Commercial heavy-duty coolant that meets "ASTM D4985" specifications MAY require an addition of SCA at the initial fill. Read the label or the instructions that are provided by the OEM of the product.

Use the equation that is in Table 32 to determine the amount of Perkins SCA that is required when the cooling system is initially filled.

Table 32

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 33 is an example for using the equation that is in Table 32 .

Table 33

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 coolant of all types REQUIRE periodic additions of an SCA.

Test the coolant periodically for the concentration of SCA. For the interval, refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section). Test the concentration of SCA.

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.

Use the equation that is in Table 34 to determine the amount of Perkins SCA that is required, if necessary:

Table 34

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 35 is an example for using the equation that is in Table 34 .

Table 35

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)	× 0.023	0.35 L (11.7 oz)

Cleaning the System of Heavy-Duty Coolant

Perkins cooling system cleaners are designed to clean the cooling system of harmful scale and corrosion. Perkins cooling system cleaners dissolve mineral scale, corrosion products, light oil contamination and sludge.

- 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.

- The cooling system must be free from rust, scale, and any deposits, before corrosion inhibitors can be effective

To clean the cooling system of heavy-duty antifreeze, perform the following steps:

1. Drain the cooling system.
2. Fill the system with suitable distilled or deionized water.

NOTICE

Most commercial cooling system cleaning agents are corrosive and their use is not recommended by Perkins. If these cleaning agents have to be used to clean heavy deposits, then they should not be left in the system any longer than recommended by manufacturers. Also the engine temperature should not exceed 30° C (86° F).

The system must be thoroughly flushed with distilled or deionized water after use of cleaning agents.

NOTICE

Cleaning agents for industrial cooling system must not be used. These cleaning agents are very aggressive and cause damage to cooling system components.

3. Dissolve a suitable cleaning agent in water: use non-foaming detergent to clean oil contamination or a cooling system cleaner to clean deposits. Consult your Perkins dealer for suitable product.
4. Run the engine for approximately 30 minutes, leave the engine to cool down, and drain the system.
5. Take a sample of the solution from the system. Allow the sample to sit for at least 30 minutes and check for signs of oil or deposits. If contaminant is still present repeat step 1 to step 4.
6. Flush the system with distilled or deionized water.
7. Fill the system with new coolant.

i08335312

Maintenance Interval Schedule

Ensure that the Safety Information, Warnings, and Instructions are read and understood before operation or maintenance procedures are performed.

Note: The frequency that the engine oil is changed will be affected if the load factor for the engine is greater than 40 percent. Consult your Perkins distributor if assistance is required to calculate the load factor for your engine.

Before each consecutive interval is performed, all of the maintenance requirements from the previous interval must also be performed.

When Required

" Battery - Replace"	60
"Battery or Battery Cable - Disconnect"	
" Engine - Clean"	67
" Engine Air Cleaner Element - Replace"	68
" Fuel System - Prime"	74
"Severe Service Application - Check"	

Daily

" Cooling System Coolant Level - Check"	65
" Driven Equipment - Check"	67
" Engine Air Cleaner Service Indicator - Inspect"	69
" Engine Oil Level - Check"	70
" Fuel System Primary Filter/Water Separator - Drain"	79

" Walk-Around Inspection"	83
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Every 50 Service Hours or Weekly

" Fuel Tank Water and Sediment - Drain"	79
---	----

Every 250 Service Hours or 6 Months

" Alternator and Fan Belts - Inspect/Adjust"	58
--	----

Every 500 Service Hours

" Fuel System Filter - Replace"	76
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Every 500 Service Hours or 1 Year

" Battery Electrolyte Level - Check"	60
" Cooling System Supplemental Coolant Additive (SCA) - Test/Add"	66
" Engine Air Cleaner Element - Replace"	68
" Engine Oil and Filter - Change"	71
" Hoses and Clamps - Inspect/Replace"	80
"Radiator - Clean"	

Every 1000 Service Hours

" Alternator and Fan Belts - Replace"	59
" Engine Valve Lash - Inspect/Adjust"	73
" Turbocharger - Inspect"	82

Every 2000 Service Hours

" Alternator - Inspect"	58
" Engine Crankcase Breather - Replace"	69
" Engine Mounts - Inspect"	70
" Starting Motor - Inspect"	82

Every 3000 Service Hours

" Fuel Injector - Test/Change"	73
--------------------------------	----

“ Water Pump - Inspect” 84

Every 3000 Service Hours or 2 Years

“ Cooling System Coolant (Commercial Heavy-Duty)
- Change” 61

Every 6000 Service Hours or 3 Years

“ Cooling System Coolant (ELC) - Change” 63

i02322311

Alternator - Inspect

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

Check the alternator and the battery charger for correct operation. If the batteries are correctly charged, the ammeter reading should be very near zero. All batteries should be kept charged. The batteries should be kept warm because temperature affects the cranking power. If the battery is too cold, the battery will not crank the engine. When the engine is not run for long periods of time or if the engine is run for short periods, the batteries may not fully charge. A battery with a low charge will freeze more easily than a battery with a full charge.

i02166535

Alternator and Fan Belts - Inspect/Adjust

Inspection

To maximize the engine performance, inspect the belts for wear and for cracking. Replace belts that are worn or damaged.

For applications that require multiple drive belts, replace the belts in matched sets. Replacing only one belt of a matched set will cause the new belt to carry more load because the older belt is stretched. The additional load on the new belt could cause the new belt to break.

If the belts are too loose, vibration causes unnecessary wear on the belts and pulleys. Loose belts may slip enough to cause overheating.

To accurately check the belt tension, a suitable gauge should be used.

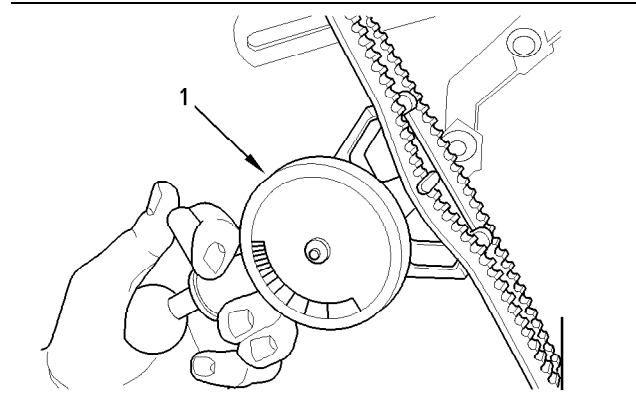


Illustration 32

g01003936

Typical example

(1) Burroughs Gauge

Install the gauge (1) at the center of the belt between the alternator and the crankshaft pulley and check the belt tension. The correct tension for a new belt is 400 N (90 lb) to 489 N (110 lb). The correct tension for a used belt that has been in operation for 30 minutes or more at the rated speed is 267 N (60 lb) to 356 N (80 lb).

If twin belts are installed, check and adjust the tension on both belts.

Adjustment

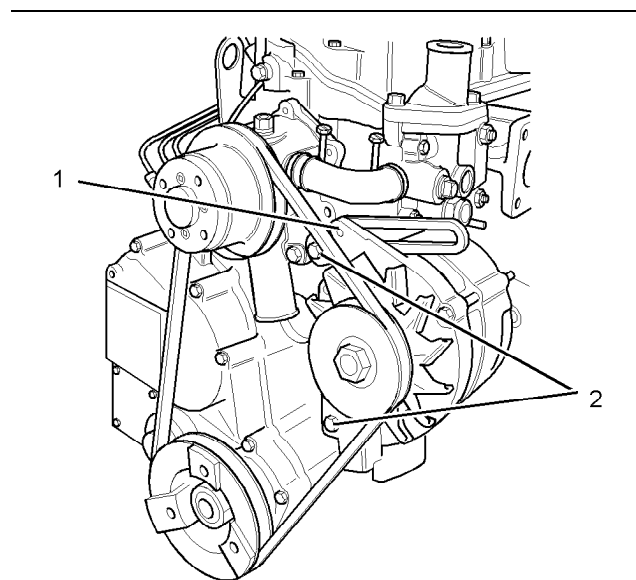


Illustration 33

g01091158

Typical example

(1) Adjusting bolt
(2) Mounting bolts

1. Loosen the mounting bolts (2) and the adjusting bolt (1).

2. Move the alternator in order to increase or decrease the belt tension.
3. Tighten the adjusting bolt (1). Tighten the mounting bolts (2). Refer to the Specifications Manual for the correct torque settings.

i08094157

Alternator and Fan Belts - Replace

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the engine is equipped with fan guards, remove the fan guards. Refer to the Original Equipment Manufacturer (OEM) for the correct removal procedure

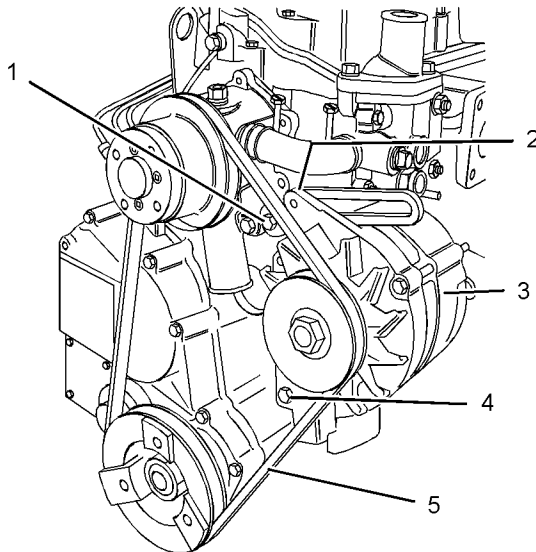


Illustration 34

g01325726

Typical example

2. Loosen bolt (1), bolt (2), and bolt (4).

3. Push alternator (3) toward the engine and remove V-belt (5) from the pulleys.

Installation Procedure

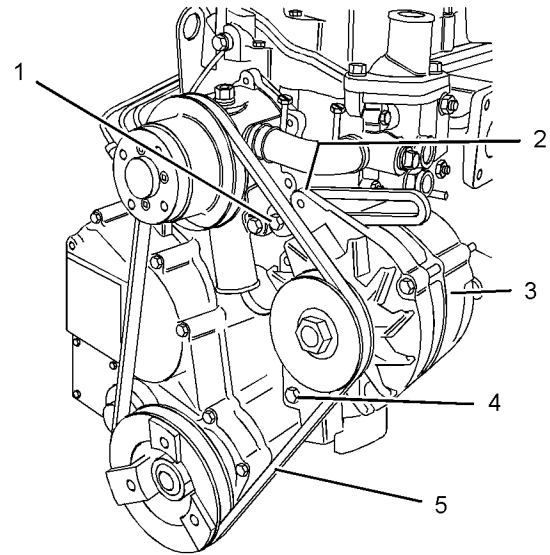


Illustration 35

g01325726

Typical example

1. Install V-belt (5) in position on the pulleys. Refer to illustration 34 for the correct belt routing.
2. Slide alternator (3) away from the engine. Refer to this Operation and Maintenance Manual, "Alternator and Fan Belts - Inspect/Adjust" for information on the correct belt tension. Tighten bolt (1), bolt (2), and (4) to a torque of 25 N·m (18 lb ft).
3. When new belts are installed, check the belt tension again after 20 hours of engine operation.

For applications that require multiple drive belts, replace the belts in matched sets. Replacing only one belt of a matched set will cause the new belt to carry more load because the older belt is stretched. The additional load on the new belt could cause the new belt to break.

- If the engine is equipped with fan guards, install the fan guards. Refer to the OEM for the correct installation procedure

i02322315

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.

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

- Remove the used battery.
- Install the new battery.

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

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

i02747977

Battery Electrolyte Level - Check

When the engine is not run for long periods of time or when the engine is run for short periods, the batteries may not fully recharge. Ensure a full charge in order to help prevent the battery from freezing. If batteries are correctly charged, the ammeter reading should be very near zero, when the engine is in operation.

WARNING

All lead-acid batteries contain sulfuric acid which can burn the skin and clothing. Always wear a face shield and protective clothing when working on or near batteries.

- Remove the filler caps. Maintain the electrolyte level to the “FULL” mark on the battery.

If the addition of water is necessary, use distilled water. If distilled water is not available use clean water that is low in minerals. Do not use artificially softened water.

- Check the condition of the electrolyte with a suitable battery tester.
- Install the caps.
- Keep the batteries clean.

Clean the battery case with one of the following cleaning solutions:

- Use a solution of 0.1 kg (0.2 lb) baking soda and 1 L (1 qt) of clean water.
- Use a solution of ammonium hydroxide.

Thoroughly rinse the battery case with clean water.

i09570426

i08038786

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. Open the battery isolator. Disconnect the negative battery terminal. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, two negative connections 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 to help prevent accidental starting.
7. Proceed with necessary system repairs.
8. To connect the battery, connect the positive connection before the negative connection.

Cooling System Coolant (Commercial Heavy-Duty) - 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.

Note: Inspect the water pump and the water temperature regulator after the cooling system has been drained. During this maintenance procedure, consider replacing 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.

Maintenance Section

Cooling System Coolant (Commercial Heavy-Duty) - Change

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.

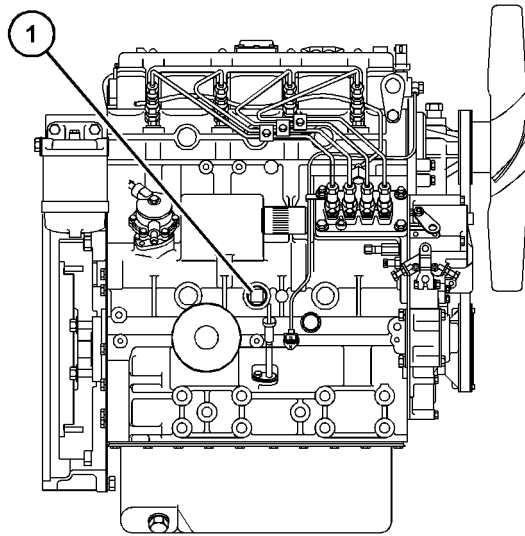


Illustration 36

g06518654

Drain plug option

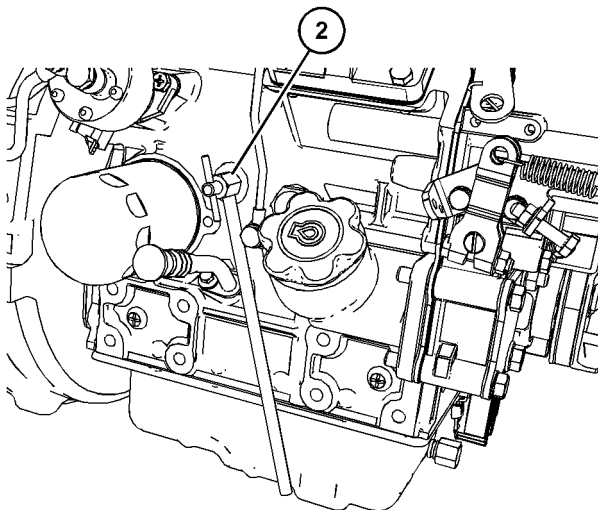


Illustration 37

g06518652

Drain tap option

2. Remove drain plug (1) or open drain tap (2) for the engine.
3. Remove the drain plug or open the drain tap on the radiator.
4. 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 tap or install the drain plug to the engine.
3. Close the drain tap 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.

4. Fill the cooling system with clean water. Install the cooling system filler cap.
5. Start and run the engine at low idle until the temperature reaches 49 to 66 °C (120 to 150 °F).
6. 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 tap or remove the drain plug on the engine. Open the drain tap 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 tap or install the drain plug on the engine.
2. Close the drain tap 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 Commercial Heavy-Duty Coolant. Add Supplemental Coolant Additive to the coolant. For the correct amount, 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.
4. Start and run the engine at low idle. Increase the engine rpm to high idle. Run the engine at high idle for one minute to purge the air from the cavities of the engine block. Stop the engine.
5. 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.
6. 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.
7. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i08045515

Cooling System 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. During this maintenance procedure, consider replacing 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.

Maintenance Section
Cooling System Coolant (ELC) - Change

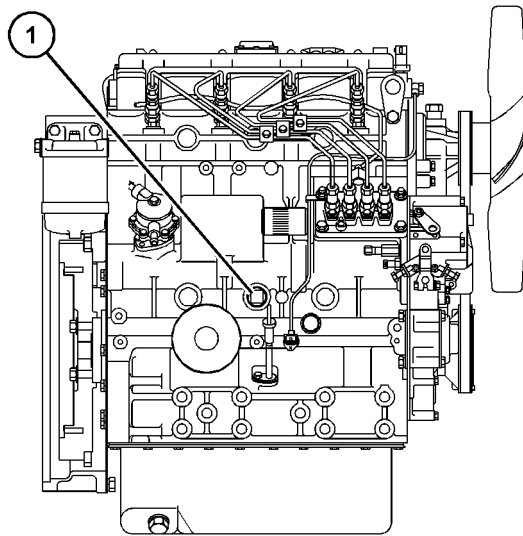


Illustration 38

g06518654

Drain plug option

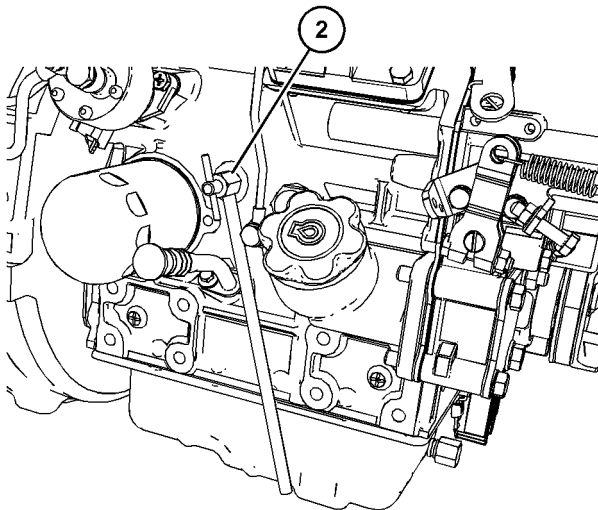


Illustration 39

g06518652

Drain tap option

2. Remove drain plug (1) or open drain tap (2) for the engine.
3. Remove the drain plug or open the drain tap on the radiator.
4. 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 one 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.

i04408743

Cooling System Coolant Level - Check

Engines With a Coolant Recovery Tank

Note: The cooling system may not have been provided by Perkins. The procedure that follows is for typical cooling systems. Refer to the OEM information for the correct procedures.

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

NOTICE

When any servicing or repair of the engine cooling system is performed, the procedure must be performed with the engine on level ground. This will allow you to accurately check the coolant level. This will also help in avoiding the risk of introducing an air lock into the coolant system.

1. Observe the coolant level in the coolant recovery tank. Maintain the coolant level to "COLD FULL" mark on the coolant recovery tank.

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.

2. Loosen filler cap slowly in order to relieve any pressure. Remove the filler cap.
3. Pour the correct coolant mixture into the tank. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for information on the correct mixture and type of coolant. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for the cooling system capacity. Do not fill the coolant recovery tank above "COLD FULL" mark.

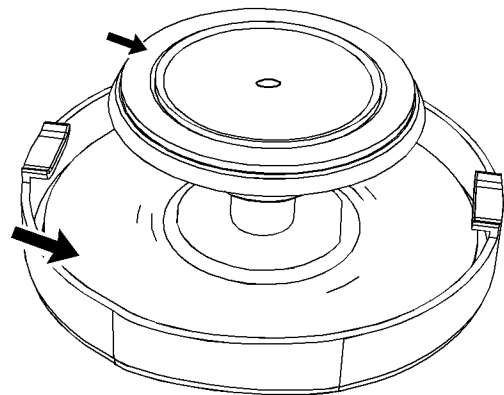


Illustration 40

g02590196

Filler cap

4. Clean filler cap and the receptacle. Reinstall the filler cap and inspect the cooling system for leaks.

Note: The coolant will expand as the coolant heats up during normal engine operation. The additional volume will be forced into the coolant recovery tank during engine operation. When the engine is stopped and cool, the coolant will return to the engine.

Engines Without a Coolant Recovery Tank

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

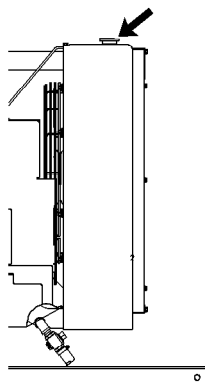


Illustration 41

g00285520

Cooling system filler cap

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. Remove the cooling system filler cap slowly in order to relieve pressure.
2. Maintain the coolant level at the maximum mark that is correct for your application. If the engine is equipped with a sight glass, maintain the coolant level to the correct level in the sight glass.
3. Clean the cooling system filler cap and inspect the gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a suitable pressurizing pump in order to pressure test the filler cap. The correct pressure is stamped on the face of the filler cap. If the filler cap does not retain the correct pressure, install a new filler cap.

4. Inspect the cooling system for leaks.

i03644948

Cooling System Supplemental Coolant Additive (SCA) - Test/Add

WARNING

Cooling system coolant additive contains alkali. To help prevent personal injury, avoid contact with the skin and the eyes. Do not drink cooling system coolant additive.

Test for SCA Concentration

Heavy-Duty Coolant/Antifreeze and SCA

NOTICE

Do not exceed the recommended six percent supplemental coolant additive concentration.

Use a Coolant Conditioner Test Kit in order to check the concentration of the SCA.

Add the SCA, If Necessary

NOTICE

Do not exceed the recommended amount of supplemental coolant additive concentration. Excessive supplemental coolant additive concentration can form deposits on the higher temperature surfaces of the cooling system, reducing the engine's heat transfer characteristics. Reduced heat transfer could cause cracking of the cylinder head and other high temperature components. Excessive supplemental coolant additive concentration could also result in radiator tube blockage, overheating, and/or accelerated water pump seal wear. Never use both liquid supplemental coolant additive and the spin-on element (if equipped) at the same time. The use of those additives together could result in supplemental coolant additive concentration exceeding the recommended maximum.

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.

NOTICE

When any servicing or repair of the engine cooling system is performed the procedure must be performed with the engine on level ground. This will allow you to accurately check the coolant level. This will also help in avoiding the risk of introducing an air lock into the coolant system.

i06791792

1. Slowly loosen the cooling system filler cap in order to relieve the pressure. Remove the cooling system filler cap.

Note: Always discard drained fluids according to local regulations.

2. If necessary, drain some coolant from the cooling system into a suitable container in order to allow space for the extra SCA.
3. Add the correct amount of SCA. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for more information on SCA requirements.
4. Clean the cooling system filler cap and inspect the gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a suitable pressurizing pump in order to pressure test the filler cap. The correct pressure is stamped on the face of the filler cap. If the filler cap does not retain the correct pressure, install a new filler cap.

i02151646

Driven Equipment - Check

Refer to the OEM specifications for more information on the following maintenance recommendations for the driven equipment:

- Inspection
- Adjustment
- Lubrication
- Other maintenance recommendations

Perform any maintenance for the driven equipment which is recommended by the OEM.

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 be directed 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, and the starter. Protect the fuel injection pump from fluids to wash the engine.

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

i08154921

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.

Servicing the Air Cleaner Elements

Note: The air filter system may not have been provided by Perkins. The procedure that follows, is for a typical air filter system. Refer to the OEM information for the correct procedure.

If the air cleaner element becomes plugged, the air can split the material of the air cleaner element. Unfiltered air will drastically accelerate internal engine wear. Refer to the OEM information for the correct air cleaner elements for your application.

- Check the pre-cleaner (if equipped) and the dust bowl daily for accumulation of dirt and debris. Remove any dirt and debris, as needed.
- Operating in dirty conditions may require more frequent service of the air cleaner element.
- The air cleaner element should be replaced at least one time per year.

Replace the dirty air cleaner elements with clean air cleaner elements. Before installation, the new air cleaner elements should be thoroughly checked for tears and/or holes in the filter material. Inspect the gasket or the seal of the air cleaner element for damage. Maintain a supply of suitable air cleaner elements for replacement purposes.

Air Cleaners

Some application can have dual elements. The dual air cleaner contains a primary air cleaner element and a secondary air cleaner element. Both element must be replaced at the same time.

Do not replace the air cleaner filter elements in a dirty environment, as dirt can enter the air system when the elements are removed.

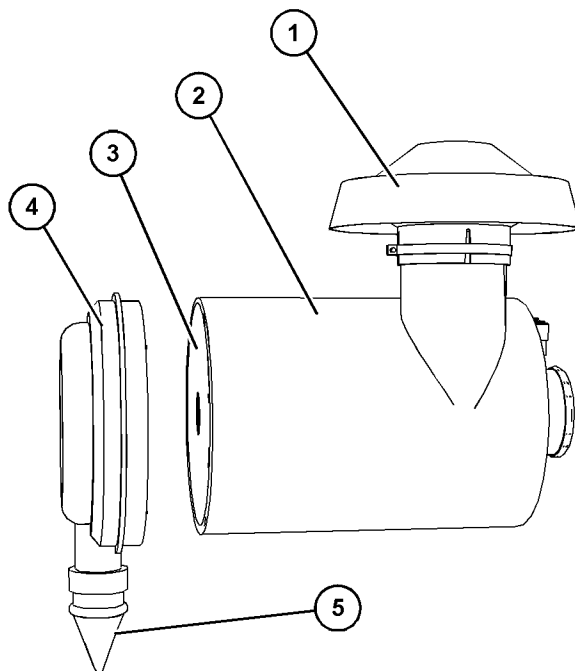


Illustration 42

g06217098

Typical example

- (1) Top Cover
- (2) Air Cleaner Body
- (3) Primary Air Filter Element
- (4) End Cover
- (5) Vacuum Valve

1. Ensure that the outer body of the air cleaner to be serviced is clean and free from dirt.
2. Inspect the top cover (1) and if necessary remove top cover to clean cover. Ensure that dirt cannot enter the air cleaner system with top cover removed. If necessary, clean top cover and install.
3. Remove end cover (4) from air cleaner body (2). If necessary, clean end cover and ensure that the vacuum valve (5) is clean and free from dirt. Check the vacuum valve (5) for wear or damage, replace if necessary.
4. Remove primary air filter element (3) and if equipped, remove the secondary air filter element (Not Shown). Discard all old air filter elements.
5. If equipped, install new secondary air filter element (Not Shown) and install new primary air filter element (3).

6. Install end cover (4) to air cleaner body (2) and secure end cover. If necessary, reset the air service indicator, refer to this Operation and Maintenance Manual, Engine Air Cleaner Service Indicator - Inspect for more information.

i02335405

Engine Air Cleaner Service Indicator - Inspect

Some engines may be equipped with a different service indicator.

Some engines are equipped with a differential gauge for inlet air pressure. The differential gauge for inlet air pressure displays the difference in the pressure that is measured before the air cleaner element and the pressure that is measured after the air cleaner element. As the air cleaner element becomes dirty, the pressure differential rises. If your engine is equipped with a different type of service indicator, follow the OEM recommendations in order to service the air cleaner service indicator.

The service indicator may be mounted on the air cleaner element or in a remote location.

- Check the movement of the yellow core when the engine is accelerated to the engine rated speed. The yellow core should latch at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the yellow core does not latch at the greatest vacuum, the service indicator should be replaced. If the new service indicator will not reset, the hole for the service indicator may be restricted.

The service indicator may need to be replaced frequently in environments that are severely dusty.

i02657627

Engine Crankcase Breather - Replace

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

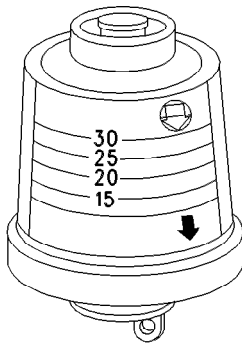


Illustration 43

g00103777

Typical service indicator

Observe the service indicator. The air cleaner element should be cleaned or the air cleaner element should be replaced when one of the following conditions occur:

- The yellow diaphragm enters the red zone.
- The red piston locks in the visible position.

Test the Service Indicator

Service indicators are important instruments.

- Check for ease of resetting. The service indicator should reset in less than three pushes.

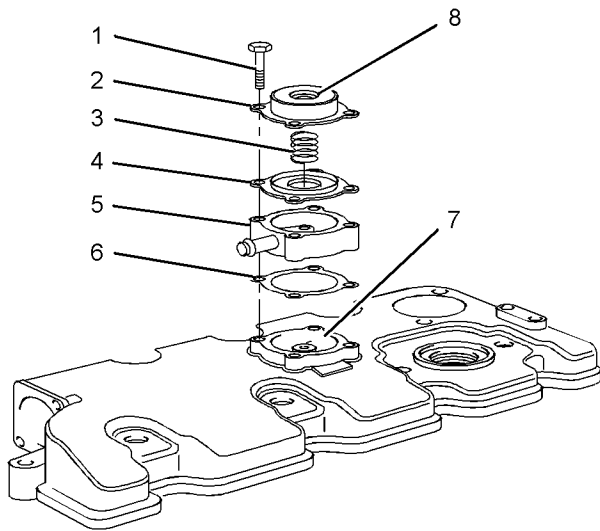


Illustration 44

g01335247

Typical example

- (1) Screws for the breather cover
- (2) Breather cover
- (3) Spring
- (4) Diaphragm and plate
- (5) Spacer for turbocharged engines only
- (6) Joint for turbocharged engines only
- (7) Cavity
- (8) Vent hole

1. Loosen the screws (1) and remove the breather cover (2) from the valve mechanism cover.
2. Remove the spring (3). Remove the diaphragm and plate (4).
3. For turbocharged engines, remove the spacer (5) and the joint (6).
4. Clean the vent hole (8) and the cavity (7) in the valve mechanism cover.

NOTICE

Make sure that the components of the breather assembly are installed correctly. Engine damage may occur if the breather assembly is not working correctly.

5. For turbocharged engines, install a new joint (6) and the spacer (5).

6. Install a new diaphragm and plate (4) for the breather assembly into the cavity (7) of the valve mechanism cover or the spacer (5) for turbocharged engines.

7. Install a new spring (3).

8. Install the breather cover (2) and the four screws (1). Tighten the screws.

i07819538

Engine Mounts - Inspect

Note: The engine mounts may not have been supplied by Perkins. Refer to the Original Equipment Manufacturer (OEM) information for further details on the engine mounts and the correct bolt torque.

Inspect the engine mounts for deterioration and for correct bolt torque. Excessive engine vibration can be caused by the following conditions:

- Incorrect mounting of the engine
- Deterioration of the engine mounts
- Loose engine mounts

Any engine mount that shows deterioration should be replaced. Refer to the OEM information for the recommended torques.

When the engine mounts are supplied by Perkins the maintenance procedure will be supplied in the Disassembly and Assembly manual for your engine.

i06812544

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.

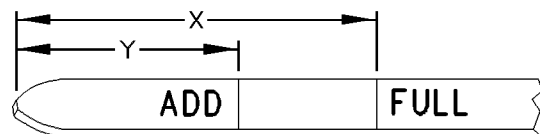


Illustration 45

g00110310

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

NOTICE

Perform this maintenance with the engine stopped.

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.

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

i08155318

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 one of the following methods to drain the engine crankcase oil:

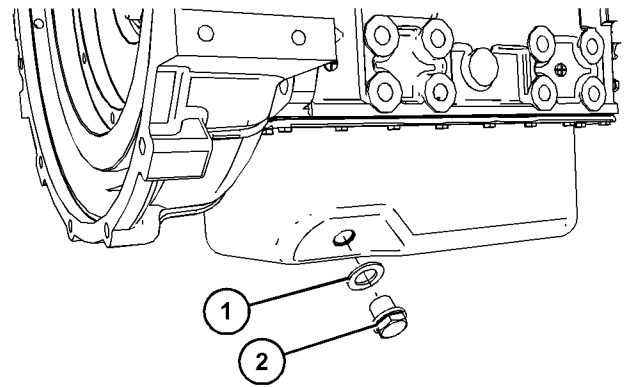


Illustration 46

g06518218

1. Remove drain plug (2) from the engine oil pan and drain the oil into a suitable container for storage or disposal.
2. Remove sealing washer (1) from the drain plug and clean the oil drain plug.
3. Install new sealing washer (1) to the drain plug.
4. Install drain plug (2) to the engine oil pan. Tighten the drain plug to a torque of 34 N·m (300.93 lb in)

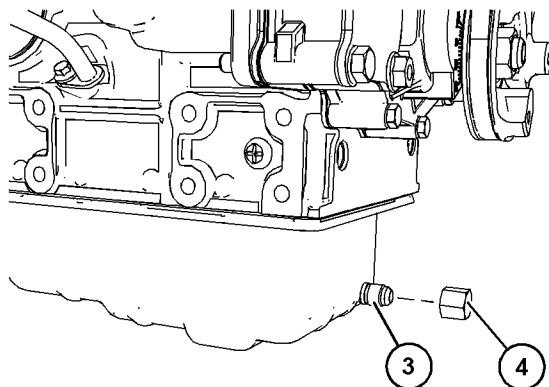


Illustration 47

g06518231

1. Remove drain cap (4) from engine oil pan outlet (3) and drain the oil into a suitable container for storage or disposal.
2. Clean the oil drain cap.
3. Install drain cap (4) to the engine oil pan outlet (3). Tighten the drain cap to a torque of 18 N·m (159.31 lb in).

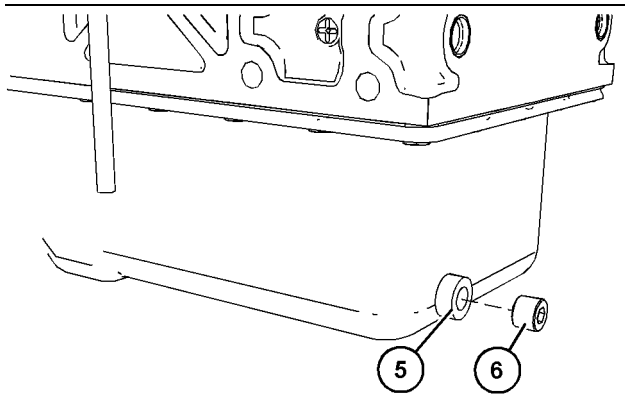


Illustration 48

g06523773

1. Remove drain plug (6) from engine oil pan outlet (5) and drain the oil into a suitable container for storage or disposal.
 2. Clean oil drain plug (6).
 3. Install drain plug (6) to engine oil pan outlet (5). Tighten the drain plug to a torque of 26 N·m (230.12 lb in).
- If the engine is equipped with a drain valve, turn the drain valve knob counterclockwise to drain the oil. After the oil has drained, turn the drain valve knob clockwise to close the drain valve.

Replace the Oil Filter

NOTICE

Perkins oil filters are built to Perkins specifications. Use of an oil filter not recommended by Perkins could result in severe engine damage to the engine bearings, crankshaft, etc., as a result of the larger waste particles from unfiltered oil entering the engine lubricating system. Only use oil filters recommended by Perkins.

1. Remove the oil filter with a suitable tool.

Note: The following actions can be carried out as part of the preventive maintenance program.

2. Cut the oil filter open with a suitable tool. Break apart the pleats and inspect the oil filter for metal debris. An excessive amount of metal debris in the oil filter may indicate early wear or a pending failure.

Use a magnet to differentiate between the ferrous metals and the non-ferrous metals that are found in the oil filter element. Ferrous metals may indicate wear on the steel and cast iron parts of the engine.

Non-ferrous metals may indicate wear on the aluminum parts, brass parts, or bronze parts of the engine. Parts that may be affected include the following items: main bearings, rod bearings, turbocharger bearings, and cylinder heads.

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter. Consult your Perkins dealer or your Perkins distributor to arrange for a further analysis if an excessive amount of debris is found in the oil filter.

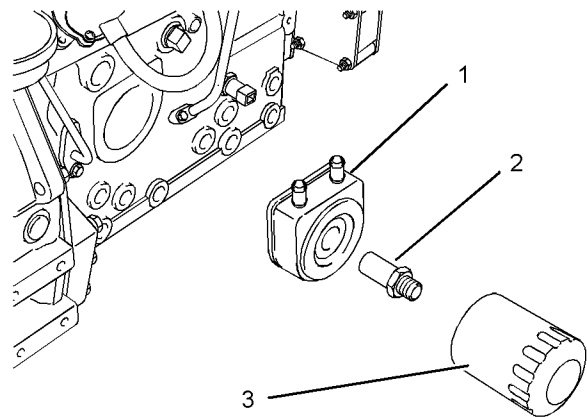


Illustration 49

g01334593

- (1) Oil cooler
- (2) Adapter
- (3) Oil filter

Note: The oil cooler (1) and the adapter (2) are installed on engines that have a turbocharger.

3. Clean the sealing surface of the cylinder block or the oil cooler (1).
4. Apply clean engine oil to the new oil filter seal (3).

NOTICE

Do not fill the oil filters with oil before installing them. This oil would not be filtered and could be contaminated. Contaminated oil can cause accelerated wear to engine components or engine damage.

5. Install the oil filter. Tighten the oil filter by hand. Do not overtighten the oil filter.

Fill the Engine Crankcase

1. Remove the oil filler cap. Refer to this Operation and Maintenance Manual, Fluid Recommendations 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 on refill capacities.

NOTICE

If equipped with an auxiliary oil filter system or a remote oil filter system, follow the OEM or filter manufacturer's recommendations. Under filling or overfilling the crankcase with oil can cause engine damage.

NOTICE

To prevent crankshaft bearing damage, crank the engine with the fuel OFF. This will fill the oil filters before starting the engine. Do not crank the engine for more than 30 seconds.

2. Start the engine and run the engine at "LOW IDLE" for two minutes. Perform this procedure to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filter for oil leaks.
3. Stop the engine and allow the oil to drain back to the sump for a minimum of ten minutes.

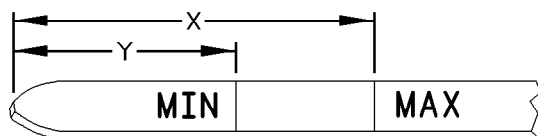


Illustration 50

g00986928

Typical example

4. Remove the oil level gauge to check the oil level. Maintain the oil level between the "MIN" and "MAX" marks on the oil level gauge.

i02171102

Engine Valve Lash - Inspect/Adjust

This maintenance is recommended by Perkins as part of a lubrication and preventive maintenance schedule in order to help provide maximum engine life.

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 can not 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.

Refer to Systems Operation/Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust" for more information.

i02154268

Fuel Injector - Test/Change

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

⚠ WARNING

Make sure that you wear eye protection at all times during testing. When fuel injection nozzles are tested, test fluids travel through the orifices of the nozzle tip with high pressure. Under this amount of pressure, the test fluid can pierce the skin and cause serious injury to the operator. Always keep the tip of the fuel injection nozzle pointed away from the operator and into the fuel collector and extension.

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 disconnected fuel system component.

Regular maintenance of the fuel injectors is recommended by Perkins. The fuel injectors must be removed and tested by an authorized agent. The fuel injectors should not be cleaned as cleaning with incorrect tools can damage the nozzle. The fuel injectors should be renewed only if a fault with the fuel injectors occurs. Some of the problems that may indicate that new fuel injectors are needed are listed below:

- The engine will not start or the engine is difficult to start.
- Not enough power
- The engine misfires or the engine runs erratically.
- High fuel consumption
- Black exhaust smoke
- The engine knocks or there is vibration in the engine.
- Excessive engine temperature

For further information on the removal and the installation of the fuel injectors, refer to the Disassembly and Assembly manual.

For further information on the testing of fuel injectors, refer to the Testing and Adjusting manual.

Identification of a suspect Fuel Injector

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

NOTICE

If your skin comes into contact with high pressure fuel, obtain medical assistance immediately.

NOTICE

If a fuel injector is suspected of operating outside of normal parameters it should be removed by a qualified technician. The suspect fuel injector should be taken to an authorised agent for inspection.

Operate the engine at a fast idle speed in order to identify the faulty fuel injector. Individually loosen and tighten the union nut for the high pressure pipe to each fuel injector. Do not loosen the union nut more than half a turn. There will be little effect on the engine speed when the union nut to the faulty fuel injector is loosened.

Consult your authorized Perkins dealer or your Perkins distributor for further assistance.

i08037197

Fuel System - Prime

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 is replaced.

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.

There are two types of fuel filter that may be installed on these engines. The procedure to prime the fuel system will depend on the type of filter that is installed on the engine and the type of connector that is installed on the fuel injection pump. Both types of filter and connections are shown.

Use the following procedure to prime the fuel system:

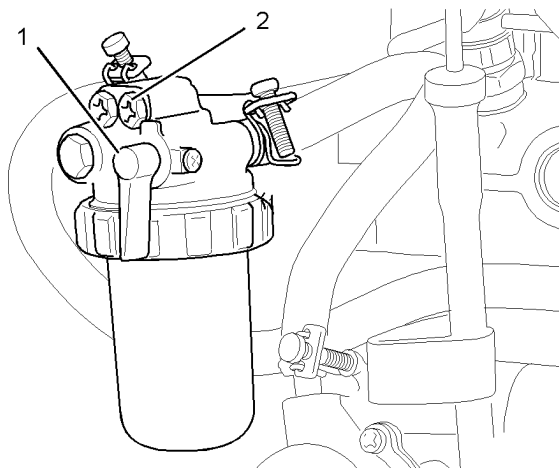


Illustration 51

g01122124

Fuel filter with element

- (1) Fuel valve
(2) Vent screw

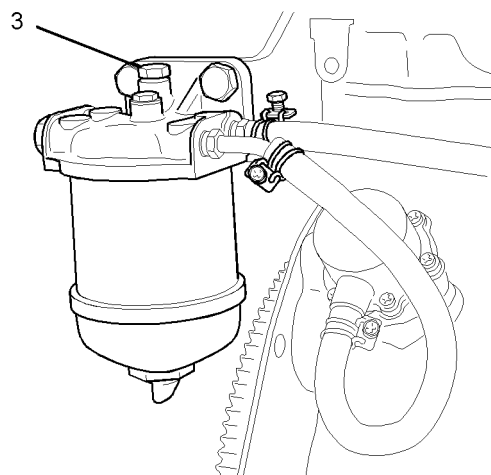


Illustration 52

g01122125

Fuel filter with canister

- (3) Vent screw

1. Ensure that the fuel valve (1) for the fuel filter that has an element is in the ON position. The fuel valve for the fuel filter that has a canister may be located away from the engine. Refer to the OEM information for further details.
2. Loosen the vent screw (2) or (3).

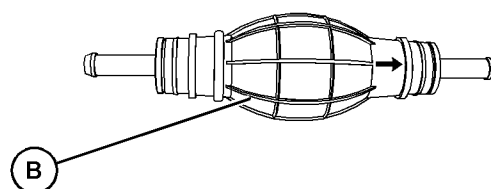
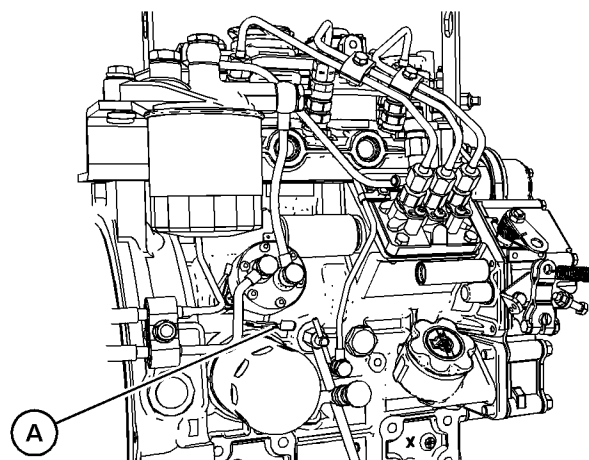


Illustration 53

g06518138

(A) Lift pump hand priming option.

(B) Loose part hand priming option.

3. Operate the hand primer. Refer to illustration 53

4. When fuel free from air flows from the vent screw tighten the vent screw.

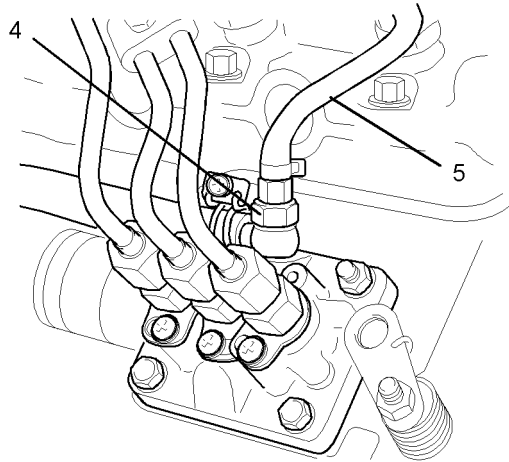


Illustration 54

g01122126

Connector that is installed on 2 and 3 cylinder engines

- (4) Connector bolt
(5) Fuel return hose for the injector

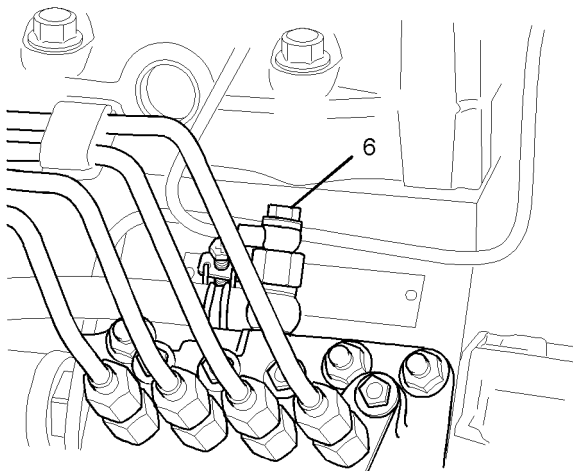


Illustration 55

g01122127

Connector that is installed on 4 cylinder engines

- (6) Connector bolt

5. Loosen the connector (4) or (6) at the fuel injection pump.

Note: For illustration 54, the fuel return hose (5) may need to be removed at the fuel injection pump.

6. Operate the hand primer. When fuel free from air flows from the connector tighten the connector bolt.

7. Try to start the engine.

Note: Do not operate the starting motor for more than 15 seconds. If the engine does not start after 15 seconds, stop and wait for 30 seconds before trying again.

i02154450

Fuel System 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 disconnected fuel system component.

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 Filter With Canister

1. Close the fuel supply valve.

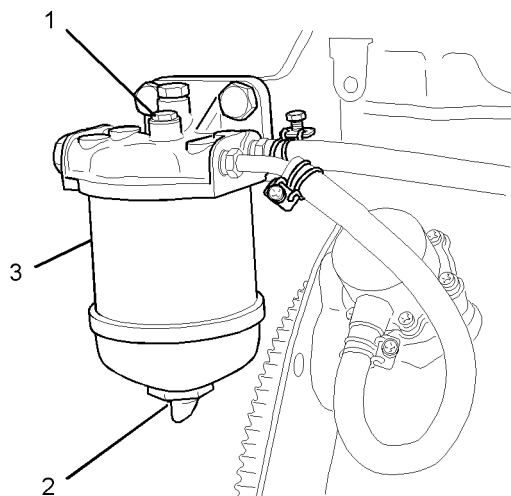


Illustration 56

g01122129

2. Clean the outside of the fuel filter assembly.
3. Open the fuel drain (2) in the bottom of the filter assembly, if equipped. Drain the fuel into a suitable container.
4. Loosen the setscrew (1).
5. Remove the canister (3).

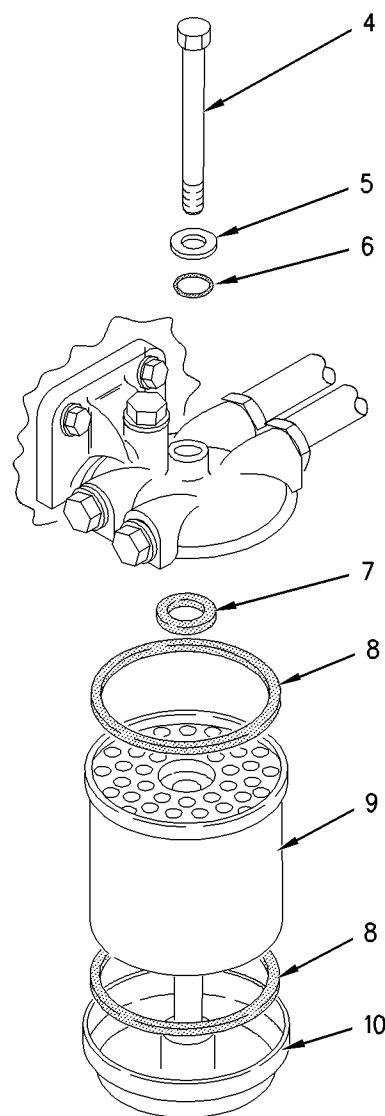


Illustration 57

g00917937

6. Assemble the following items: seals (8), seal (7), canister (9) and base (10). Place washer (5) and seal (6) on setscrew (4).
7. Fasten the assembly to the fuel filter base with setscrew (4).

The fuel system will need to be primed after the new filter is installed. Refer to this Operation and Maintenance Manual, "Fuel System - Prime".

Fuel Filter With Element

1. Close the fuel supply valve (1).

Maintenance Section
Fuel System Filter - Replace

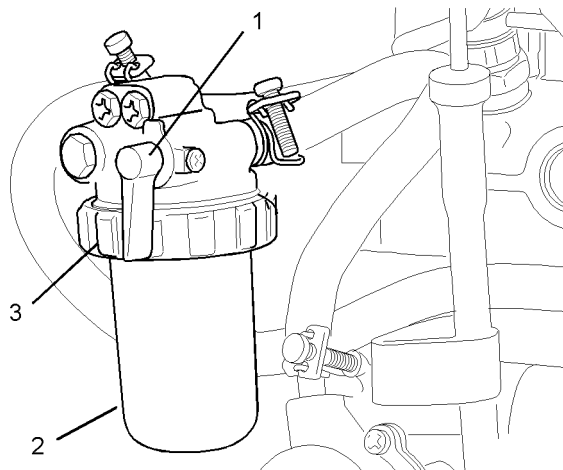


Illustration 58

g01122130

2. Clean the outside of the fuel filter assembly.
3. Loosen the locking ring (3).
4. Remove the casing for the filter (2) and the element.

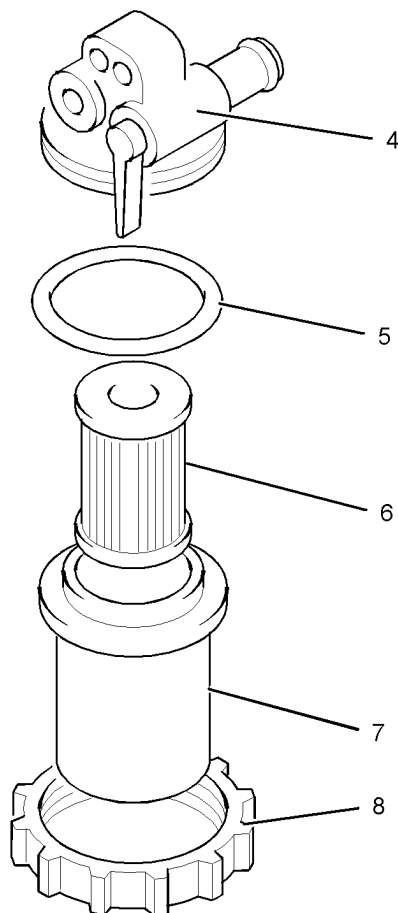


Illustration 59

g01122131

5. Assemble the following items: seal (5), filter element (6) and casing (7).
6. Install the assembled items to the filter head (4).
7. Install the locking ring (8) to the filter head. Rotate the locking ring in order to lock the assembly.

The fuel system will need to be primed after the new filter is installed. Refer to this Operation and Maintenance Manual, "Fuel System - Prime".

i02177959

Fuel System Primary Filter/ Water Separator - Drain

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

The water separator is not a filter. The water separator separates water from the fuel. The engine should never be allowed to run with the water separator more than half full. Engine damage may result.

The fuel filter/water separator (if equipped) is not usually supplied by Perkins. The following text describes a typical fuel filter/water separator. Refer to the OEM information for further information on the fuel filter/water separator.

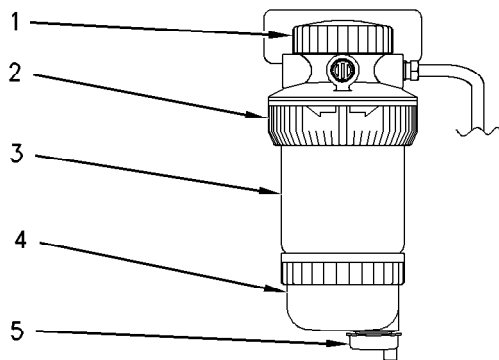


Illustration 60

g00741109

- (1) Cap
- (2) Locking ring
- (3) Element
- (4) Water separator bowl
- (5) Drain

1. Open drain (5). Catch the draining water in a suitable container. Dispose of the drained water correctly.
2. Close drain (5).

NOTICE

The water separator is under suction during normal engine operation. Ensure that the drain valve is tightened securely to help prevent air from entering the fuel system.

i02335436

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.

i02813964

Hoses and Clamps - Inspect/Replace

Inspect all hoses for leaks that are caused by the following conditions:

- Cracking
- Softness
- Loose clamps

Replace hoses that are cracked or soft. Tighten any loose clamps.

NOTICE

Do not bend or strike high pressure lines. Do not install bent or damaged lines, tubes or hoses. Repair any loose or damaged fuel and oil lines, tubes and hoses. Leaks can cause fires. Inspect all lines, tubes and hoses carefully. Tighten all connections to the recommended torque. Do not clip any other item to the high pressure lines.

Check for the following conditions:

- End fittings that are damaged or leaking
- Outer covering that is chafed or cut

- Exposed wire that is used for reinforcement
- Outer covering that is ballooning locally
- Flexible part of the hose that is kinked or crushed
- Armoring that is embedded in the outer covering

A constant torque hose clamp can be used in place of any standard hose clamp. Ensure that the constant torque hose clamp is the same size as the standard clamp.

Due to extreme temperature changes, the hose will harden. Hardening of the hoses will cause hose clamps to loosen. This can result in leaks. A constant torque hose clamp will help to prevent loose hose clamps.

Each installation application can be different. The differences depend on the following factors:

- Type of hose
- Type of fitting material
- Anticipated expansion and contraction of the hose
- Anticipated expansion and contraction of the fittings

Replace the Hoses and the Clamps

Refer to the OEM information for further information on removing and replacing fuel hoses (if equipped).

The coolant system and the hoses for the coolant system are not usually supplied by Perkins. The following text describes a typical method of replacing coolant hoses. Refer to the OEM information for further information on the coolant system and the hoses for the coolant system.

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. Allow the engine to cool.
2. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.

Note: Drain the coolant into a suitable, clean container. The coolant can be reused.

3. Drain the coolant from the cooling system to a level that is below the hose that is being replaced.

4. Remove the hose clamps.
5. Disconnect the old hose.
6. Replace the old hose with a new hose.
7. Install the hose clamps with a torque wrench.

Note: For the correct coolant, see this Operation and Maintenance Manual, "Fluid Recommendations".

8. Refill the cooling system. Refer to the OEM information for further information on refilling the cooling system.
9. Clean the cooling system filler cap. Inspect the cooling system filler cap's seals. Replace the cooling system filler cap if the seals are damaged. Install the cooling system filler cap.
10. Start the engine. Inspect the cooling system for leaks.

i09650780

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.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction to the air flow of the fan. 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, which 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 to soften mud. Clean the core from the front and rear.

Use a degreaser and steam for removal of oil and grease. Clean the core from the front and rear. 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. Accelerating the engine to high idle 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 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.

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Severe Service Application - Check

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 in order 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 in order to ensure maximum reliability and retention of full service life.

Due to individual applications, it is not possible to identify all of 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 extremely cold environments or hot environments. Valve components can be damaged by carbon buildup if the engine is frequently started and stopped in very cold temperatures. Extremely hot intake air reduces engine performance.

Quality of the air – The engine may be subjected to extended operation in environments that are dirty, dusty, or contaminated. If the equipment is not cleaned regularly, mud, dirt, and dust can accumulate and encase components, leading to increased wear and maintenance challenges. The ingress of contaminants that affect combustion air quality and exhaust gas composition should be avoided. It is recommended to ensure adequate workplace ventilation and to follow local air quality guidelines and regulations.

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

- Extended operation at low idle
- 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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Starting Motor - Inspect

Perkins recommends a scheduled inspection of the starting motor. If the starting motor fails, the engine may not start in an emergency situation.

Check the starting motor for correct operation. Check the electrical connections and clean the electrical connections. Refer to the Systems Operation, Testing and Adjusting Manual, "Electric Starting System - Test" for more information on the checking procedure and for specifications consult your Perkins dealer or your Perkins distributor for assistance.

i02184788

Turbocharger - Inspect (If Equipped)

A regular visual inspection of the turbocharger is recommended. Any fumes from the crankcase are filtered through the air inlet system. Therefore, by-products from oil and from combustion can collect in the turbocharger compressor housing. Over time, this buildup can contribute to loss of engine power, increased black smoke and overall loss of engine efficiency.

If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE

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

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

When a turbocharger bearing failure is accompanied by a significant engine performance loss (exhaust smoke or engine rpm up at no load), do not continue engine operation until the turbocharger is renewed.

A visual inspection of the turbocharger can minimize unscheduled downtime. A visual inspection of the turbocharger can also reduce the chance for potential damage to other engine parts.

Removal and Installation

Note: The turbochargers that are supplied are nonserviceable.

For options regarding the removal, installation, and replacement, consult your Perkins dealer or your Perkins distributor. Refer to the Disassembly and Assembly Manual, "Turbocharger - Remove and Turbocharger - Install" for further information.

Inspecting

NOTICE

The compressor housing for the turbocharger must not be removed from the turbocharger for cleaning.

The actuator linkage is connected to the compressor housing. If the actuator linkage is moved or disturbed the engine may not comply with emissions legislation.

1. Remove the pipe from the turbocharger exhaust outlet and remove the air intake pipe to the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.
2. Check for the presence of oil. If oil is leaking from the back side of the compressor wheel, there is a possibility of a failed turbocharger oil seal.

The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the intake air (clogged air filters), which causes the turbocharger to slobber.
3. Inspect the bore of the housing of the turbine outlet for corrosion.
4. Fasten the air intake pipe and the exhaust outlet pipe to the turbocharger housing.

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Walk-Around Inspection

Inspect the Engine for Leaks and for Loose Connections

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

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

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

NOTICE

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

NOTICE

Accumulated grease and/or oil on an engine is a fire hazard. Remove the accumulated grease and oil. Refer to this Operation and Maintenance Manual, "Engine - Clean" for more information.

- Ensure that the cooling system hoses are correctly clamped and that the cooling system hoses are tight. Check for leaks. Check the condition of all pipes.
- Inspect the water pump for coolant leaks.

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

Excessive coolant leakage may indicate the need to replace the water pump seal. For the removal of the water pump and the installation of water pump and/or seal, refer to the Disassembly and Assembly Manual, "Water Pump - Remove and Install" for more information or consult your Perkins dealer or your Perkins distributor.

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the rocker cover.
- Inspect the fuel system for leaks. Look for loose fuel line clamps and/or tie-wraps.
- Inspect the piping for the air intake system and the elbows for cracks and for loose clamps. Ensure that hoses and tubes are not contacting other hoses, tubes, wiring harnesses, etc.
- Inspect the alternator belts and any accessory drive belts for cracks, breaks or other damage.

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

- Drain the water and the sediment from the fuel tank on a daily basis in order to ensure that only clean fuel enters the fuel system.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground strap for a good connection and for good condition.
- Disconnect any battery chargers that are not protected against the current drain of the starting motor. Check the condition and the electrolyte level of the batteries, unless the engine is equipped with a maintenance free battery.
- Check the condition of the gauges. Replace any gauges that are cracked. Replace any gauge that can not be calibrated.

i01907756

Water Pump - Inspect

A failed water pump may cause severe engine overheating problems that could result in the following conditions:

- Cracks in the cylinder head
- A piston seizure
- Other potential damage to the engine

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

Visually inspect the water pump for leaks. Renew the water pump seal or the water pump if there is an excessive leakage of coolant. Refer to the Disassembly and Assembly Manual, "Water Pump - Remove and Install" for the disassembly and assembly procedure.

Warranty Section

Warranty Information

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Emissions Warranty Information

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

This engine may be covered by an Emissions Warranty. Consult your authorized Perkins dealer or distributor to determine if your engine is emissions certified and if your engine is subject to an Emissions Warranty.

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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: _____

	<u>Dealer Contact</u>	<u>Phone Number</u>	<u>Hours</u>
Sales:	_____	_____	_____
Parts:	_____	_____	_____
Service:	_____	_____	_____

