

THE HEART OF EVERY GREAT MACHINE

Operation and Maintenance Manual

403EA-11, 403EA-11T, 403EA-17, 404EA-22, and 404EA-22T Industrial Engines

QS (Engine)
QZ (Engine)
QJ (Engine)
QN (Engine)
QP (Engine)

Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

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



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

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

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

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Foreword

California Proposition 65 Warning

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



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

www.P65Warnings.ca.gov

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



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

www.P65Warnings.ca.gov

Wash hands after handling components that may contain lead.

Literature Information

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

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

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

Safety

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

Operation

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

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

Maintenance

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

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

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

Maintenance Intervals

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

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

Overhaul

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

Safety Section

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Safety Messages

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

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

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

(1) Universal Warning

 **WARNING**

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

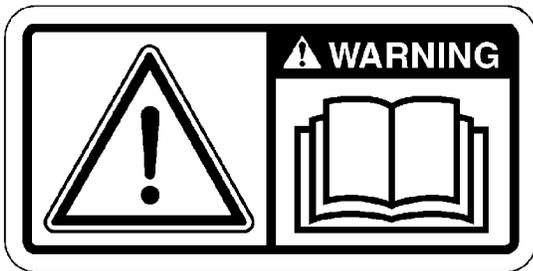


Illustration 1

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Typical example

The Universal Warning label (1) is installed in different locations. The location will change according to the physical size of the engine. Refer to illustrations 2 and 3 for the location of the label.

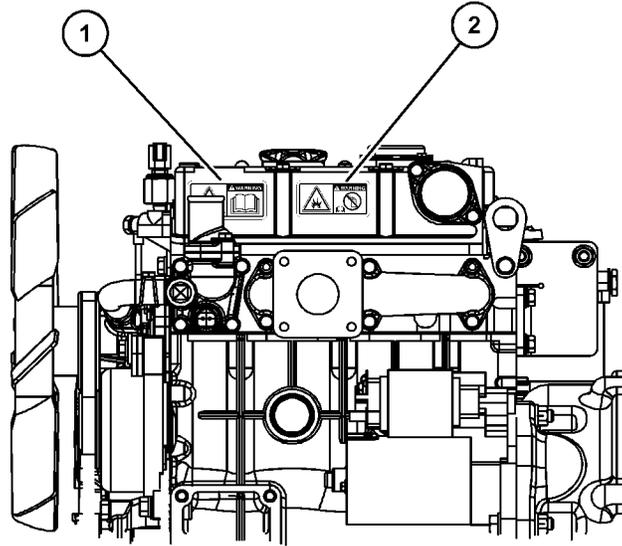


Illustration 2

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Typical example of 403EA-11 Industrial Engines

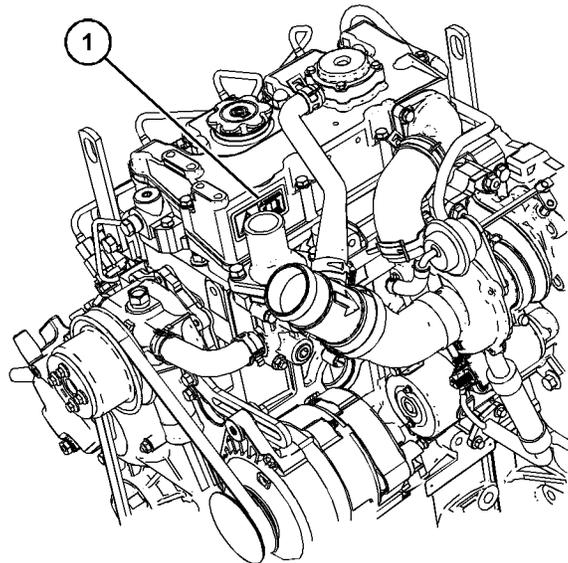


Illustration 3

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Typical example of 403EA-11T Industrial Engines

(2) Ether Warning

WARNING

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

Ether Warning label (2) is installed in different locations. The location will change according to the physical size of the engine.

On certain engines, the ether warning label is supplied loose. The ether warning label should be installed on the air cleaner or close to the air cleaner. The location will depend on the application.



Illustration 4

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General Hazard Information

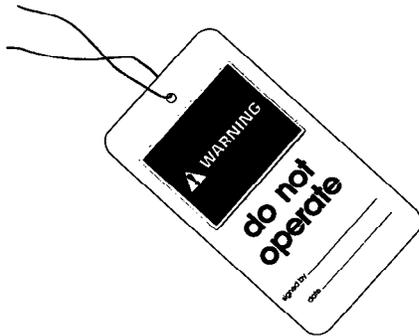


Illustration 5

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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 the engine is serviced or before the engine is repaired. Attach the warning tags to the engine and to each operator control station. When appropriate, disconnect the starting controls.

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

- Tampering with the engine installation or tampering with the OEM supplied wiring can be dangerous. Personal injury, death and/or engine damage could result.

- Vent the engine exhaust to the outside when the engine is operated in an enclosed area.
- If the engine is not running, do not release the secondary brake or the parking brake systems unless the vehicle is blocked or unless the vehicle is restrained.
- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When working around an engine, the engine must not be in operation. You may only be near a running engine to carry out maintenance procedures that require the engine to be in operation.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

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

- The engine is stopped. Ensure that the engine cannot be started.
- The protective locks or the controls are in the applied position.
- Engage the secondary brakes or parking brakes.
- Block the vehicle or restrain the vehicle before maintenance or repairs are performed.
- If equipped, disconnect the connectors for the unit injectors that are on the valve cover base. This action will help prevent personal injury from the high voltage to the unit injectors. Do not come in contact with the unit injector terminals while the engine is operating.
- Do not attempt any repairs or any adjustments to the engine while the engine is operating.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

- For initial start-up of a new engine or for starting an engine that has been serviced, make provisions to stop the engine if an overspeed occurs. 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.

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.

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

Remove the following parts with caution.

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

Use caution when cover plates are removed. Gradually loosen, but do not remove the last two bolts or nuts that are 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.

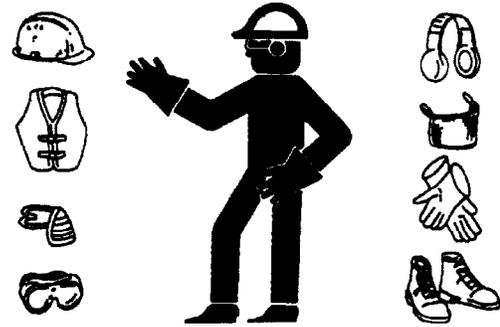


Illustration 6

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- Wear a hard hat, protective glasses, and other protective equipment, as required.
- Perkins recommend that you do not stand next to an exposed running engine unless it is necessary when carrying out daily checks or maintenance procedures. The appropriate Personal Protective Equipment (PPE) must be worn when standing next to an exposed running engine.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

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

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads to help prevent sparks.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.

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

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

Fluid Penetration

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

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

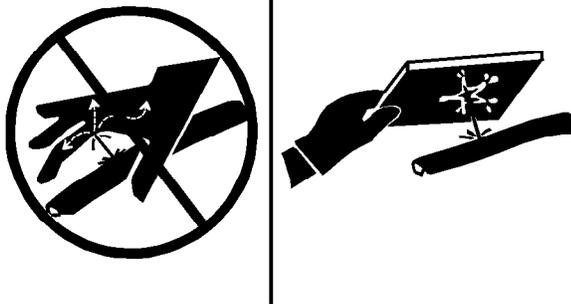


Illustration 7

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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 product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

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

Dispose of all fluids according to local regulations and mandates.

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.

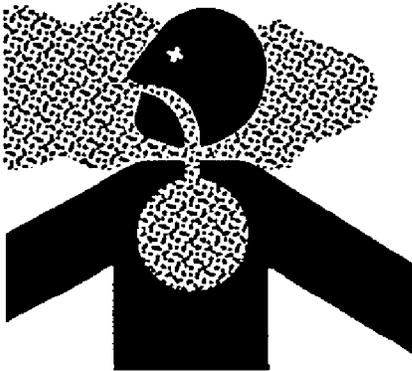
Inhalation

Illustration 8

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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

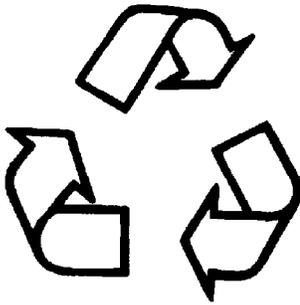


Illustration 9

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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 10

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Use of personal protection equipment (PPE) may be needed.

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

Always perform a Walk-Around Inspection, which may help you identify a fire hazard. Do not operate a product when a fire hazard exists. Contact your Perkins distributor for service.

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.

Flash fires 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 distributor for additional information about suitable protection devices.

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

All fluids that are captured in the fluid spill container should be cleaned up immediately. Failure to clean up spilled fluids can cause a fire. Fire may cause personal injury and property damage.

Store fuels and lubricants in properly 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 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 use flame to 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.

Safety Section
Fire Prevention and Explosion Prevention

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

Ensure that the engine is stopped. Inspect all lines and hoses for wear or for deterioration. Ensure that the hoses are 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 11

g00704059

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.

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.



Illustration 12

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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.

Improper 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. Charging a frozen battery may result in 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

WARNING

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

Ether is flammable and poisonous.

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.

Repair any lines that are loose or damaged. Leaks can cause fires. Consult 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 to prevent vibration, rubbing against other parts, and excessive heat.

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Crushing Prevention and Cutting Prevention

Support the component properly 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 to avoid injury to the eyes.

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

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Mounting and Dismounting

Inspect the steps, the handholds, and the work area before mounting the engine. Keep these items clean and keep these items in good repair.

Mount the engine and dismount the engine only at locations that have steps and/or handholds. Do not climb on the engine, and do not jump off the engine.

Face the engine to mount the engine or dismount the engine. With your feet and hands, always maintain a three-point contact with the steps and designated handholds. Do not use any controls as handholds.

Do not stand on components which cannot support your weight. Use an adequate ladder or use a work platform. Secure the climbing equipment so that the equipment will not move.

Do not carry tools or supplies when you mount the engine or when you dismount the engine. Use a hand line to raise and lower tools or supplies.

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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 if there is a “DO NOT OPERATE” warning tag or similar warning tag attached to the start switch. Do not move any of the controls if there is a “DO NOT OPERATE” warning tag or similar warning tag attached 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 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 to help prevent personal injury. The circuits are also provided 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 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 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. Also, check the oil temperature gauge during the heater operation.

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.

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

These engines are equipped with a glow plug starting aid in each cylinder which heats the intake air to improve starting.

i08194343

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. Engine stopping may be accomplished by shutting off the fuel supply and/or the air supply to the engine.

i08461935

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 "-" cable should be connected last from the external power source to the primary position for grounding.

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

Grounding Practices

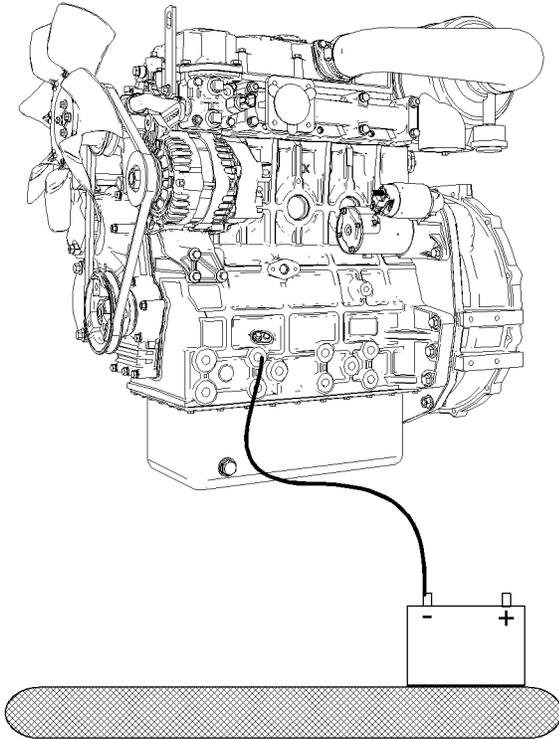


Illustration 13

g06672182

Typical example
Ground to battery

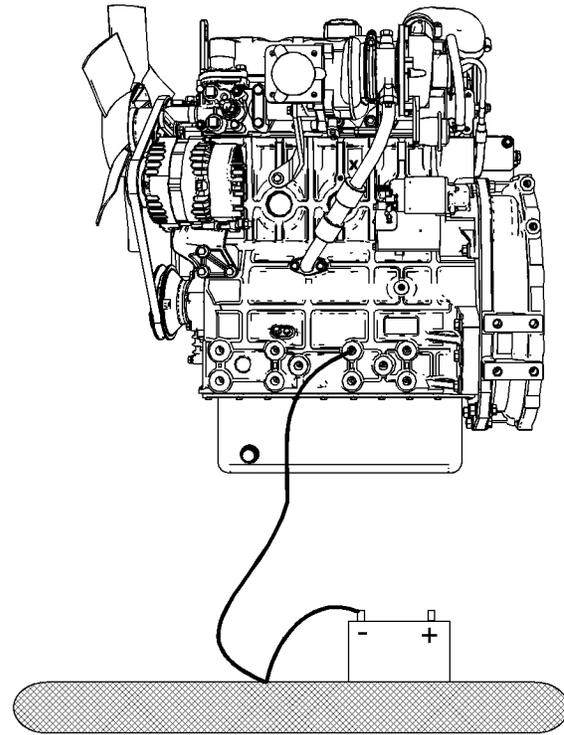


Illustration 14

g06672194

Typical example
Alternate ground to battery

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 the crankshaft bearing journal surfaces and to aluminum components.

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

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

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

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

Product Information Section

Model Views

i08625942

Model View Illustrations

Industrial Engine Model Views

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

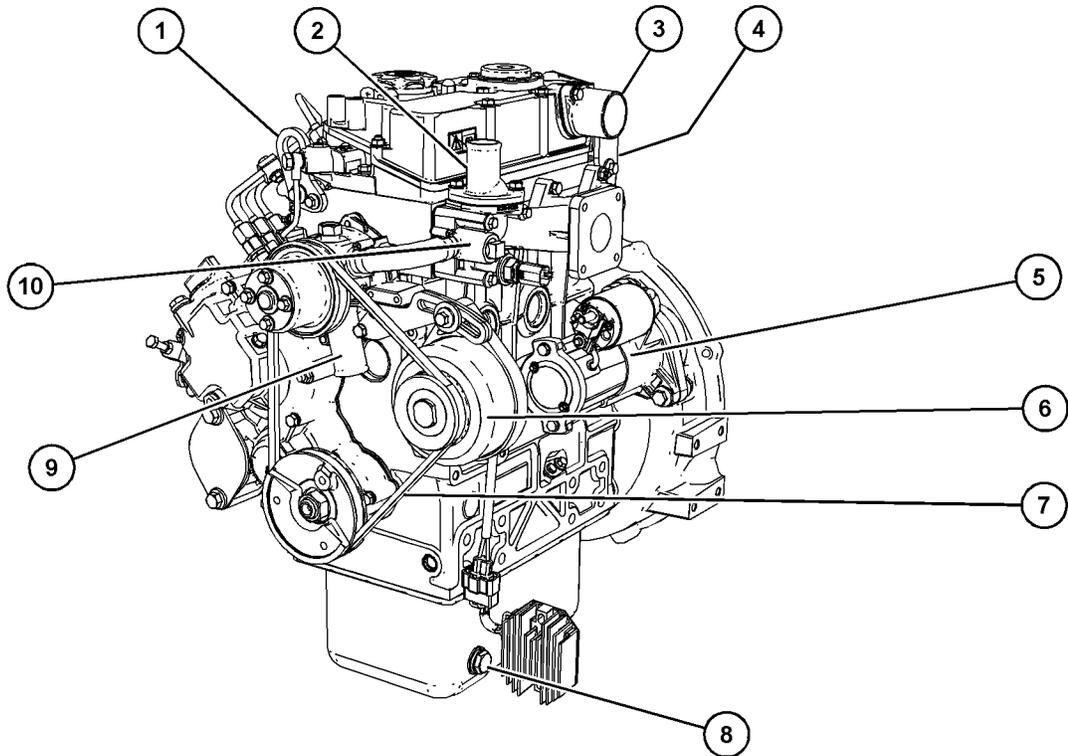
403EA-11 Engine

Illustration 15

g06697704

Typical example

- (1) Front lifting eye
- (2) Coolant outlet
- (3) Air intake
- (4) Rear lifting eye

- (5) Electric starting motor
- (6) Alternator
- (7) Drive belt
- (8) Oil drain plug

- (9) Coolant intake
- (10) Water temperature regulator housing

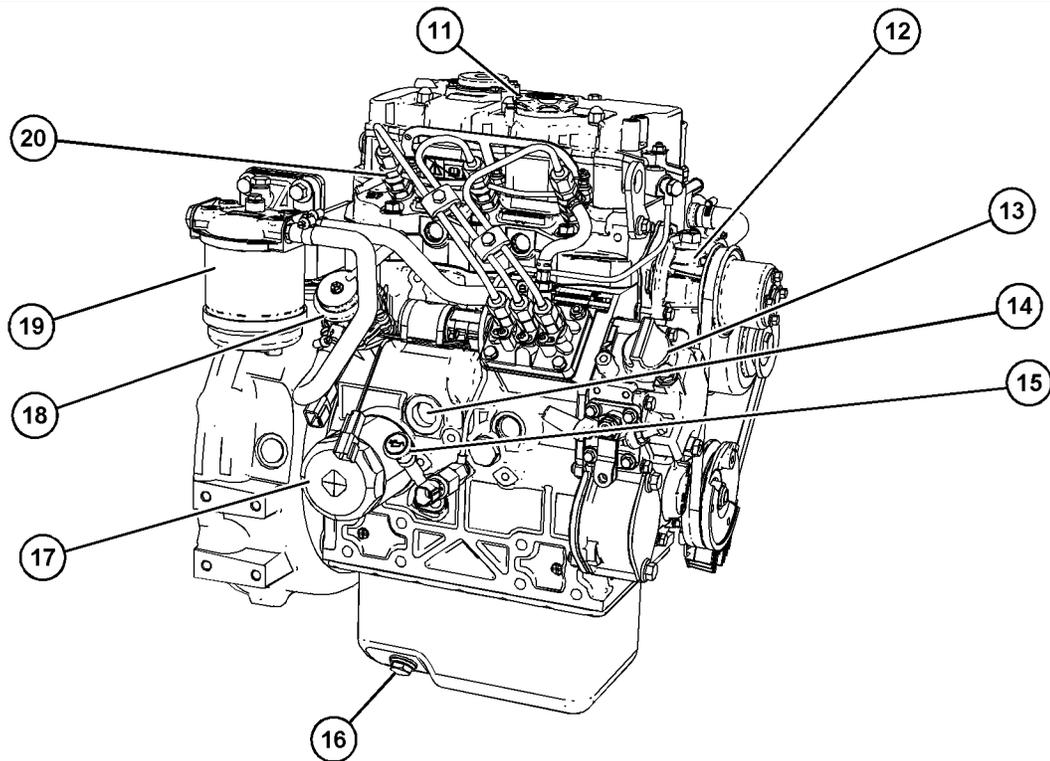


Illustration 16

g06697711

Typical example

- | | | |
|-------------------------|---------------------------|----------------------------|
| (11) Top oil filler | (15) Oil gauge (Dipstick) | (19) Secondary fuel filter |
| (12) Water pump | (16) Oil drain plug | (20) Fuel injector |
| (13) Oil filler (lower) | (17) Oil filter | |
| (14) Cooling drain plug | (18) Fuel transfer pump | |

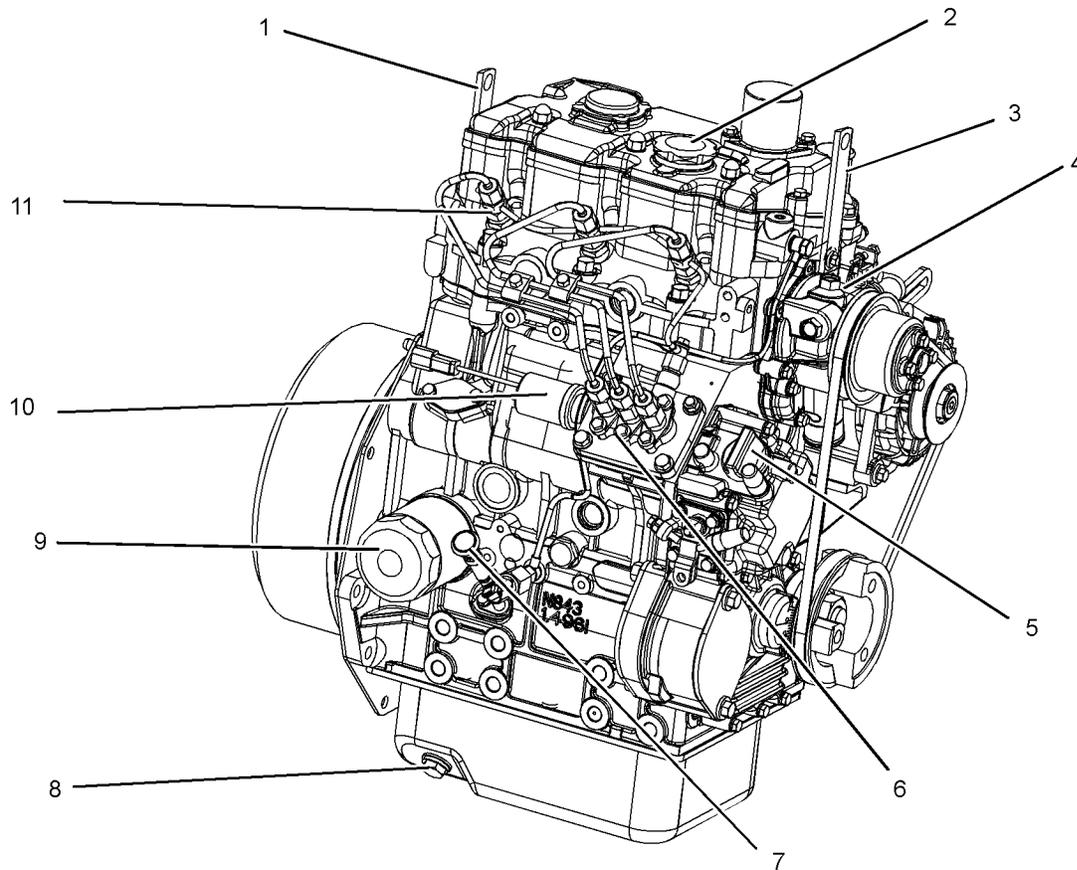
403EA-17 Engine

Illustration 17

g03378808

Typical example

- (1) Rear lifting eye
- (2) Top engine oil filler cap
- (3) Front lifting eye
- (4) Water pump

- (5) Low mounted oil filler cap
- (6) Fuel injection pump
- (7) Oil level gauge (Dipstick)
- (8) Oil drain plug

- (9) Oil filter
- (10) Governor actuator
- (11) Fuel injector

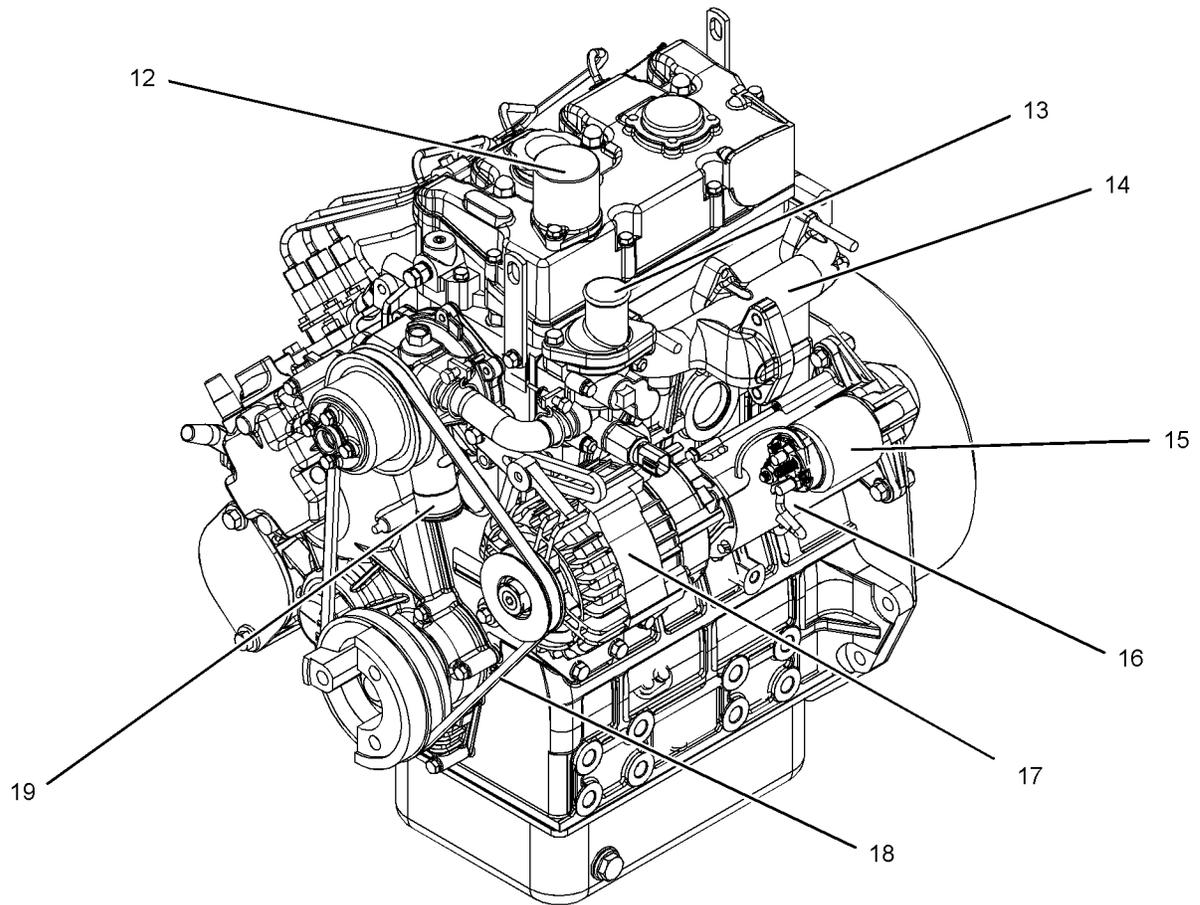


Illustration 18

g03379877

Typical example

(12) Air intake
(13) Coolant outlet
(14) Exhaust manifold

(15) Starting motor solenoid
(16) Electric starting motor
(17) Alternator

(18) Fan belt
(19) Coolant intake connection

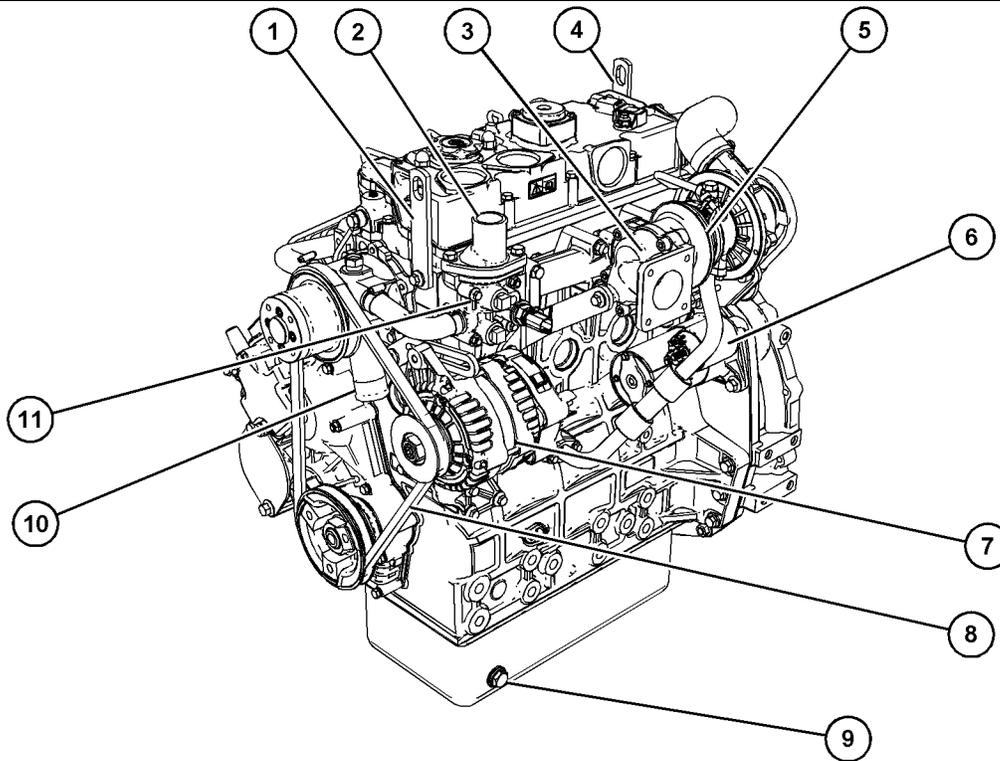
404EA-22T Turbocharged Engine

Illustration 19

g06697734

Typical example

- | | | |
|-----------------------|-----------------------------|--|
| (1) Front lifting eye | (5) Turbocharger | (9) Oil drain plug |
| (2) Coolant outlet | (6) Electric starting motor | (10) Coolant intake |
| (3) Exhaust elbow | (7) Alternator | (11) Water temperature regulator housing |
| (4) Rear lifting eye | (8) Drive belt | |

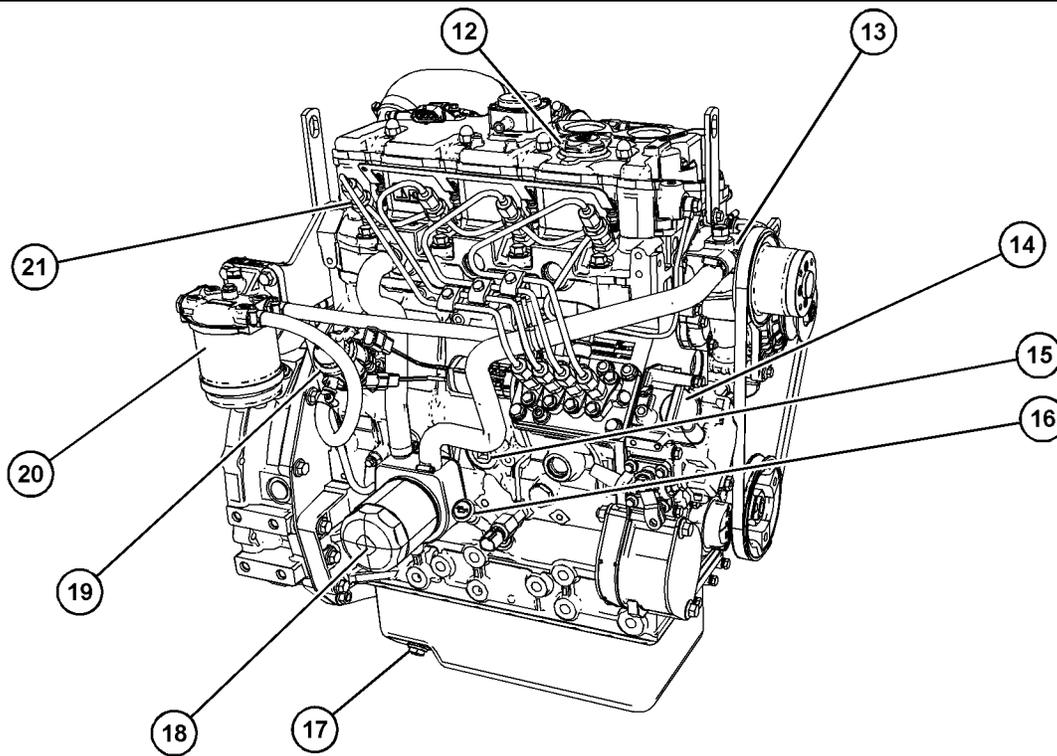


Illustration 20

g06697770

Typical example

- | | | |
|-------------------------|---------------------------|----------------------------|
| (12) Top oil filler | (16) Oil gauge (Dipstick) | (20) Secondary fuel filter |
| (13) Water pump | (17) Oil drain plug | (21) Fuel injector |
| (14) Oil filler (lower) | (18) Oil filter | |
| (15) Cooling drain plug | (19) Fuel transfer pump | |

Off Engine Components

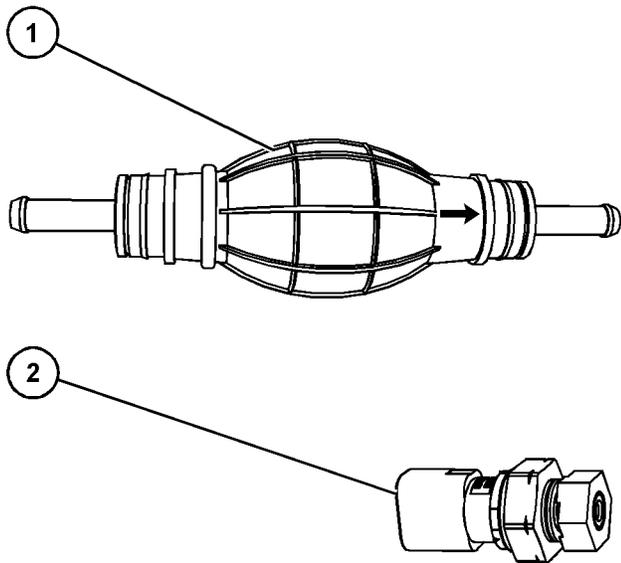


Illustration 21

g06747000

Typical example

- (1) Hand priming pump
- (2) Atmospheric pressure sensor

Fuel System Components

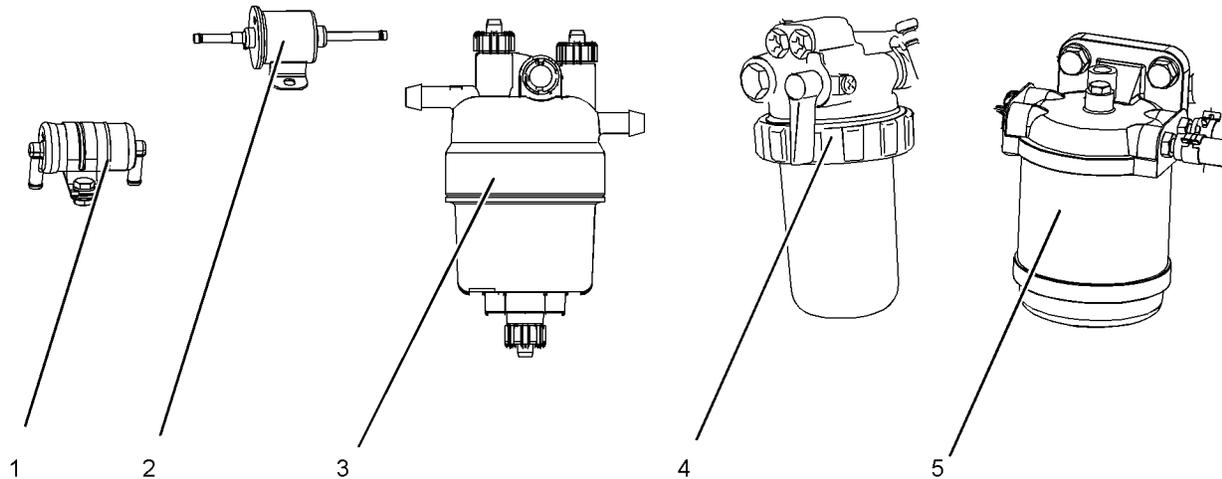


Illustration 22

g03379882

Typical example

(1) In-line fuel filter
(2) Electric fuel pump

(3) Primary fuel filter
(4) Secondary fuel filter (element type)

(5) Secondary fuel filter

Note: The electric fuel pump is an option, engines may have a mechanical fuel transfer pump installed.

i08625975

Product Description

The 403EA-11, 403EA-11T, 403EA-17, 404EA-22, and 404EA-22T engines are indirect injection engines. The engines 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 to conform to requirements for emissions.

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 on the rear main bearing.

The timing gears are stamped with timing marks 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 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. If any adjustments to the fuel injection pump timing and high idle are required, you must refer to your Perkins distributor. Some fuel injection pumps have mechanical governors that control the engine rpm. Some fuel injection pumps have a governor that is electrically controlled.

A gerotor oil pump is installed 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 proper operation and maintenance recommendations. Engine performance and efficiency also depend on the use of recommended fuels, lubrication oils, and coolants. Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule" for more information on maintenance items.

The 403EA-11T Turbocharged and 403EA-22T Turbocharged engines have a closed crankcase breather system installed. The crankcase breather gases are part of the engines measured emissions output. Any tampering with the closed crankcase breather system could invalidate the engines emissions compliance.

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.

403EA-11 Engine

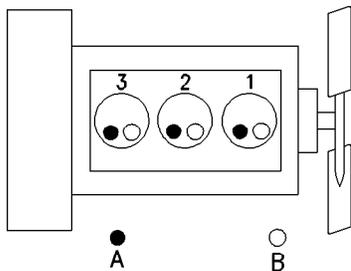


Illustration 23 g00852304

(A) Exhaust valves
(B) Inlet valves

Table 1

403EA-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)

(continued)

(Table 1, contd)

Displacement	1.131 L (69.0178 in ³)
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)
Injection	Indirect

(1) Naturally Aspirated

403EA-11T Engine

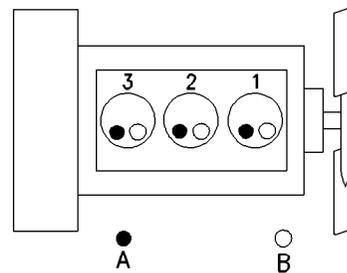


Illustration 24 g00852304

(A) Exhaust valves
(B) Inlet valves

Table 2

403EA-11T 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 (69.0178 in ³)
Aspiration	Turbocharged
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)
Injection	Indirect

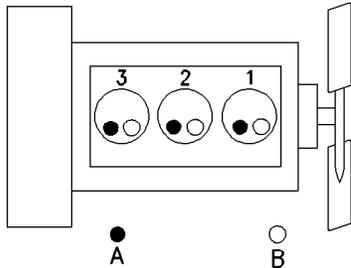
403EA-17 Engine

Illustration 25

g00852304

(A) Exhaust valves
(B) Inlet valves

Table 3

403EA-17 Engine Specifications	
Maximum Operating Speed (rpm)	2800 rpm
Cylinders and Arrangement	In-Line 3 cylinder
Bore	84 mm (3.31 inch)
Stroke	100 mm (3.94 inch)
Displacement	1.663 L (101.5 in ³)
Aspiration	Naturally Aspirated
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)
Injection	Indirect

Four Cylinder Engine 404EA-22

The 404EA-22 industrial engines have the following characteristics.

- In-line 4 cylinder
- 4 stroke cycle
- Two valves per cylinder

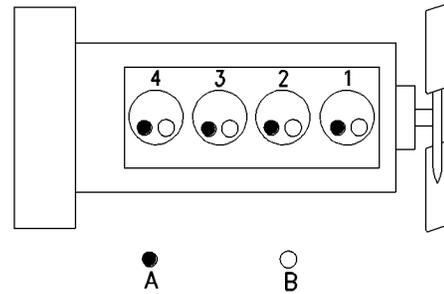


Illustration 26

g00296424

(A) Exhaust valves
(B) Inlet valves

Table 4

404EA-22 Industrial Engines	
Maximum Operating Speed (rpm)	2800 RPM
Cylinders and Arrangement	In-Line four cylinder engine
Bore	84 mm (3.307 inch)
Stroke	100 mm (3.937 inch)
Displacement	2.216 L (135.2 cubic inch)
Compression Ratio	23.3: 1
Aspiration	Naturally Aspirated
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Firing Order	1-3-4-2
Rotation (flywheel end)	Counterclockwise

Four Cylinder Engine 404EA-22T

The 404EA-22T industrial engines have the following characteristics.

- In-line 4 cylinder
- 4 stroke cycle
- Two valves per cylinder

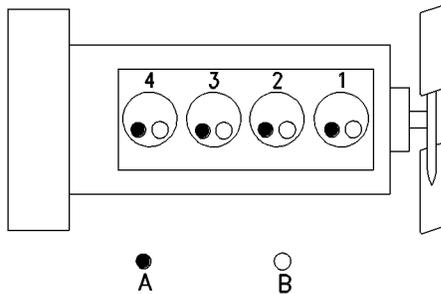


Illustration 27

g00296424

(A) Exhaust valves
(B) Inlet valves

Table 5

404EA-22T Industrial Engines	
Maximum Operating Speed (rpm)	2800 RPM
Cylinders and Arrangement	In-Line four cylinder engine
Bore	84 mm (3.307 inch)
Stroke	100 mm (3.937 inch)
Displacement	2.216 L (135.2 cubic inch)
Compression Ratio	23.3: 1
Aspiration	Turbocharged
Valve Lash Setting (Inlet)	0.20 mm (0.008 inch)
Valve Lash Setting (Exhaust)	0.20 mm (0.008 inch)
Firing Order	1-3-4-2
Rotation (flywheel end)	Counterclockwise

Service Life

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

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

Aftermarket Products and Perkins Engines

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

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

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

Product Identification Information

i08642155

Plate Locations and Film Locations

Serial Number Plate

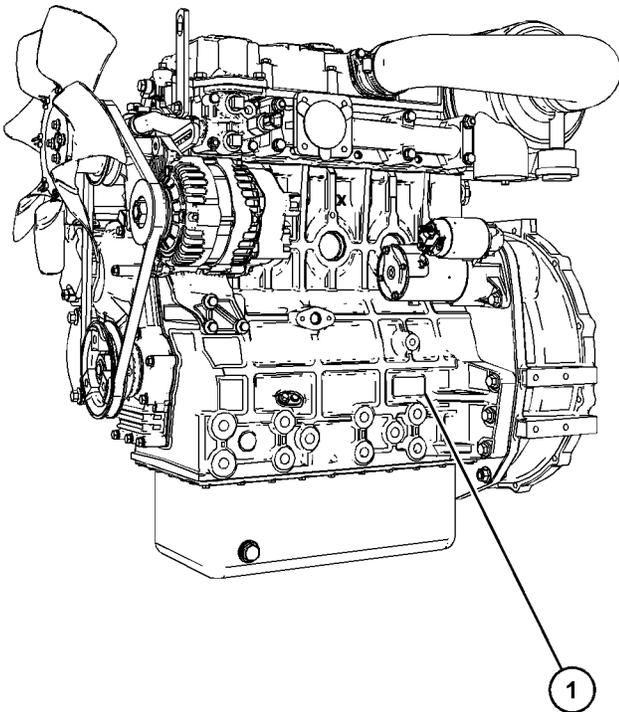


Illustration 28

g06672774

The engine serial plate (1) is on the left side of the engine to the rear of the engine cylinder block.

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

Perkins Plate

	
○ SERIAL NUMBER	○ LIST NUMBER ○
ASSEMBLED IN	(ALWAYS GIVE ALL NUMBERS)

Illustration 29

g06727366

Typical example

i00610276

Reference Numbers

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

Record for Reference

Engine Model _____

Engine Serial No. _____

Engine Arrangement No. _____

Modification No. _____

Engine Low Idle rpm _____

Engine Full Load rpm _____

Performance Specification No. _____

Primary Fuel Filter No. _____

Water Separator Element No. _____

Secondary Fuel Filter Element No. _____

Lubrication Oil Filter Element No. _____

Auxiliary Oil Filter Element No. _____

Supplemental Coolant Additive Maintenance Element No. (Optional) _____

Total Lubrication System Capacity _____

Total Cooling System Capacity _____

Air Cleaner Element No. _____

Fan Drive Belt No. _____

Alternator Belt No. _____

Operation Section

Lifting and Storage

i08462930

Product Lifting

NOTICE

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

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

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

To obtain the correct balance for lifting an application, adjust the chain lengths.

Lifting eyes are designed and installed for the specific engine arrangement. Alterations to the lifting eyes and/or the engine make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that proper lifting devices are provided.

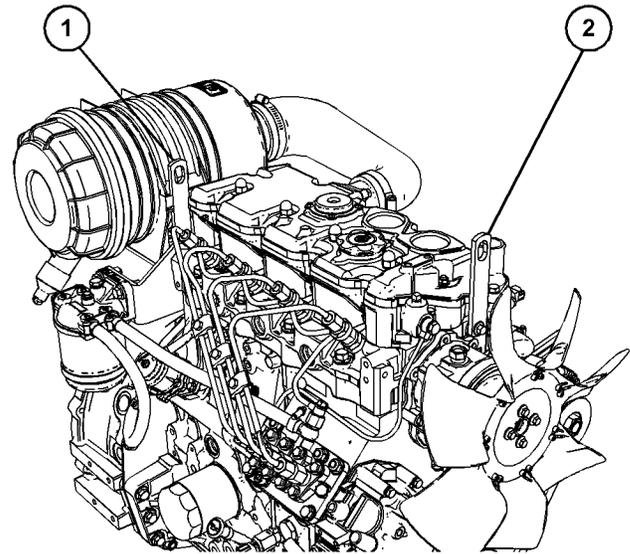


Illustration 30

g06672784

Typical example of lifting eyes for the engine

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

i04151489

Product Storage

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

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

Condition for Storage

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

Storage Period

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

Storage Procedure

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

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

1. Ensure that the engine is clean and dry.
 - a. If the engine has been operated using biodiesel, the system must be drained and new filters installed. The fuel tank will require flushing.
 - b. Fill the fuel system with an acceptable fuel. For more information on acceptable fuels refer to this Operation and Maintenance Manual, "Fluid recommendations". Operate the engine for 15 minutes in order to remove all biodiesel from the system.
2. Drain any water from the primary filter water separator. Ensure that the fuel tank is full.
3. The engine oil will not need to be drained in order to store the engine. Provided the correct specification of engine oil is used the engine can be stored for up to 6 months. For the correct specification of engine oil refer to this Operation and Maintenance Manual, "Fluid recommendations".
4. Remove the drive belt from the engine.

Sealed Coolant System

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

Open Cooling System

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

For maintenance procedures refer to this Operation and Maintenance Manual.

Monthly Checks

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

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

Gauges and Indicators

i08704158

Gauges and Indicators

Your engine may not have the same gauges or all 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.

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.

Some engine applications are equipped with Indicator Lamps. Indicator lamps can be used as a diagnostic aid. There are two lamps. One lamp has an orange lens and the other lamp has a red lens.

These indicator lamps can be used in two ways:

- The indicator lamps can be used to identify the current operational status of the engine. The indicator lamps can also indicate that the engine has a fault. This system is automatically operated via the ignition switch.
- The indicator lamps can be used to identify active diagnostic codes. This system is activated by pressing the Flash Code button.

Refer to the Troubleshooting Guide, "Indicator Lamps" for further information.

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 kPa to 413 kPa (30 psi to 60 psi) at rated rpm.

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

1. Remove the load.
2. Stop the engine.

3. Check and maintain the oil level.



Jacket Water Coolant Temperature – Typical temperature range is 82° to 96°C (147.6° to 172.8°F). The maximum allowable temperature with the pressurized cooling system at 90 kPa (13 psi) is 112° C (233.6° 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.

The coolant temperature is measured at the outlet for the water temperature regulator. The engine coolant temperature is monitored by the engine sensors.

If the engine is operating above the normal range, reduce the engine load. If high coolant temperatures are a frequent event, perform the following procedures:

1. Reduce the load on the engine.
2. Determine if the engine must be shut down immediately or if the engine can be cooled by reducing the load.
3. Inspect the cooling system for leaks. If necessary, consult your Perkins dealer or your Perkins distributor for assistance.



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. Operation at speeds exceeding high idle rpm should be kept to a minimum.



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



Engine - Electrical Preheat – This indicator comes "ON" to show that the glow plug preheat is active. The engine should only be set to "RUN" after indicator lamp on the display turns "OFF".



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 total operating hours of the engine.

Indicator Lamps

- Shutdown lamp
- Warning lamp
- Low oil pressure lamp
- Wait to start lamp (Glow plug warning lamp)

For information, refer to this manual, “Monitoring System (Table for the Indicator Lamps)” for the sequence of operation of the shutdown lamp and the warning lamp.

The function of the wait to start lamp is automatically controlled at engine start-up.

If low oil pressure is detected, the lamp will be illuminated. The reason for the illumination of the low-pressure lamp should be investigated immediately.

The glow plug warning lamp will flash to show that the engine is being held at low speed. This function will be performed at engine starting and the duration will depend on ambient temperature and engine temperature.

The lamps will illuminate for 2 seconds to check that the lamps are functioning when the keyswitch is turned to the ON position. If any of the lamps stay illuminated, or a lamp fails to be illuminated the reason should be investigated immediately.

Features and Controls

i08708034

Monitoring System (Engine Warning Indicators)

Table 6

Table for Warning Indicators					
Warning Indicator	Shutdown Indicator	Indicator State	Description of the Indication	Engine Status	Operator Action
ON	ON	Indicator Check	Keyswitch in the ON position all Indicators should illuminate for 0.5 of a second.	Power ON, Indicator check Engine is not operating.	If any of the Indicators will not illuminate during the Indicator check, the fault must be investigated immediately. If any Indicator stays illuminated or flash, the fault must be investigated immediately.
OFF	OFF	No Fault	-	Engine operating normally.	None

i08645089

Note: The engine wiring harness is not shown in the illustrations.

Sensors and Electrical Components

The illustrations within the section show the typical locations of the sensors and other electrical components on the Industrial engine. Specific engines may appear different due to the application.

The following sensors or switches can be installed on the industrial engines:

- Oil pressure switch
- Coolant temperature sensor/switch
- Atmospheric pressure sensor (Barometric pressure sensor)
- Speed sensor
- Governor actuator

Sensor Locations for the Engine

403EA-11 Engine

Note: In the following illustrations, some components have been removed to improve visibility.

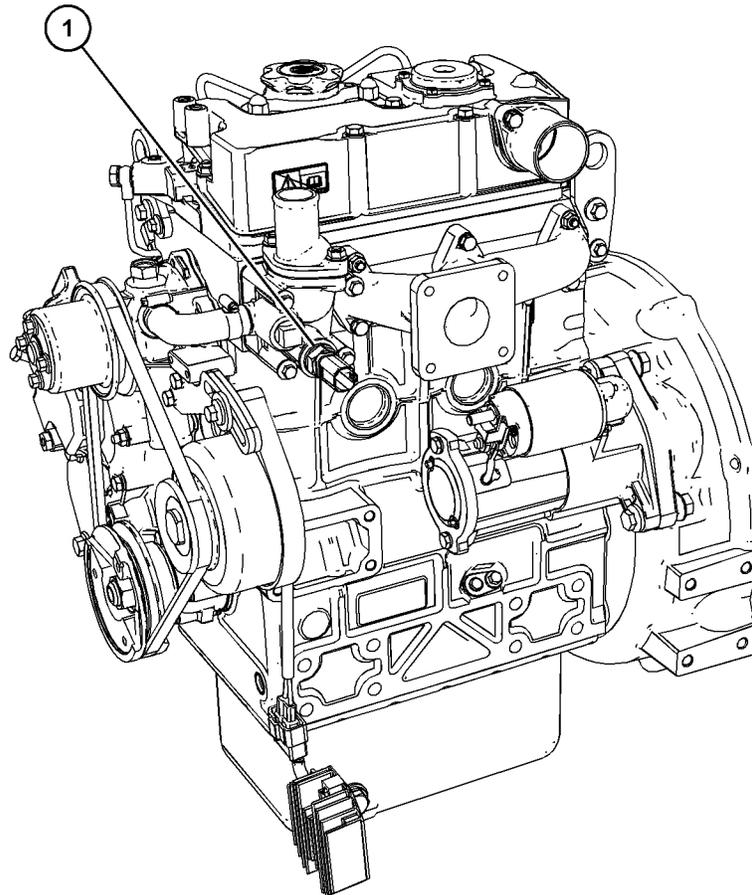


Illustration 31

g06697388

Typical example

(1) Coolant temperature sensor/switch

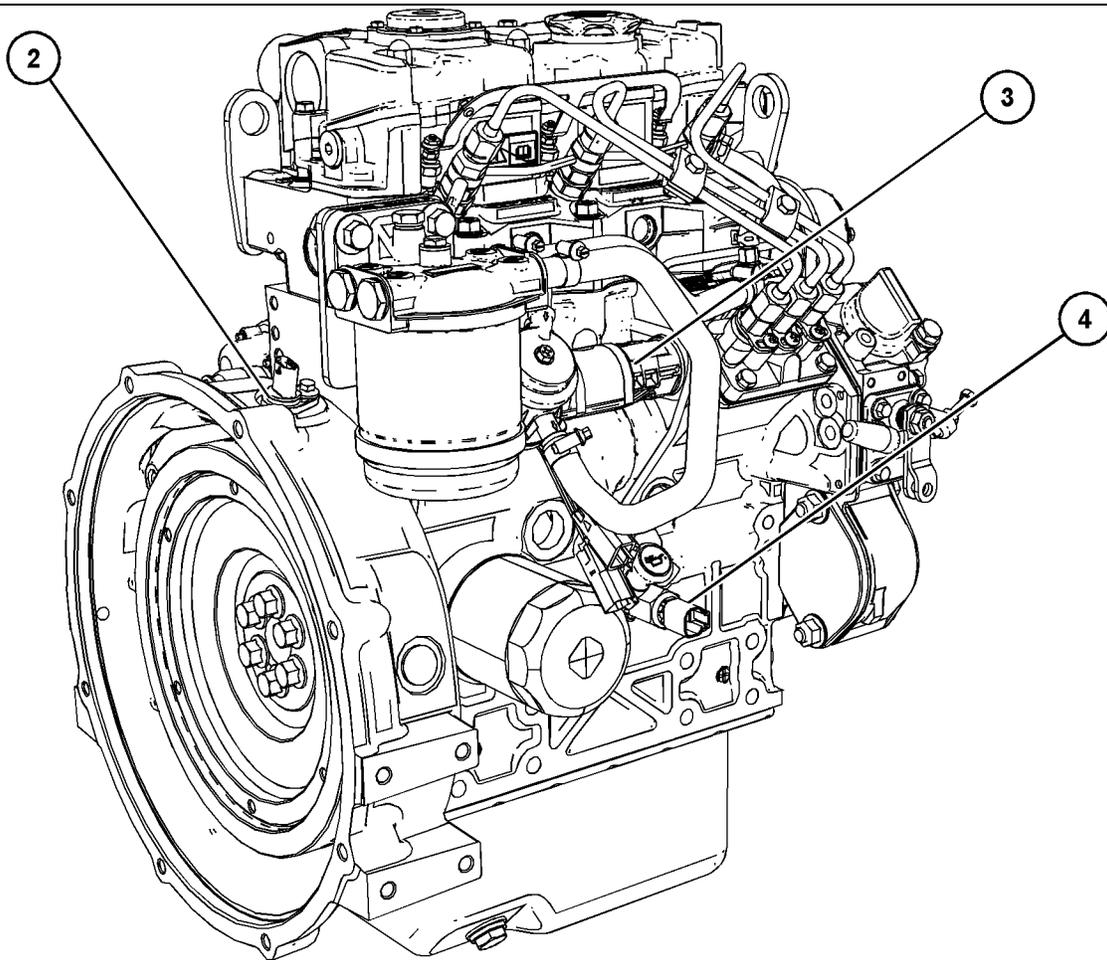


Illustration 32

g06747150

Typical example

(2) Speed sensor

(3) Governor actuator

(4) Oil pressure switch

403EA-11T Engine

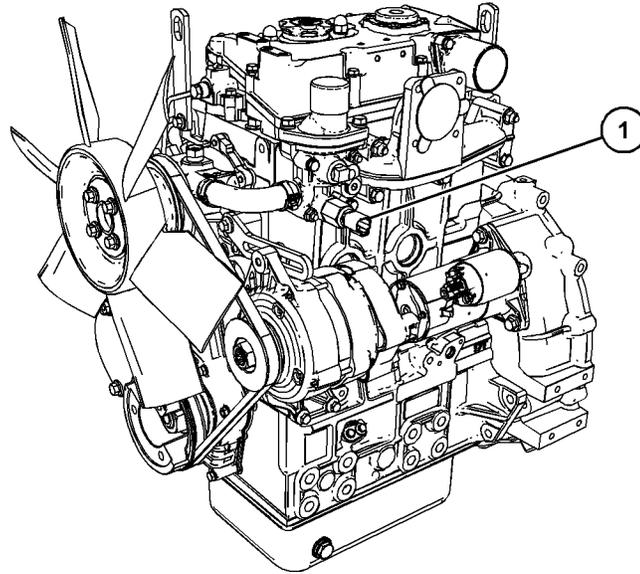


Illustration 33

g06697927

Typical example

(1) Coolant temperature sensor/switch

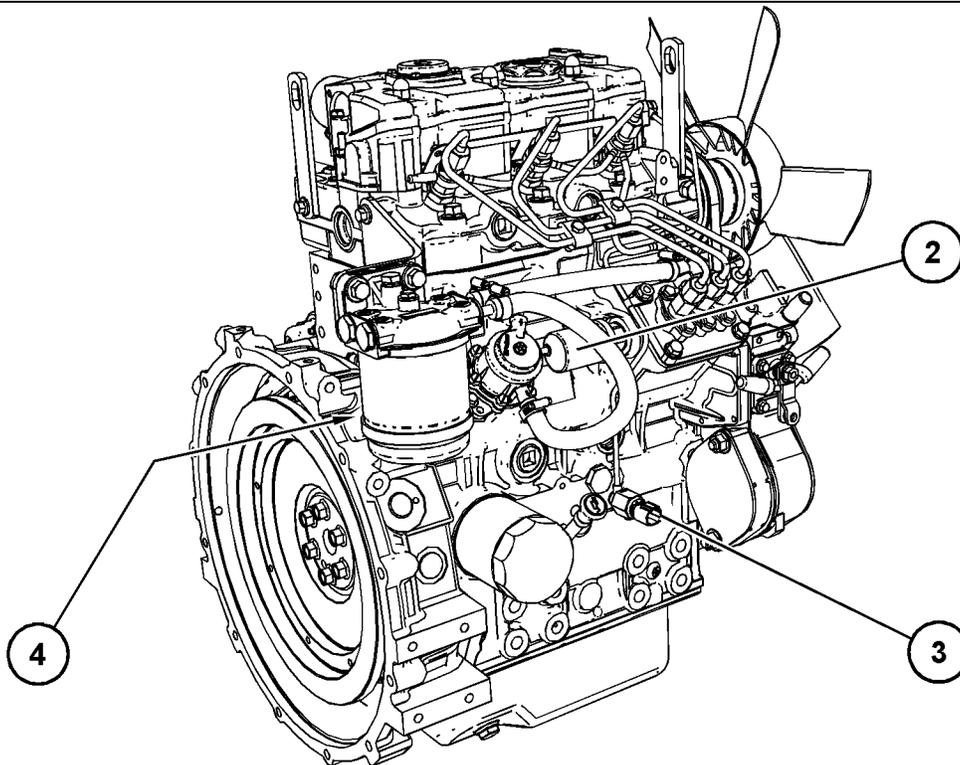


Illustration 34

g06747151

Typical example

(2) Governor actuator

(3) Oil pressure switch

(4) Speed sensor

404EA-22T Turbocharged Engine

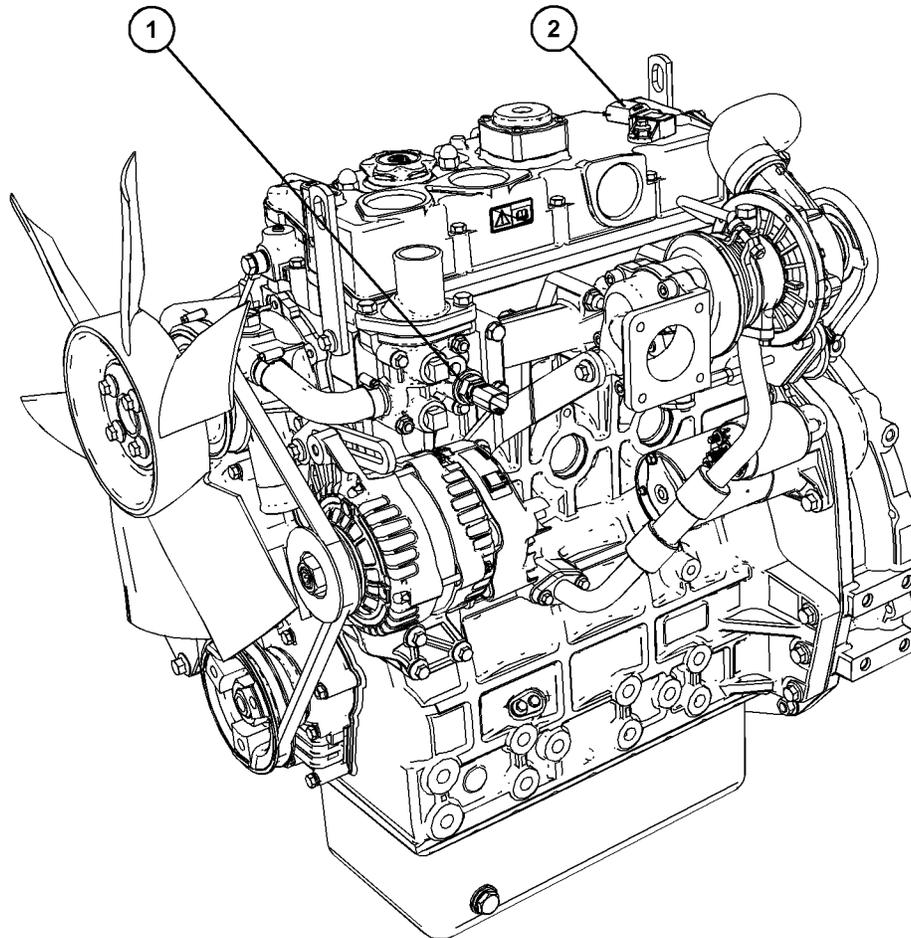


Illustration 35

g06697297

Typical example

(1) Coolant temperature sensor/switch

(2) Inlet manifold temperature and pressure
sensor (if equipped)

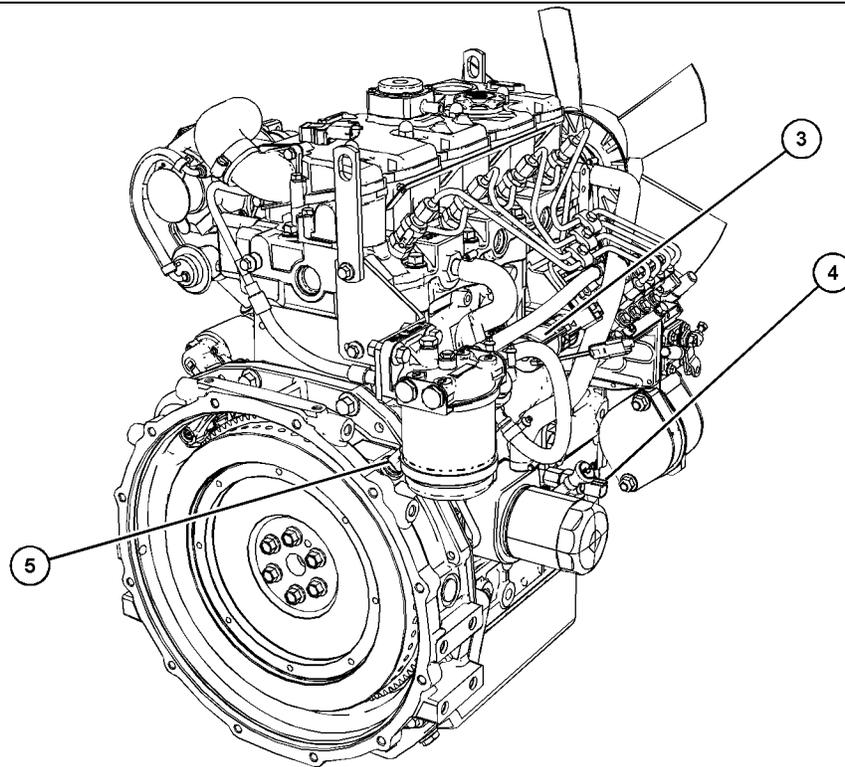


Illustration 36

g06747162

Typical example

(3) Governor actuator

(4) Oil pressure switch

(5) Speed sensor

Detailed views

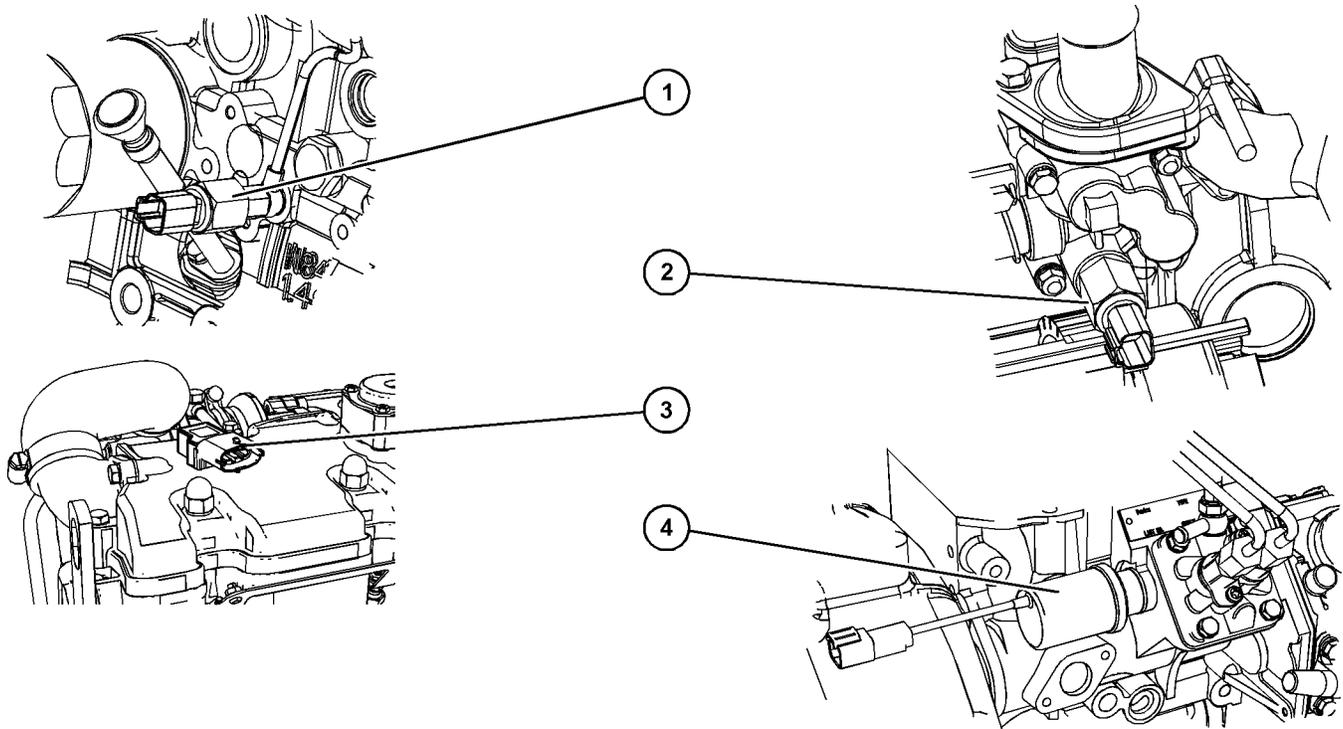


Illustration 37

g06731659

Typical examples

- | | |
|---------------------------------------|--|
| (1) Oil pressure sensor | (3) Inlet air temperature sensor (if equipped) |
| (2) Coolant temperature sensor/switch | (4) Governor actuator |

i02672017

Engine Shutoffs and Engine Alarms

Shutoffs

Shutoffs and alarms are electrically operated or mechanically operated. The operation of all electric shutoffs and alarms utilize components which actuate switches in a sensing unit.

Shutoffs are set at critical levels for the following items: operating temperature, operating pressure, operating level and operating rpm. The particular shutoff may need to be reset before the engine will start.

NOTICE

Always determine the cause of the engine shutdown. Make necessary repairs before attempting to restart the engine.

Be familiar with the following items:

- Types and locations of shutoff
- Conditions which cause each shutoff to function
- The resetting procedure that is required to restart the engine

Alarms

Alarms consist of a switch and a contactor. The switches are wired to the contactors. The contactors activate alarm circuits in an annunciator panel. Your engine may be equipped with the following switches:

Engine oil pressure – The engine oil pressure switch indicates when oil pressure drops below rated system pressure.

Coolant level – The low coolant level switch indicates when the coolant level is low.

Coolant temperature – The coolant temperature switch indicates high jacket water coolant temperature.

Note: The sensing element of the coolant temperature switch must be submerged in coolant in order to operate.

Engines may be equipped with alarms in order to alert the operator when undesirable operating conditions occur.

NOTICE

When an alarm is activated, corrective measures must be taken before the situation becomes an emergency in order to avoid possible engine damage.

If corrective measures are not taken within a reasonable time, engine damage could result. The alarm will continue until the condition is corrected. The alarm may need to be reset.

A switch may be installed in the alarm while the engine is stopped for repairs. Before the engine is started, ensure that the switch is moved to the ON position and that the warning lights are flashing. The engine will not be protected if the switch is left in the OFF position.

Testing the Shutoff and Alarm System

Most control panels are equipped with a lamp test switch. Turn the switch to the ON position in order to check the indicator lights for proper operation. Replace faulty bulbs immediately.

NOTICE

During testing, abnormal operating conditions must be simulated. Perform the tests correctly in order to help prevent possible engine damage.

Refer to the Service Manual for more information on testing procedures or consult your Perkins dealer.

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Fuel Shutoff

The fuel shutoff actuator is on the fuel injection pump. When the fuel shutoff actuator is activated, the actuator moves the fuel rack to the "OFF" position to stop the engine.

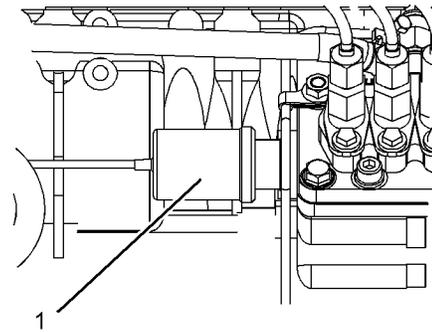


Illustration 38

g01305771

Typical example

(1) Fuel shutoff actuator

An electronically controlled governor actuator (if equipped) operates the fuel rack to reduce the fuel delivery. The reduced fuel delivery will alter the engine speed and also stop the engine.

i08657577

Overspeed

- 403EA-11 _____ 4000 Revolution Per Minute (RPM)
- 403EA-11T Turbocharged engine _____ 2850 Revolution Per Minute (RPM)
- 403EA-17 _____ 2600 Revolution Per Minute (RPM)
- 404EA-22 _____ 3600 Revolution Per Minute (RPM)
- 404EA-22T Turbocharged engine _____ 3000 Revolution Per Minute (RPM)

Engine Starting

i01486758

Before Starting Engine

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

- For the maximum service life of the engine, make a thorough inspection before the engine is started. Look for the following items: oil leaks, coolant leaks, loose bolts and trash buildup. Remove trash buildup and arrange for repairs, as needed.
- 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.

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 (if equipped) is engaged. Check electrical cables and check the battery for poor connections and for corrosion.
- Reset all of the shutoffs or alarm components.
- Check the engine lubrication oil level. Maintain the oil level between the "ADD" mark and the "FULL" mark on the oil level gauge.
- Check the coolant level. Observe the coolant level in the coolant recovery tank (if equipped). Maintain the coolant level to the "FULL" mark on the coolant recovery tank.
- If the engine is not equipped with a coolant recovery 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 driven equipment has been disengaged. Minimize electrical loads or remove any electrical loads.

i08704488

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 for controls on your application. Use the following procedure to start the engine.

1. Disengage any equipment that is driven by the engine.

Note: During key ON, the indicator lamps will be illuminated for 0.5 of a second to check the lamp operation. If any of the indicator lamps do not illuminate check the bulb.

2. Turn the keyswitch to the RUN position. Leave the keyswitch in the RUN position until the warning light for the glow plugs is extinguished.
3. When the wait to start lamp for the glow plugs has been extinguished turn the keyswitch to the START position. The starter motor will then crank the engine.

Note: The operating period of the wait to start lamp for the glow plugs will change due to the ambient air temperature.

NOTICE

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

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

4. Allow the keyswitch to return to the RUN position after the engine starts.
5. Repeat step 2 through step 4 if the engine fails to start.
6. Constant speed engines should be allowed to reach operating speed with no load. Operate engine for 2 minutes before applying load.

i08704496

Cold Weather Starting

 **WARNING**

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

The ability to start the engine will be improved at temperatures below -18°C (0°F) or at high altitude above 2000 m (6561 ft) from the use of a jacket water heater or extra battery capacity.

When Group 2 diesel fuel is used, the following items provide a means of minimizing starting problems and fuel problems in cold weather: Engine oil pan heaters, jacket water heaters, fuel heaters, and fuel line insulation.

Use the procedure that follows for cold weather starting.

1. Disengage any driven equipment.

Note: During key ON, the indicator lamps will be illuminated for 0.5 of a second to check the lamp operation. If any of the indicator lamps do not illuminate, check the bulb.

2. Turn the keyswitch to the RUN position. Leave the keyswitch in the RUN position until the wait to start lamp for the glow plugs is extinguished.
3. When the wait to start lamp for the glow plugs is extinguished, turn the keyswitch to the START position to engage the electric starting motor and crank the engine.

Note: The operating period of the warning light for the glow plugs will change due to the ambient air temperature.

NOTICE

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

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

4. Allow the keyswitch to return to the RUN position after the engine starts.
5. Repeat step 2 through step 4 if the engine fails to start.

Note: The engine should not be "raced" to speed up the warm-up process.

6. Allow the engine to idle for 3 to 5 minutes, or allow the engine to idle until the water temperature indicator begins to rise. When idling after the engine has started in cold weather, increase the engine rpm to 1400 rpm. This operation 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.
7. Operate the engine at low load until all systems reach operating temperature. Check the gauges during the warm-up period.
8. Constant speed engines could be allowed to reach operating speed with no load. Operate the engine for 2 minutes before applying load.

i08704508

Starting with Jump Start Cables

(Do Not Use This Procedure in Hazardous Locations that have Explosive Atmospheres)

WARNING

The connection of battery cables to a battery and the disconnection of battery cables from a battery may cause an explosion which may result in injury or death. The connection and the disconnection of other electrical equipment may also cause an explosion which may result in injury or death. The procedures for the connection and the disconnection of battery cables and other electrical equipment should only be performed in a nonexplosive atmosphere.

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 possible, first diagnose the reason for the starting failure. Refer to Troubleshooting, “Engine Will Not Crank and Engine Cranks But Will Not Start” for further information. 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 by using another battery with jump-start cables. The condition of the battery can be rechecked after the engine has been switched OFF.

NOTICE

Ensure that a 12 VDC battery source is used to start the engine. Never attempt to start an engine from an external power source such as electric welding equipment, which has a voltage that is unsuitable for engine starting and will damage the electrical system.

NOTICE

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

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

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

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

1. Turn the start switch on the stalled engine to the OFF position. Turn off all the engines accessories.
2. Connect one positive end of the jump-start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump-start cable to the positive cable terminal of the electrical source.
3. Connect one negative end of the jump-start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump-start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting the combustible gases that are produced by some batteries.
4. Start the engine in the normal operating procedure. Refer to this Operation and Maintenance Manual, “Starting the Engine”.
5. Immediately after the engine is started, disconnect the jump-start cables in reverse order.

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

After starting, the engine may be held at low speed for up to 30 seconds to allow engine systems to stabilize. The duration will depend on ambient temperature, time since last run and other factors.

Operation Section
After Starting Engine

After starting the engine and allowing the engine to stabilize, increase the engine speed to 1500 RPM for 10 seconds to ensure that the alternator begins to charge the battery.

Note: In ambient temperatures from 0° to 48°C (0° to 86.4°F), the warm-up time is approximately 3 minutes. In temperatures below 0°C (32°F), additional warm-up time may be required.

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

Do not check the fuel injection lines with the engine or the starting motor in operation. If you inspect the engine in operation, always use the proper inspection procedure to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General Hazard Information" for more information.

- Check for fluid and air leaks at idle rpm, and at one-half full rpm (no load on the engine) before operating the engine under load. This check may not be possible in some applications.
- Allow the engine to idle for 3 to 5 minutes, or allow the engine to idle until the water temperature indicator begins to rise. 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 whilst 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

General Engine Operation

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

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

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

NOTICE

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

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Engine Warm-up

1. Run the engine at low idle for three to five minutes, or run the engine at low idle until the jacket water temperature starts to rise.

More time may be necessary when the temperature is below -18°C (0°F).

2. Check all of the gauges during the warm-up period.
3. Perform another walk-around inspection. Check the engine for fluid leaks and air leaks.

4. Increase the rpm to the rated rpm. Check for fluid leaks and air leaks. The engine may be operated at full rated rpm and at full load when the jacket water temperature reaches 60°C (140°F).

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Engaging the Driven Equipment

1. Operate the engine at one-half of the rated rpm, when possible.
2. Engage the driven equipment without a load on the equipment, when possible.

Interrupted starts put excessive stress on the drive train. Interrupted starts also waste fuel. To get the driven equipment in motion, engage the clutch smoothly with no load on the equipment. This method should produce a start that is smooth and easy. The engine rpm should not increase and the clutch should not slip.

3. Ensure that the ranges of the gauges are normal when the engine is operating at one-half of the rated rpm. Ensure that all gauges operate properly.
4. Increase the engine rpm to the rated rpm. Always increase the engine rpm to the rated rpm before the load is applied.
5. Apply the load. Begin operating the engine at low load. Check the gauges and equipment for proper operation. After normal oil pressure is reached and the temperature gauge begins to move, the engine may be operated at full load. Check the gauges and equipment frequently when the engine is operated under load.

Extended operation at low idle or at reduced load may cause increased oil consumption and carbon buildup in the cylinders. This carbon buildup results in a loss of power and/or poor performance.

i07818141

Fuel Conservation Practices

The efficiency of the engine can affect the fuel economy. The design and technology in manufacturing provides maximum fuel efficiency in all applications. Always ensure that genuine filters are used. Follow the recommended procedures to attain optimum performance for the life of the engine.

Operation Section
Fuel Conservation Practices

- Avoid spilling fuel.

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

- Be aware of the properties of the different fuels. Use only the recommended fuels. Refer to the Operations and Maintenance Manual, "Fuel Recommendations" for further information.
- Avoid unnecessary idling.
- Shut off the engine rather than idle for long periods of time.
- Observe the service indicator frequently. Keep the air cleaner elements clean.
- Ensure that the turbocharger is operating correctly so that the proper air/fuel ratio is maintained. Clean exhaust indicates proper functioning.
- Maintain a good electrical system.

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

- Ensure that the belts are correctly adjusted. The belts should be in good condition. Refer to the Specifications manual for further information.
- Ensure that all 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 these items will help maintain operating temperatures.

Engine Stopping

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i06832774

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 depends 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 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

- After starting the engine, the engine speed will be governed for up to a maximum of 30 seconds. After this period, the engine should be operated at low loads until a minimum coolant operating temperature of 80° C (176° F) is achieved.

- Achieving operating temperature will help prevent the intake valves and exhaust valves from sticking.
- The cooling system and the lubrication system for the engine do not lose heat immediately upon shutdown. This means that an engine can be shut down for a period and the retained heat within the engine will allow the engine readily start.
- Install the correct specification of engine lubricant before the beginning of cold weather. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended viscosity of oil.
- Check all rubber parts (hoses, fan drive belts) weekly.
- Check all electrical wiring and connections for any fraying or damaged insulation.
- Keep all batteries fully charged and warm by ensuring that the engine is allowed correct operation at normal operating temperature.
- Fill the fuel tank at the end of each shift.
- Check the air cleaners and the air intake daily. Check the air intake more often when you operate in snow.
- Ensure that the glow plugs are in working order. Refer to Troubleshooting, "Glow Plug Starting Aid-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 lubrication properties and the wear protection that the oil provides for the engine. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for the recommended viscosity of oil.

At temperatures below -10°C (14°F) damage to engine components can occur if the engine is allowed to operate at high load and speed immediately after starting.

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 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:

- Starting ability is improved.
- Warm up time is reduced.

An electric block heater can be activated once the engine is stopped. A block heater can be 110 V DC or 240 V DC. The output can be 600/1000W. Consult your Perkins dealer or your Perkins distributor for more information.

Idling the Engine

After starting the engine, the engine speed will be governed for a maximum period of 30 seconds. When idling after the engine is started in cold weather, increase the engine rpm from 1000 rpm to 1200 rpm. This idling will warm up the engine more quickly. Maintaining an elevated low idle speed for extended periods will be easier with the installation of a hand throttle. The engine should not be "raced" to speed up the warm up process.

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

Recommendations for Coolant Warm Up

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

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

When starting and stopping an engine many times without being operated to warm up completely, the carbon deposits become thicker. This starting and stopping 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 these reasons, when the engine is started, the engine must be operated until the coolant temperature is 80°C (176°F) minimum. Carbon deposits on the valve stem will be kept at a minimum. The free operation of the valves and the valve components will be maintained.

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

The Water Temperature Regulator and Insulated Heater Lines

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

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

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

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

Recommendation for Crankcase Breather Protection

Crankcase ventilation gases contain a large quantity of water vapor. This water vapor can freeze in cold ambient conditions and can plug or damage the crankcase ventilation system. If the engine is operated in temperatures of -25°C (-13°F) or lower, measures must be taken to prevent freezing and plugging of the breather system. Insulated hoses and an insulated canister assembly should be installed. A heater unit must also be installed into the breather system. Both measures are required to protect the engine when working in temperatures of -25°C (-13°F) or lower.

i07926238

Radiator Restrictions

Perkins discourages the use of airflow restriction devices that are mounted in front of radiators. Airflow restriction can cause the following conditions:

- High exhaust temperatures
- Power loss
- Excessive fan usage
- Reduction in fuel economy

Reducing air flow over components will also affect under hood temperatures. Reducing air flow can increase surface temperatures and could affect component reliability.

If an airflow restriction device must be used, the device should have a permanent opening directly in line with the fan hub. The device must have a minimum opening dimension of at least 770 cm^2 (120 in^2).

A centered opening that is directly in line with the fan hub is specified to prevent an interrupted airflow on the fan blades. Interrupted airflow on the fan blades could cause a fan failure.

Perkins recommends a warning device for the inlet manifold temperature and/or the installation of an inlet air temperature gauge. The warning device for the inlet manifold temperature should be set at 75°C (167°F). The inlet manifold air temperature should not exceed 75°C (167°F). Temperatures that exceed this limit can cause power loss and potential engine damage.

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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".

Properties of the diesel fuel can have a significant effect on the engine cold start capability. It is critical that the low temperature properties of diesel fuel are acceptable 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 the diesel fuel begin to form crystals. The cloud point of the fuel must be below lowest ambient temperature to prevent filters from plugging.

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

Cold Filter Plugging Point (CFPP) is a temperature at which a particular fuel will pass through a standardized filtration device. This CFPP gives an estimate of the lower operability temperature of fuel

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, "Fuel For Cold-Weather Operation"

Another important fuel property which can affect cold start and operation of diesel engine is Cetane number. Detail and requirements of this property are given in 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, service intervals and refueling of the fuel tank. Draining will help prevent water and/or sediment from being pumped from the fuel storage tank and into the engine fuel tank.

Fuel Filters

After you change the fuel filter, 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 In-line filter, 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 so, the temperature of the fuel must not exceed 73 °C (163 °F) at the fuel transfer pump. The fuel heater should be installed before the electric lift pump.

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 more 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.

403EA-11 Engine

Table 7

403EA-11 Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	3.4 L (0.9 US gal)	4.4 L (1.2 US gal)
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 more 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.

403EA-17 Engine

Table 8

403EA-17 Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	4.8 L (1.27 US gal)	6.3 L (1.66 US gal)
Total Lubrication System ⁽²⁾		

(continued)

(Table 8, contd)

- (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 more 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.

404EA-22T Engine

Table 9

404EA-22T Turbocharged Engines Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	7.2 L (1.90 US gal)	8.5 L (2.25 US gal)
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 more 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 to determine the amount of coolant that is required for the Total Cooling System.

403EA-11 Engine

Table 10

403EA-11 Engine Refill Capacities		
Compartment or System	Liters	US gallons
Engine Only	1.9	0.5
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.

403EA-17 Engine

Table 11

403EA-17 Engine Refill Capacities		
Compartment or System	Liters	US gallons
Engine Only	3.7	0.98
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.

404EA-22 Engine

Table 12

404EA-22 Turbocharged Engine Refill Capacities		
Compartment or System	Liters	US gallons
Engine Only	4.5	1.19
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.

(Table 12, contd)

- (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.

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Fluid Recommendations

General Lubricant Information

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

- API _____ American Petroleum Institute
- SAE _____ Society Of Automotive Engineers Inc.
- ACEA _____ Association des Constructeurs European Automobiles.
- ECF-3 _____ Engine Crankcase Fluid

Licensing

The Engine Oil Licensing and Certification System by the American Petroleum Institute (API) and the Association des Constructeurs European Automobiles and (ACRA) 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.

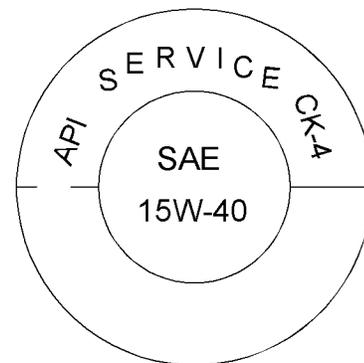


Illustration 39

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Typical API symbol

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.

(continued)

Refer to Perkins Diesel Engines Fluids Recommendations, M0113102 for additional information that relates to oil.

Engine Oil

Commercial Oils

Perkins recommends use of Perkins Diesel Engine Oil for all Perkins engines. Perkins unique oil formulations have been developed to provide full performance and maximum service life of your engine, and in tests have been shown to provide superior protection. Available in suitable API classifications to meet the emissions requirements and performance of your engine, Refer to 13 for the correct oil specification for your engine. Consult your Perkins distributor for more information on these multi-grade oils.

NOTICE

Perkins require the use of the following specification of engine oil. Failure to use the appropriate specification of engine oil will reduce the life of your engine. Failure to use the appropriate specification of engine oil will also reduce the life of your aftertreatment system.

Table 13

Oil Specification
API CK-4 ACEA E9 ECF-3

API CK-4 and ACEA E9 oil categories have the following chemical limits:

- 0.1 percent maximum sulfated ash
- 0.12 percent maximum phosphorous
- 0.4 percent maximum sulfur

The chemical limits were developed to maintain the expected life of the engine aftertreatment system. The performance of the engine aftertreatment system can be adversely affected if oil that is not specified in table 13 is used.

The life of your Aftertreatment system is defined by the accumulation of ash on the surface of the filter. Ash is the inert part of the particulate matter. The system is designed to collect this particulate matter. There is a small percentage of particulate matter that is left behind as the soot is burnt. This matter will eventually block the filter, causing loss of performance and increased fuel consumption. Most of the ash comes from the engine oil which is gradually consumed during normal operation. This ash is passes through the exhaust. To meet the designed life of the product, the use of the appropriate engine oil is essential. The oil specification that is listed in table 13 has low ash content.

Maintenance intervals for engines that use biodiesel – The oil change interval can be adversely affected by the use of biodiesel. Use oil analysis to monitor the condition of the engine oil. Use oil analysis also to determine the oil change interval that is optimum.

Note: API FA-4 oil is designed for use in selected on-highway applications and is NOT designed to support off-road applications, including Perkins Engines. DO NOT use API FA-4 oil for Perkins engines. These engine oils are not approved by Perkins and these engine oils must not be used: CC, CD, CD-2, CF-4, CG-4, CH-4, and CI-4.

Lubricant Viscosity Recommendations for Direct Injection (DI) Diesel Engines

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 illustration 40 (minimum temperature) to determine the required oil viscosity for starting a cold engine.

Refer to illustration 40 (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.

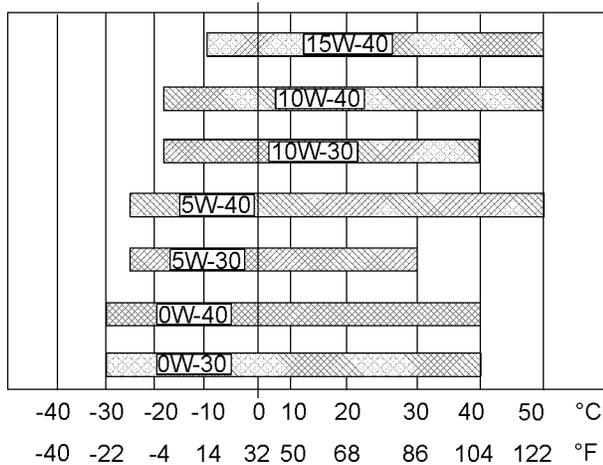


Illustration 40

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Lubricant Viscosities

Supplemental heat is recommended for cold soaked starts below the minimum ambient temperature. Supplemental heat may be required for cold soaked starts that are above the minimum temperature that is stated, depending on the parasitic load and other factors. Cold soaked starts occur when the engine has not been operated for a period of time. This interval will allow the oil to become more viscous due to cooler ambient temperatures.

Aftermarket Oil Additives

Perkins does not recommend the use of aftermarket additives in oil. Aftermarket additives are not necessary to achieve the engines 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 oils additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil. This failure 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:

- See the appropriate "Lubricant Viscosities". Refer to the illustration 40 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".

Oil analysis

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

The 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 oil analysis. The oil analysis includes the following tests:

- The Wear Rate Analysis monitors the wear of the engines 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 oils 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.

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Fluid Recommendations

General Coolant Information

NOTICE

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

NOTICE

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

NOTICE

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

Clean the cooling system for the following reasons:

- Contamination of the cooling system
- Overheating of the engine
- Foaming of the coolant

NOTICE

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

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

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

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

Refer to Perkins Diesel Engines Fluids Recommendations, M0113102 for additional information that relates to coolant.

Water

Water is used in the cooling system to transfer heat.

Note: The water must be used with an inhibitor to protect the engine.

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 14 .

Table 14

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

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

- Local water utility company
- Agricultural agent
- Independent laboratory

Additives

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

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

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

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

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

Glycol

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

- Boiling
- Freezing

- Cavitation of the water pump

For optimum performance, Perkins recommends a 50 percent by volume of glycol in the finished coolant (also referred to as 1:1 mixture).

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

Note: 100 percent pure glycol will freeze at a temperature of $-13\text{ }^{\circ}\text{C}$ ($8.6\text{ }^{\circ}\text{F}$).

Most conventional antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. Refer to Table 15 and refer to table 16 .

Table 15

Ethylene Glycol	
Concentration	Freeze Protection
50 Percent	$-36\text{ }^{\circ}\text{C}$ ($-33\text{ }^{\circ}\text{F}$)
60 Percent	$-51\text{ }^{\circ}\text{C}$ ($-60\text{ }^{\circ}\text{F}$)

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 16

Propylene Glycol	
Concentration	Freeze Protection
50 Percent	$-29\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$)

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

Note: Some commercially available coolants are based on alternative fluids, such as 1, 3-propanediol (beta-propylene glycol, PDO), glycerin (glycerol), or mixtures of these alternatives with ethylene/propylene glycols. At the time of publication of this document no industry standard exists for coolants based on these chemicals. Until such standard/specifications are published and evaluated by Perkins, use of PDO, glycerine, or other alternative coolants are not recommended in Perkins diesel engines.

Coolant Recommendations

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

ELC - extended life coolant. A coolant that relies on organic inhibitors for corrosion and cavitation protection. Also called OAT coolant (Organic Acid Technology).

SCA - supplemental coolant additive, concentrated inorganic inhibitor package.

Extender - concentrated organic inhibitor package.

Conventional Coolant - a coolant that relies on inorganic inhibitors for corrosion and cavitation protection.

Hybrid Coolant - a coolant in which the corrosion and cavitation protection is based on a mixture of organic and inorganic inhibitors.

The following coolants are recommended for used in Perkins diesel engines:

Preferred – Perkins ELC

Acceptable – A commercial heavy-duty antifreeze that meets “ASTM D6210” or “ASTM D4985” specifications.

NOTICE

The Perkins industrial engines with a NOx reduction system must be operated with a minimum 30% volume glycol-water mixture, Perkins recommends 50% volume glycol-water mixture of water and glycol. The 50% concentration allows the NOx reduction system to operate correctly at high ambient temperatures.

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.

NOTICE

A commercial heavy-duty antifreeze that meets “ASTM D4985” specification requires a treatment with an SCA at the initial fill. Read the label or the instructions that are provided by the manufacturer of the product.

NOTICE

A commercial heavy-duty antifreeze that meets either “ASTM D4985” or “ASTM D6210” specification requires the SCA concentration to be checked at 500-hour service intervals.

Perkins recommends a 50% mixture of water and glycol. This mixture of water and glycol will provide optimum heavy-duty performance as an antifreeze. This ratio may be changed to 40% water to 60% glycol if extra freezing protection is required.

A mixture of SCA inhibitor and water is acceptable but will not give as much corrosion, boiling and, freezing protection as ELC. Perkins recommends a 6 percent to 8 percent concentration of SCA in those cooling systems. Distilled water or deionized water is preferred.

Table 17

Coolant Service Life	
Coolant Type	Service Life ⁽¹⁾
Perkins ELC	6,000 Service Hours or Three Years
Commercial Heavy-Duty Antifreeze that meets "ASTM D6210"	3000 Service Hours or Two Year
Commercial SCA inhibitor and Water	3000 Service Hours or One Year

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

Perkins ELC

Perkins provides ELC for use in the following applications:

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

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

ELC is available in a premixed cooling solution with distilled water. ELC is a 50 percent by volume of glycol mixture. The Premixed ELC provides freeze protection to -36°C (-33°F). The Premixed ELC is recommended for the initial fill of the cooling system. The Premixed ELC is also recommended for topping off the cooling system.

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

ELC Cooling System Maintenance

Correct additions to the Extended Life Coolant

NOTICE

Use only Perkins products for pre-mixed coolants.

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

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

NOTICE

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

Do not use supplemental coolant additive (SCA).

ELC Cooling System Cleaning

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

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

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

Changing to Perkins ELC

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

Note: Use distilled or deionized water in the solution.

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

NOTICE

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

NOTICE

Most commercial cooling system cleaning agents are corrosive and their use is not recommended by Perkins.

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

ELC Cooling System Contamination**NOTICE**

Mixing ELC with other products reduces the effectiveness of the ELC and shortens the ELC service life. Failure to follow these recommendations can result in shortened cooling system component life.

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

- Drain the cooling system into a suitable container. Dispose of the coolant according to local regulations. Flush the system with a 5 to 10 percent solution of Perkins ELC. Fill the system with the Perkins ELC.
- Maintain the system as a conventional Heavy-Duty Coolant. Treat the system with an SCA. Change the coolant at the interval that is recommended for the conventional Heavy-Duty Coolant.

Commercial Heavy-Duty Antifreeze and SCA**NOTICE**

Commercial Heavy-Duty Coolant which contains Amines 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 glycol concentration to ensure adequate protection against boiling or freezing. Perkins recommends the use of a refractometer for checking the glycol concentration. A hydrometer should not be used.

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

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

NOTICE

Do not mix types and brands of coolant.

Do not mix brands and types of SCAs.

Do not mix SCAs and Extenders.

Only use SCAs or Extender approved by coolant manufacturer and compatible with coolant.

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

Coolants conforming to ASTM D4985 and not conforming D6210 require the addition of SCA at initial fill.

Use the equation that is in Table 18 to determine the amount of SCA that is required when the cooling system is initially filled.

Table 18

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 19 is an example for using the equation that is in Table 18 .

Table 19

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

Adding The SCA to The Heavy-Duty Coolant For Maintenance

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

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

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

Use the equation that is in Table 20 to determine the amount of SCA that is required, if necessary:

Table 20

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 21 is an example for using the equation that is in Table 20 .

Table 21

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 Antifreeze

Note: Before corrosion inhibitors can be effective the cooling system must be free from rust, scale and deposits.

- Drain the cooling system.
- Before filling the cooling system with acceptable quality water, pre-dissolve the cleaning agent in the water. Use a non-foaming detergent to clean oil contamination, consult your Perkins dealer for suitable product.

NOTICE

Most commercial cooling system cleaning agents are corrosive and their use is not recommended by Perkins.

The cooling system must be thoroughly flushed with clean water after using cleaning agents.

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

- Run the engine for approximately 30 minutes and then leave the engine to cool down.
- Take a sample of the solution from the cooling system, drain the system.
- Allow the sample to sit for at least 30 minutes and check for signs of oil and deposits. If oil and deposits are still present, repeat the procedure.
- Flush the system with clean water.
- Fill the system with new coolant.

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Fluid Recommendations (General Fuel Information)

- **Glossary**
- ISO _____International Standards Organization
- ASTM _____American Society for Testing and Materials
- HFRR _____High Frequency Reciprocating Rig for Lubricity testing of diesel fuels
- FAME _____Fatty Acid Methyl Esters

- CFR _____ Co-ordinating Fuel Research
- ULSD _____ Ultra Low Sulfur Diesel
- RME _____ Rape Methyl Ester
- SME _____ Soy Methyl Ester
- EPA _____ Environmental Protection Agency of the United States
- PPM _____ Parts Per Million
- DPF _____ Diesel Particulate Filter
- v/v _____ (volume of solute)/(volume of solution)
- CFPP _____ Cold Filter Plugging Point
- BTL _____ Biomass to liquid
- GTL _____ Gas to liquid
- CTL _____ Coal to liquid
- HVO _____ Hydrotreated Vegetable Oil

General Information

NOTICE

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

NOTICE

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

Refer to Perkins Diesel Engines Fluids Recommendations, M0113102 for additional information that relates to fuel.

Diesel Fuel Requirements

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

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

Satisfactory engine performance depends on the use of a good quality fuel. The use of a good quality fuel will give the following results: long engine life and acceptable exhaust emissions levels. The fuel must meet the minimum requirements that are stated in the table 22 .

NOTICE

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

Maintenance Section
General Fuel Information

Table 22

"Perkins Specification for Distillate Diesel Fuel"				
Property	UNITS	Requirements	"ASTM" Test	"ISO/Other" Test
Aromatics	%Volume	35% maximum	"D1319"	"ISO 3837"
Ash	%Weight	0.01% maximum	"D482"	"ISO 6245"
Carbon Residue on 10% Bottoms	%Weight	0.20% maximum	"D524"	"ISO 4262"
Cetane Number ⁽¹⁾	-	40 minimum in North America 45 minimum in European Union	"D613 or D6890"	"ISO 5165"
Cloud Point	°C	The cloud point must not exceed the lowest expected ambient temperature.	"D2500"	"ISO 3015"
Copper Strip Corrosion	-	No. 3 maximum	"D130"	"ISO 2160"
Distillation	°C	50% at 250° C (482° F) minimum 90% at 350° C (662° F) maximum	"D86"	"ISO 3405"
Density at 15 °C (59 °F) ⁽²⁾	kg/M ³	800 minimum and 860 maximum	No equivalent test	"ISO 3675""ISO 12185"
Flash Point	°C	legal limit	"D93"	"ISO 2719"
Thermal Stability	-	Minimum of 80% reflectance after aging for 180 minutes at 150 °C (302 °F)	"D6468"	No equivalent test
Pour Point	°C	6 °C (42.8 °F) minimum below ambient temperature	"D97"	"ISO 3016"
Sulfur ⁽³⁾	%mass	0.0010 % Stage V Europe and 0.0015 % Tier 4 Final North America	"D5453"	"ISO 20846"
Kinematic Viscosity ⁽⁴⁾	MM ² /S (cSt)	The viscosity of the fuel that is delivered to the fuel injection pump. 1.4 minimum and 4.5 maximum	"D445"	"ISO 3405"
Water and sediment	% weight	0.05% maximum	"D1796"	"ISO 3734"
Water	% weight	0.02% maximum	"D1744"	No equivalent test
Sediment	% weight	0.05% maximum	"D473"	"ISO 3735"
Gums and Resins ⁽⁵⁾	mg/100mL	10 mg per 100 mL maximum	"D381"	"ISO 6246"
Lubricity corrected wear scar diameter at 60 °C (140 °F). ⁽⁶⁾	mm	0.52 maximum	"D6079"	"ISO 12156-1"
Fuel Cleanliness ⁽⁷⁾	-	"ISO 18/16/13"	"D7619"	"ISO 4406"
Trace Metals ⁽⁸⁾	mg/mg	Max 1 or non-detectable	"D7111"	
Oxidation Stability	g/m ³	Max 25	"D2274"	"ISO 12205"
	Hours ⁽⁹⁾	Min 20		"EN 15751"

(continued)

(Table 22, contd)

- (1) To insure minimum cetane number of 40 a distillate diesel fuel should have minimum cetane index of 44 when "ASTM D4737" test method is used. A fuel with a higher cetane number is recommended to operate at a higher altitude or in cold weather
- (2) Density range allowed includes summer and winter diesel fuel grades.
- (3) Follow the national, state, local, and other governing authorities for guidance concerning the fuel requirements in your area. In Europe for non-road Stage V emissions regulations require sulfur free diesel fuels with sulphur content less than 0.0010 percent (10 PPM) (mg/kg)). In the USA, EPA regulations require use of ULSD fuel with less than 0.0015 percent (15 PPM) (mg/kg)) sulfur content. Use of diesel fuel with higher than 15 PPM sulphur limit in these engines will harm or permanently damage emissions control systems and/or shorten their service interval.
- (4) The values of the fuel viscosity are the values as the fuel is delivered to the fuel injection pumps. Fuel should also meet the minimum viscosity requirement and the fuel should meet the maximum viscosity requirements at 40 °C (104 °F) of either the "ASTM D445" test method or the "ISO 3104" test method. If a fuel with a low viscosity is used, cooling of the fuel may be required to maintain "1.4 cSt" or greater viscosity at the fuel injection pump. Fuels with a high viscosity might require fuel heaters to lower the viscosity to "1.4 cSt" at the fuel injection pump.
- (5) Follow the test conditions and procedures for gasoline (motor).
- (6) The lubricity of a fuel is a concern with low sulfur and ultra low sulfur fuel. To determine the lubricity of the fuel, use the "ISO 12156-1 or 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.
- (7) Recommended cleanliness level for fuel as dispensed into machine or engine fuel tank is "ISO 18/16/13" or cleaner as per "ISO 4406". Refer to the "Contamination Control Recommendations for Fuels".
- (8) Examples of trace metals include but not limited to Cu, Fe, Mn, Na, P, Pb, Si, and Zn. Use of metal-based additives is not allowed.
- (9) Additional limit for fuel containing FAME. Fuel containing more than 2% v/v FAME must meet both tests.

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

NOTICE

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

Engines that are manufactured by Perkins are certified with the fuel that is prescribed by the United States Environmental Protection Agency. Engines that are manufactured by Perkins are certified with the fuel that is prescribed by the European Certification. Perkins does not certify diesel engines on any other fuel.

NOTICE

The Perkins diesel engines must be operated using Ultra Low Sulfur Diesel. The sulphur content of this fuel must be lower than 15 PPM. This fuel complies with the emissions regulations that are prescribed by the Environmental Protection Agency of the United States. In Europe, sulfur free diesel fuels with sulphur content less than 0.0010 percent (10 PPM) (mg/kg)) is required by regulation for use in engines certified to EU nonroad Stage V emissions.

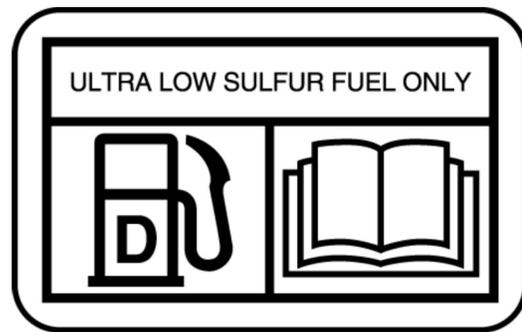


Illustration 41

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Illustration 41 is a representation of the label that will be installed next to the fuel filler cap on the fuel tank of the application.

The fuel specifications that are listed in the table 23 are released as acceptable to use on Perkins diesel engines.

Table 23

Acceptable Fuel Specification for the diesel engines ⁽¹⁾	
Fuel Specification	Comments
EN590	European Automotive Diesel Fuel (DERV)

(continued)

(Table 23, contd)

"ASTM D975 GRADE 1D S15"	"North American Light Distillate Diesel fuel with less than 15 PPM sulfur level"
"ASTM D975 GRADE 2D S15"	"North American Middle Distillate general-purpose Diesel fuel with less than 15 PPM sulfur level"
"JIS K2204"	"Japanese Diesel Fuel" Must meet the requirements that are stated in the section "Lubricity".
"BS 2869: 2010 CLASS A2 or EU equivalent"	"EU Off-Road Diesel fuel. Acceptable from 2011 MUST have less than 10 PPM sulfur level"

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

Diesel Fuel Characteristics

Cetane Number

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

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

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

Viscosity

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

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

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

Density

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

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

Sulfur

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

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

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

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

NOTICE

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

Lubricity

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

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

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

NOTICE

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

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

Distillation

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

Recommendation for Biodiesel and Using B20

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

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

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

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

Note: The percentages given are volume-based.

The U.S. distillate diesel fuel specification "ASTM D975-09a" includes up to B5 (5 percent) biodiesel.

European distillate diesel fuel specification EN590: 2010 includes up to B7 (7 percent) biodiesel.

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

Specification Requirements

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

In Europe diesel blends up to B20 must meet the requirements listed in the latest edition of "EN16709" B20 specification.

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

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

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

Engine Service Requirements

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

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

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

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

Performance-Related Issues

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

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

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

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

General Requirements

Biodiesel has poor oxidation stability, which can result in long-term problems in the storage of biodiesel. Biodiesel fuel should be used within 6 months of manufacture. Equipment should not be stored with the B20 biodiesel blends in the fuel system for longer than 3 months.

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

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

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

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

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

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

Renewable and Alternative Fuels

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

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

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

These paraffinic fuels have virtually no sulphur or aromatics and have very high cetane numbers which enable very clean burning and efficient engine operation. Chemically these fuels are similar to diesel fuel derived from petroleum and are therefore suitable to use in diesel engines as a replacement or blend stock with conventional diesel fuel. To be acceptable renewable and alternative fuels must meet latest edition of the paraffinic diesel fuel specification "CENTS 15940". The fuel should also meet requirements described in table 22, Perkins Specification for Distillate Diesel Fuel, EN590, or latest ASTM D975 specification.

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

Fuel for Cold-Weather Operation

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

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

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

Aftermarket Fuel Additives

NOTICE

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

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

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

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

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

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

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

Note: For the best results, your fuel supplier should treat the fuel when additives are required. The treated fuel must meet the requirements that are stated in table 22.

Perkins Diesel Fuel System Cleaner

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

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

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

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

Detailed instructions on the rate of which the fuel cleaner must be used are on the container.

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

Contamination Control Recommendations for Fuels

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

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

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

- Use high-quality fuels per recommended and required specifications
- Fill fuel tanks with fuels of “ISO 18/16/13” cleanliness level or cleaner, in particular for engines with common rail and unit injection systems. When you refuel the tank, filter the fuel through a 4 µm absolute filter (Beta 4 = 75 up to 200) to reach the recommended cleanliness level. This filtration should be installed at the device that dispenses the fuel to the fuel tank. In addition, filtration at the dispensing point should remove water to ensure that fuel is dispensed at 500 ppm water or less.
- Perkins recommends the use of bulk fuel filter / coalescer units which clean the fuel of both particulate contamination and water in a single pass.
- Ensure that you use Perkins Advanced Efficiency Fuel Filters. Change your fuel filters per recommended service requirements or as needed.
- Drain your water separators daily.
- Drain your fuel tanks of sediment and water per the Operation and Maintenance Manual instructions.
- Install and maintain a properly designed bulk filter / coalescer filtration system. Continuous bulk filtration systems may be required to ensure that dispensed fuel meets the cleanliness target. Consult your Perkins distributor for availability of bulk filtration products.
- Centrifugal filters may need to be used as a pre-filter with fuel that is severely contaminated with gross amounts of water and/or large particulate contaminants. Centrifugal filters can effectively remove large contaminants. Centrifugal filters may not be able to remove the small abrasive particles required to achieve the recommended “ISO” cleanliness level. Bulk filter / coalescers are necessary as a final filter to achieve the recommended cleanliness level.
- Install desiccant type breathers of 4 µm or less absolute efficiency with the ability to remove water on bulk storage tanks.
- Follow proper practices of fuel transportation. Filtration from the storage tank to the application promotes the delivery of clean fuel. Fuel filtration can be installed at each transport stage to keep the fuel clean.
- Cover, protect, and ensure cleanliness of all connection hoses, fittings, and dispensing nozzles.

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

Maintenance Recommendations

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System Pressure Release

Coolant System

WARNING

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

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

Fuel System

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

High-Pressure Fuel Lines (If Equipped)

WARNING

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

The high-pressure fuel lines are between the high-pressure fuel pump and the high-pressure fuel manifold. The high-pressure fuel lines are also between the fuel manifold and cylinder head. These fuel lines are different from fuel lines on other fuel systems.

The following are the differences:

- The high-pressure fuel lines are constantly charged with high pressure.
- The internal pressures of the high-pressure fuel lines are higher than other types of fuel system.

Before any service or repair is performed on the engine fuel lines, perform the following tasks:

1. Stop the engine.
2. Wait for 10 minutes.

Do not loosen the high-pressure fuel lines to remove air pressure from the fuel system.

Engine Oil

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

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Severe Service Application

Severe service is the application of an engine that exceeds the current published standards for that engine range. Or results in the engine being used at the extremes of certain operating conditions.

- 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 distributor to determine if the engine is operating within the defined parameters.

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

Due to individual applications, it is not possible to identify all the factors which can contribute to severe service operation. Consult your Perkins 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 exposed to extended operation in an environment that is dirty or dusty, unless the equipment is cleaned regularly. Mud, dirt, and dust can encase components. Maintenance can be very difficult. The buildup can contain corrosive chemicals.

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

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

Incorrect Operating Procedures

- Extended operation at low idle
- Frequent hot shutdowns
- Frequent stop/starts exceeding 10 engine starts in a 1-hour period
- Operating at excessive loads
- Operating at excessive speeds
- Operating outside the intended application
- Operating with fuel which does not meet the standards for distillate diesel fuel as stated in Perkins Diesel Engines Fluids Recommendations, M0113102
- Operating with a blend of distillate fuel which contains more than 20 percent biodiesel

Incorrect Maintenance Procedures

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

i08675040

Maintenance Interval Schedule

When Required

“ Battery - Recycle” 77
 “ Battery - Replace” 77
 “ Battery or Battery Cable - Disconnect” 78
 “ Engine Air Cleaner Element - Replace” 89
 “ Fuel System - Prime” 98

Daily

“ Cooling System Coolant Level - Check” 86
 “ Driven Equipment - Check” 89
 “ Engine Air Cleaner Service Indicator - Inspect” 90
 “ Engine Air Precleaner - Check/Clean” 91
 “ Engine Oil Level - Check” 92
 “ Fuel System Primary Filter/Water Separator - Drain” 101
 “ Walk-Around Inspection” 104

Every 50 Service Hours or Weekly

“ Fuel Tank Water and Sediment - Drain” 102

Every 250 Service Hours or 6 Months

“ Alternator and Fan Belts - Inspect/Adjust” 74
 “ Engine Oil Sample - Obtain” 93

Every 250 Service Hours or 1 Year

“ Cooling System Supplemental Coolant Additive (SCA) - Test/Add” 88

Every 500 Service Hours

“ Fan Clearance - Check” 97

Every 500 Service Hours or 1 Year

“ Battery Electrolyte Level - Check” 77
 “ Engine Air Cleaner Element - Replace” 89
 “ Engine Oil and Filter - Change” 94

“ Engine Protective Devices - Check” 96
 “ Fuel System Filter - Replace” 100
 “ Hoses and Clamps - Inspect/Replace” 102
 “ Radiator - Clean” 103

Every 1000 Service Hours

“ Alternator and Fan Belts - Replace” 76
 “ Engine Valve Lash - Check” 96
 “ Turbocharger - Inspect” 104

Every 1500 Service Hours

“ Engine Crankcase Breather - Replace” 91

Every 2000 Service Hours

“ Alternator - Inspect” 74
 “ Engine Mounts - Inspect” 92
 “ Starting Motor - Inspect” 104

Every 3000 Service Hours

“ Fuel Injector - Test/Change” 97

Every 3000 Service Hours or 2 Years

“ Coolant (Commercial Heavy-Duty) - Change” 82
 “ Coolant Temperature Regulator - Replace” 82

Every 6000 Service Hours

“ Coolant (ELC) - Change” 78

Commissioning

“ Fan Clearance - Check” 97

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.

i08671096

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

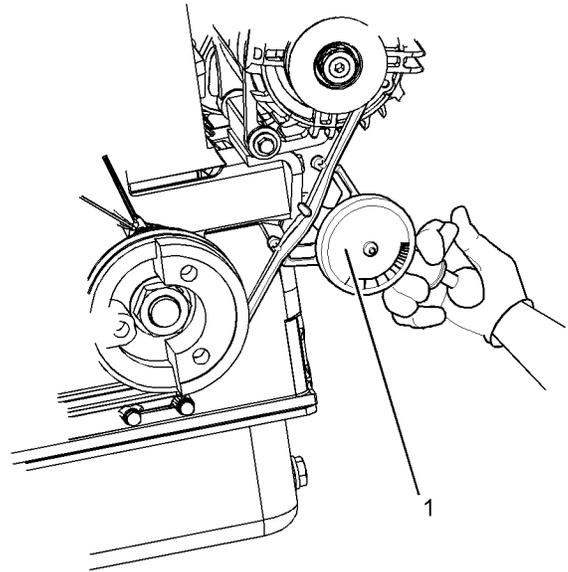


Illustration 42

g03383147

Typical example

(1) Borroughs 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 on a specific engine is detailed in table 24 . The correct tension for a used belt on a specific engine that has been in operation for 30 minutes or more at the rated speed is detailed in table 24 .

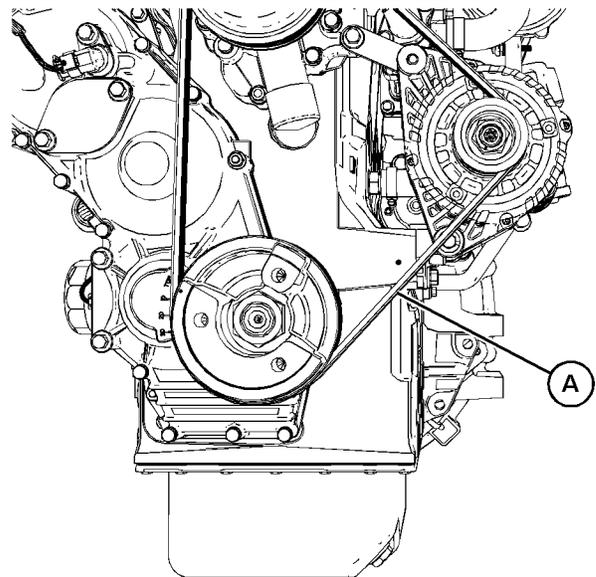


Illustration 43

g06582287

Typical example

For inspections that are done with a suitable belt frequency meter, install the belt frequency meter on the span of the belt at Position "A". Refer to table 24 for the correct frequency for a new belt or used belt on a specific engine. Table 24 also gives the approximate span of belt between crankshaft pulley and alternator pulley.

Table 24

Alternator Belt Tension and Frequency					
Engine Model	Approximate Span (mm)	New belt		Used Belt	
		Frequency (Hz)	Tension (Nm) and (lb)	Frequency (Hz)	Tension (Nm) and (lb)
403EA-11 Naturally Aspirated	167 mm - 205 mm	190-200 Hz	400 N (90 lb)	160-170 Hz	300 N (67 lb)
403EA-11 Turbocharged	167 mm - 205 mm	222-229 Hz	425 to 456 N (95.5 to 102.5 lb)	205-214 Hz	364 to 395 N (82 to 89 lb)
403EA-17	215 mm - 225 mm	150-170 Hz	400 to 489 N (90 to 110 lb)	130-145 Hz	267 to 356 N (60 to 80 lb)
404EA-22	236 mm - 247 mm	130-150 Hz	400 to 489 N (90 to 110 lb)	110-130 Hz	267 to 356 N (60 to 80 lb)

Adjustment

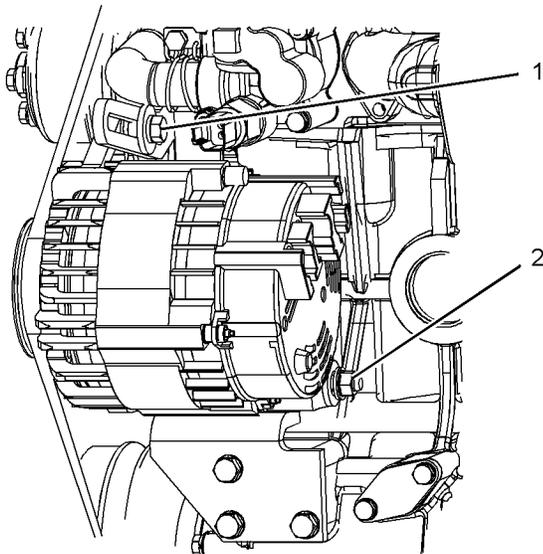


Illustration 44
 Typical example

g03383151

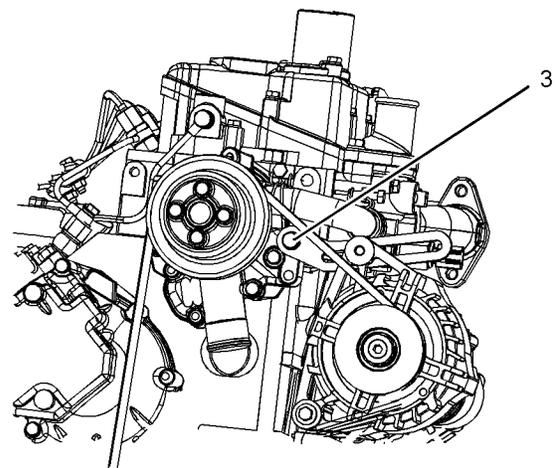


Illustration 45
 Typical example

g03383155

1. Loosen adjusting bolt (1) and mounting bolt and nut (2). Loosen bolt (3).
2. Move the alternator to increase or decrease the belt tension.

3. Tighten adjusting bolt (1) and tighten mounting bolts and nut (2) to a torque of 22 N·m (194 lb in). Tighten bolt (3) to a torque of 22 N·m (194 lb in).

i08673488

Alternator and Fan Belts - Replace (Single-V Belt)

Removal Procedure

1. If the engine is equipped with fan guards, remove the fan guards. Refer to your Perkins distributor for further assistance.

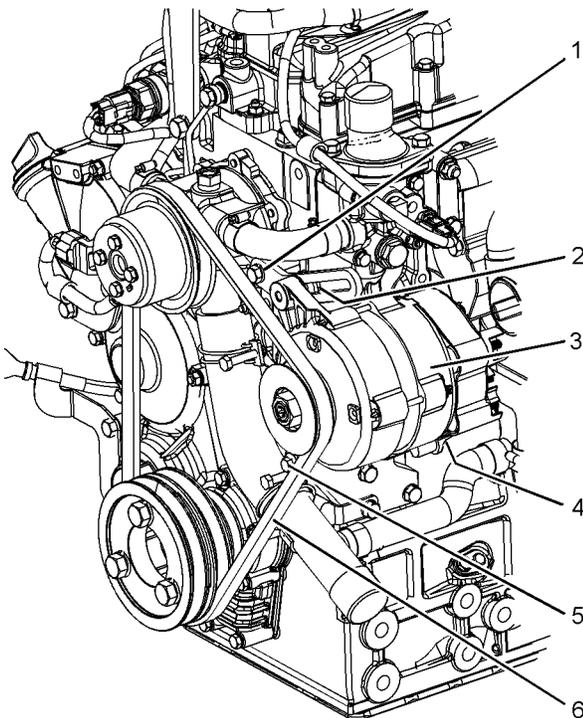


Illustration 46

g06540190

Typical example

2. Loosen bolt (1) and bolt (2) (not shown) on the adjuster link.
3. Loosen nut (4) (not shown) and bolt (5).

4. Push alternator (3) toward the engine and remove alternator belt (6).

Installation Procedure

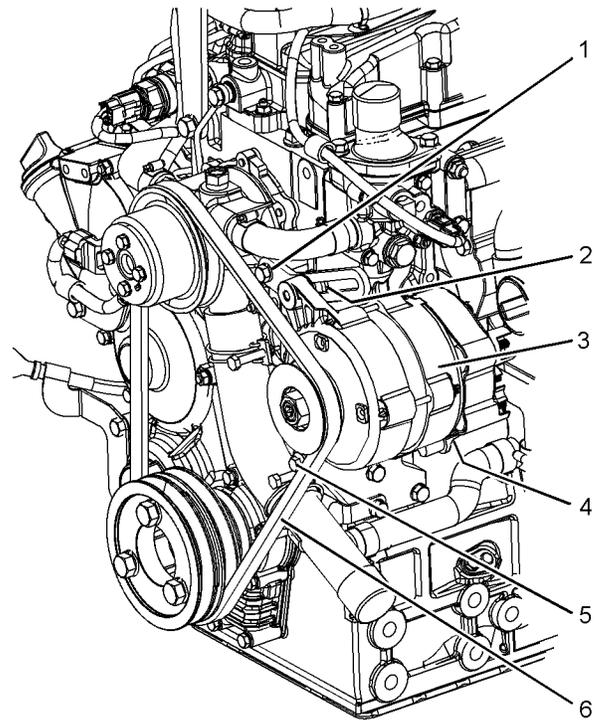


Illustration 47

g06540190

Typical example

1. Position alternator belt (6) onto alternator (3), the water pump pulley, and the crankshaft pulley. Ensure that the alternator belt is correctly positioned onto the alternator pulley, the water pump pulley, and the crankshaft pulley, refer to Illustration 46 .
2. Slide alternator (3) away from the engine to tighten belt (6) to the correct tension.

The belt tension for a new belt is from 400 N to 489 N (90 lb to 110 lb).
3. Tighten bolt (1), bolt (2) to a torque of 25 N·m (221 lb in).
4. Tighten nut (4) (not shown) and bolt (5) to a torque of 25 N·m (221 lb in).
5. If the engine is equipped with fan guards, install the fan guards. Refer to your Perkins distributor for further assistance.

Note: When a new belt is 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.

i08397621

Battery - Recycle

Always recycle a battery. Never discard a battery. Return used batteries to one of the following locations:

- A battery supplier
- An authorized battery collection facility
- A recycling facility

i08397624

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.

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

1. Turn the key start switch to the OFF position. Remove the key and all electrical loads.
2. Turn OFF the battery charger. Disconnect the charger.
3. Turn battery isolator switch to OFF position.

4. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the ground plane. Disconnect the cable from the NEGATIVE “-” battery terminal.
5. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

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

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

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

8. Connect the cable from the starting motor to the POSITIVE “+” battery terminal.
9. Connect the cable from the ground plane 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.

1. 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.
2. Check the condition of the electrolyte with a suitable battery tester.
3. Install the caps.
4. 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.

i08357764

Battery or Battery Cable - Disconnect

WARNING

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

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

1. Turn the start switch to the OFF position. Turn the ignition switch (if equipped) to the OFF position and remove the key and all electrical loads.
2. Disconnect the negative battery terminal at the battery that goes to the start switch. Ensure that the cable cannot contact the terminal. When four 12 volt batteries are involved, the negative side of two batteries must be disconnected.
3. Tape the leads to help prevent accidental starting.
4. Proceed with necessary system repairs. Reverse the steps to reconnect all cables.

i08673443

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.

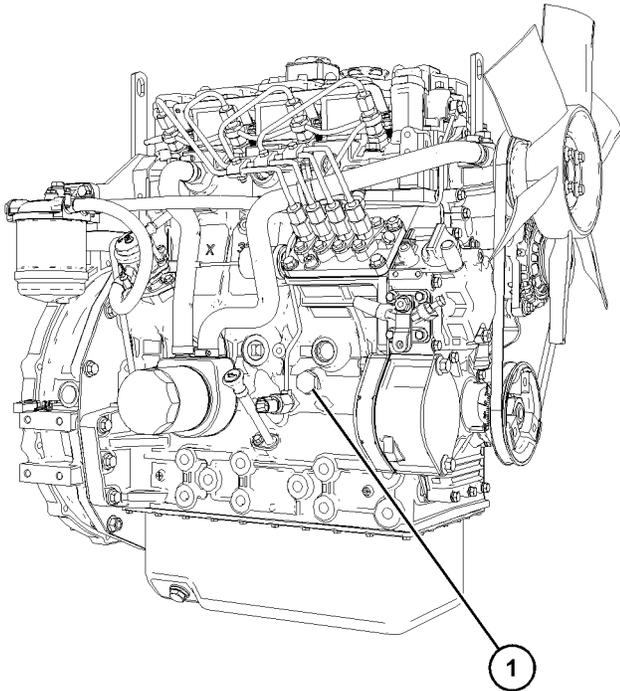


Illustration 48

g06675854

Drain plug option

Note: Refer to Operation and Maintenance Manual, “General Hazard Information” for information on Containing Fluid Spillage.

2. Open the cooling system drain valve (if equipped).
If the cooling system is not equipped with a drain valve, remove one of the drain plug (1).

Allow the coolant to drain into a suitable container.

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.

Drain Plugs for Factory Installed Radiators

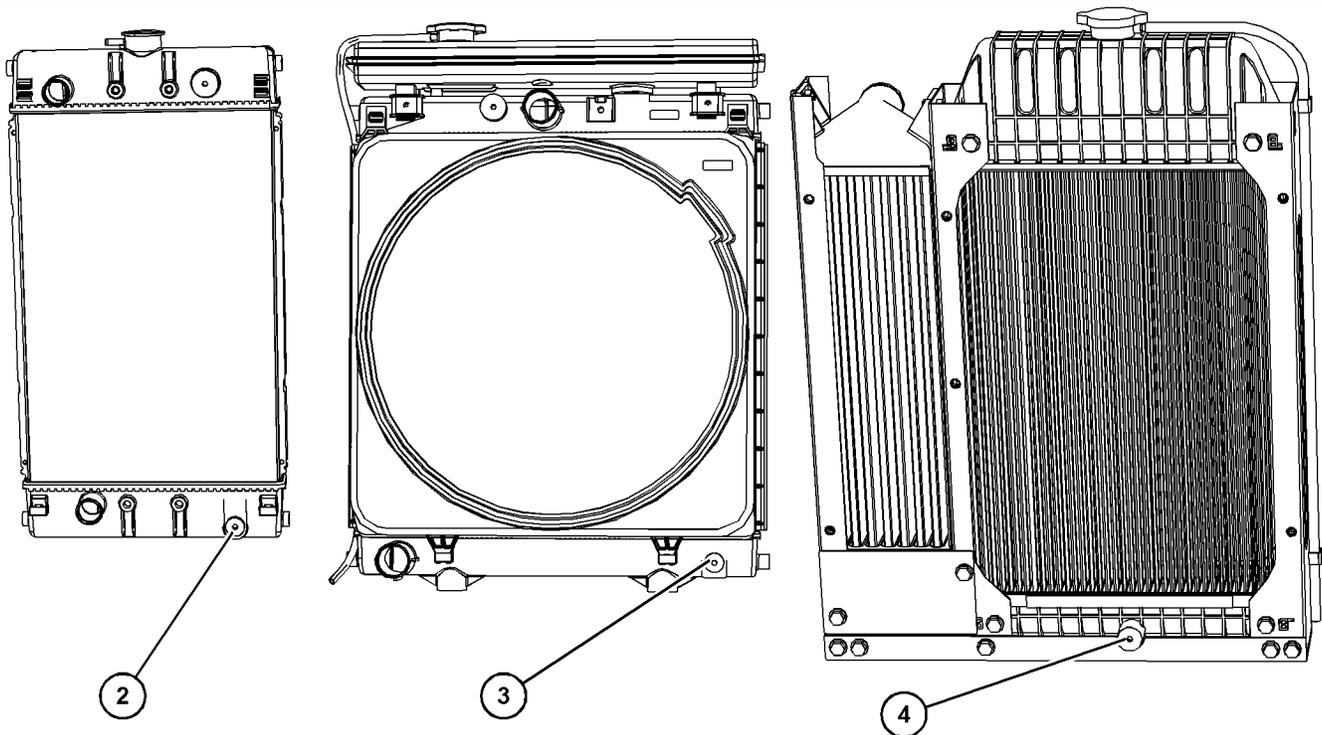


Illustration 49

g06164641

Typical example

(2) Three cylinder radiator drain plug

(3) Four cylinder turbocharged engine radiator drain plug

(4) Four cylinder turbocharged engine drain plug front of radiator

- Tighten drain plug (2) to a torque of 4 N·m (35.4 lb in)
- Tighten drain plug (3) to a torque of 4 N·m (35.4 lb in)
- Tighten drain plug (4) to a torque of 6 N·m (53. lb in)

Flush

1. Flush the cooling system with clean water to remove any debris.
2. Install the drain plug or close the drain tap if equipped on the engine. Close the drain cock or install the drain plug on the radiator. Refer to "Drain Plugs for Factory Installed Radiators" for more information on the correct torques for drain plugs.

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).

NOTICE

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

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

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. Install the drain plug or close the drain tap (if equipped) on the engine.
2. Install the drain plug or close the drain tap (if equipped) 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 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.
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.

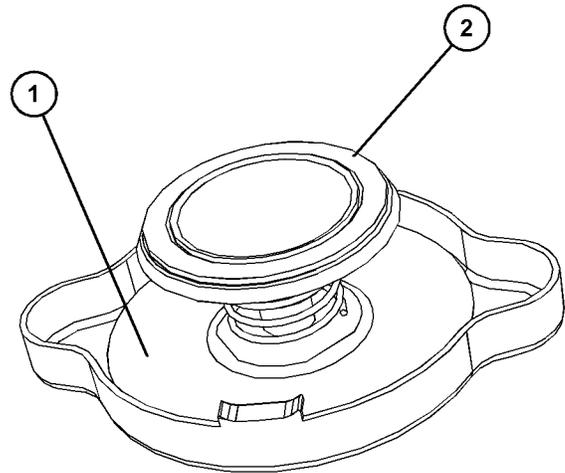


Illustration 50

g06165279

Typical example

6. Clean the cooling system filler cap (1). Inspect the gasket (2) 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.

- Cooling system filler cap pressure for three cylinder engine 95 kPa (13.7 psi)
- Cooling system filler cap pressure for four cylinder engine 110 kPa (15.9 psi)

Note: 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 passes the pressure test check, install the filler cap. If required install new cooling system filler cap.

7. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

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i05160120

Coolant Temperature Regulator - Replace

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

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

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

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

NOTICE

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

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

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

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

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

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

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.

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.
-

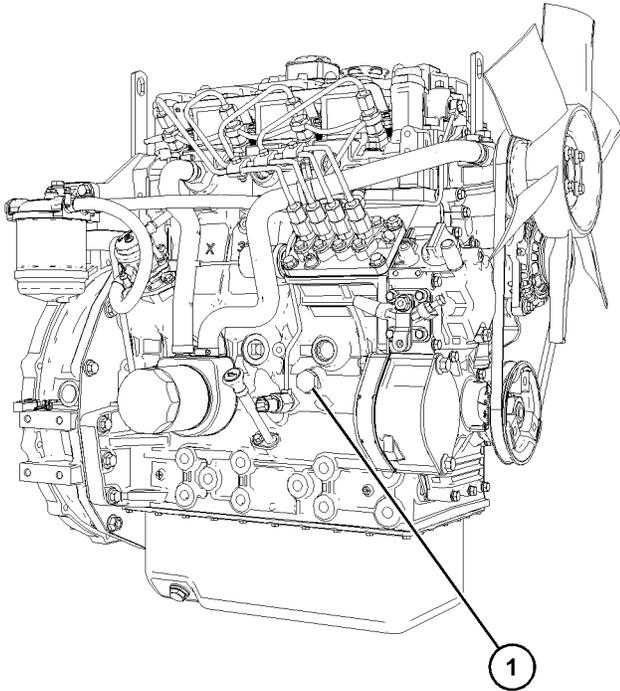


Illustration 51

g06675854

Drain plug option

Note: Refer to Operation and Maintenance Manual, “General Hazard Information” for information on Containing Fluid Spillage.

2. Open the cooling system drain valve (if equipped).
If the cooling system is not equipped with a drain valve, remove one of the drain plug (1).

Allow the coolant to drain into a suitable container.

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.

Drain Plugs for Factory Installed Radiators

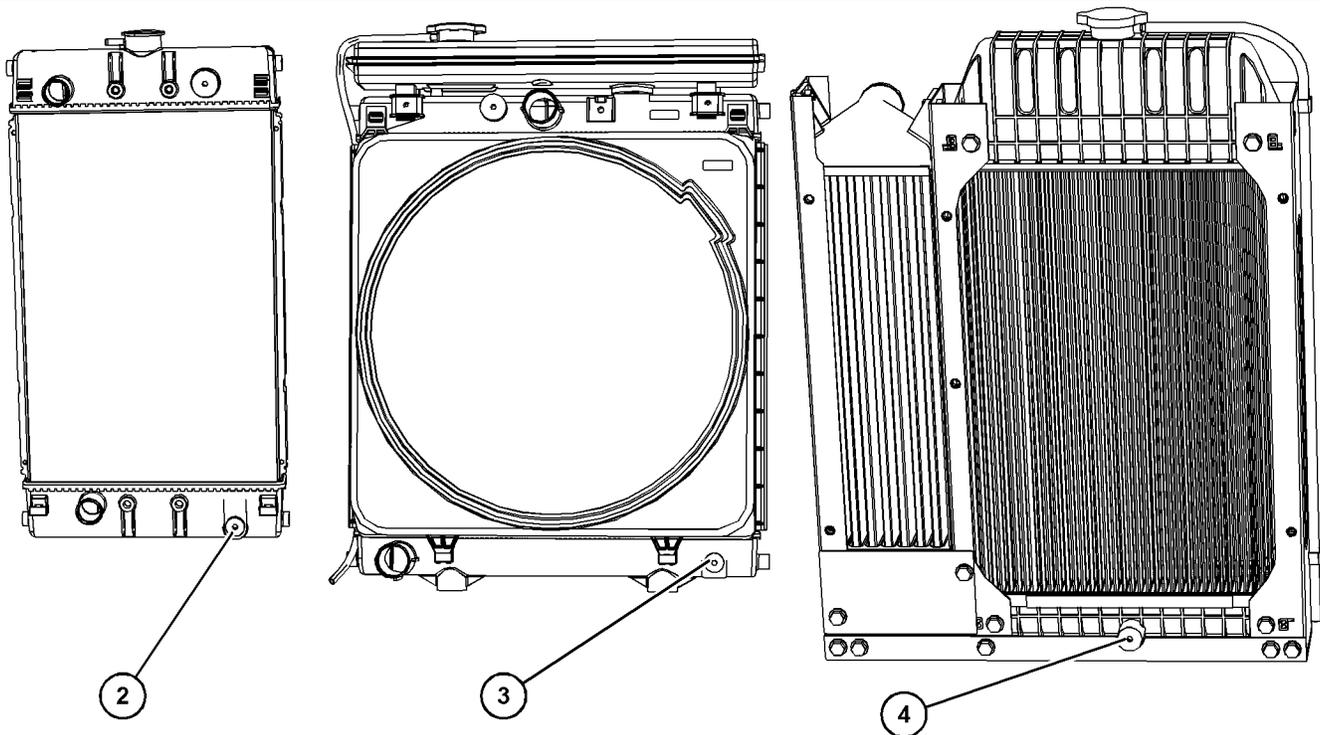


Illustration 52

g06164641

Typical example

(2) Three cylinder radiator drain plug

(3) Four cylinder turbocharged engine radiator drain plug

(4) Four cylinder turbocharged engine drain plug front of radiator

- Tighten drain plug (2) to a torque of 4 N·m (35.4 lb in)
- Tighten drain plug (3) to a torque of 4 N·m (35.4 lb in)
- Tighten drain plug (4) to a torque of 6 N·m (53. lb in)

3. Close the drain tap or install the drain plug on the radiator. Refer to "Drain Plugs for Factory Installed Radiators" for more information on the correct torques for drain plugs.

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.

Flush

1. Flush the cooling system with clean water to remove any debris.
2. Install the drain plug to the engine or close the drain tap if equipped.

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).

NOTICE

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

To avoid damage to the cooling system, make sure to completely flush the cooling system with clear water. Continue to flush the system until all signs of the cleaning agent are gone.

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. Install the drain plug or close the drain tap (if equipped) on the engine.
2. Install the drain plug or close the drain tap (if equipped) 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.

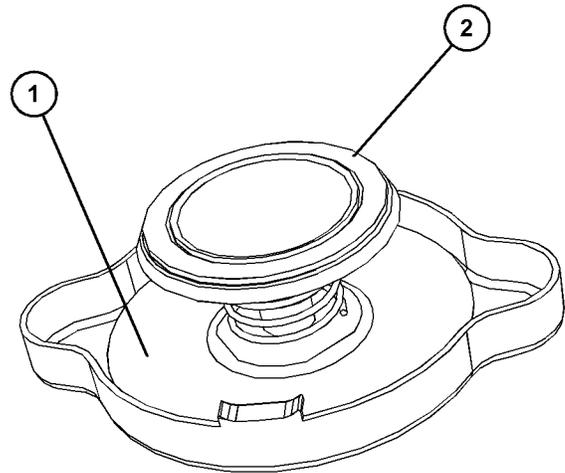


Illustration 53

g06165279

Typical example

6. Clean the cooling system filler cap(1). Inspect the gasket (2) 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.

- Cooling system filler cap pressure for three cylinder engine 95 kPa (13.7 psi)
- Cooling system filler cap pressure for four cylinder engine 110 kPa (15.9 psi)

Note: 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 passes the pressure test check, install the filler cap. If required install new cooling system filler cap.

7. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i06914881

Cooling System Coolant Level - Check

WARNING

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

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

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 procedure will allow you to check accurately the coolant level. This procedure will also help in avoiding the risk of introducing an air lock into the coolant system.

Remove the cooling system filler cap slowly to relieve the pressure within the cooling system.

For the correct coolant level, refer to the OEM information.

Factory Installed Radiators

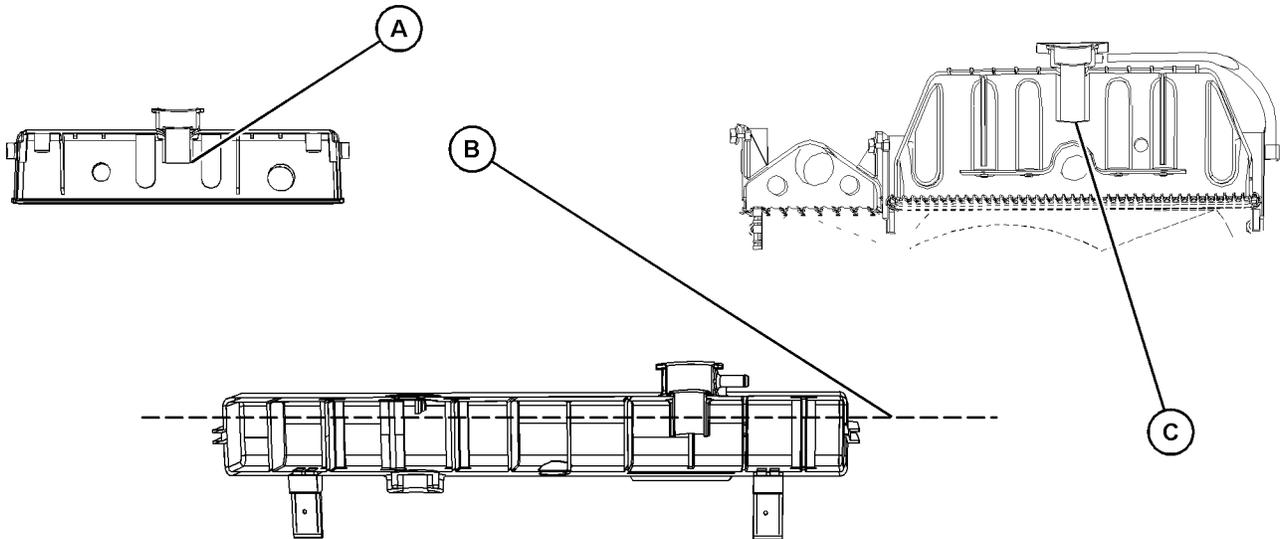


Illustration 54

g06165264

Typical example

- The coolant level (A) is for factory installed radiator with the three cylinder engine.
- The coolant level (B) is for factory installed radiator with the four cylinder turbocharged engine. Once the level has been reached, add 0.5 L (0.13210 US gal) of coolant.

- The coolant level (C) is for factory installed radiator with the four cylinder turbocharged aftercooled engine.

Radiator Cap

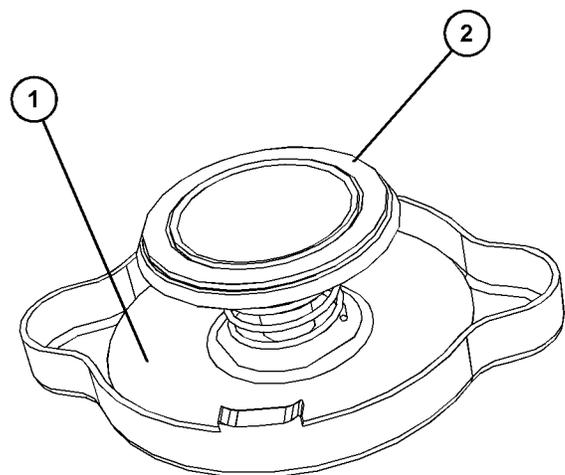


Illustration 55

g06165279

Typical example

Clean the cooling system filler cap and check the condition of the filler cap gasket (1). Replace the cooling system filler cap if the filler cap gasket (1) or the sealing surface (2) are damaged.

The radiator filler cap should be checked at regular intervals to insure that the filler cap relieve pressure is correct. The cooling system fill cap pressure is:

- Cooling system filler cap pressure for three cylinder engine 95 kPa (13.7 psi)
- Cooling system filler cap pressure for four cylinder engine 110 kPa (15.9 psi)

Reinstall the cooling system filler cap when all checks are complete.

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.

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.

i08397642

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.

i07192903

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 starter. Protect the fuel injection pump from fluids when washing 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.

Maintenance Section
Engine Air Cleaner Service Indicator - Inspect

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.

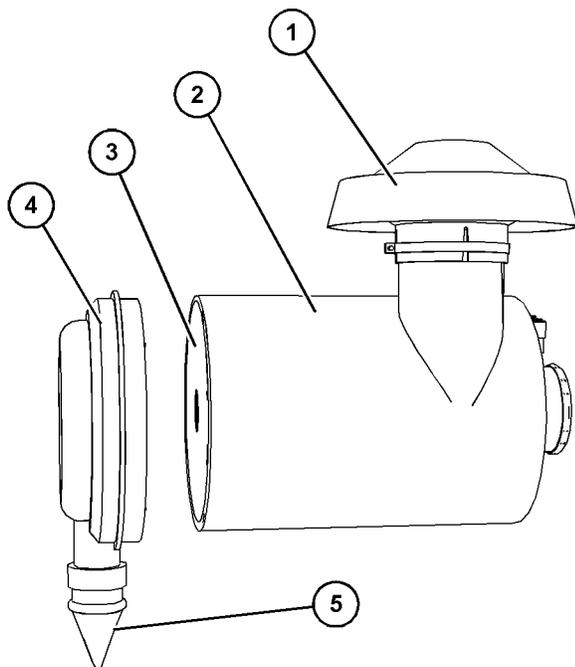


Illustration 56

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.

i08397637

Engine Air Cleaner Service Indicator - Inspect (If Equipped)

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 and 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 clean side of the air cleaner housing or in a remote location.

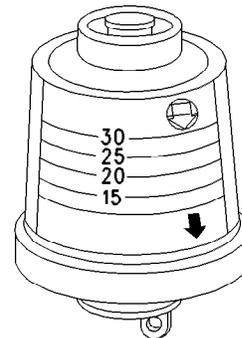


Illustration 57

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.
- Check the movement of the service indicator core when the engine is run at full load speed. The core should latch approximately at the greatest vacuum that is attained.

If the service indicator does not reset easily, or if the 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 plugged.

If necessary, replace the service indicator more frequently in environments that are severely dusty. Replace the service indicator annually regardless of the operating conditions. Replace the service indicator when the engine is overhauled, and whenever major engine components are replaced.

Note: When a new service indicator is installed, excessive force may crack the top of the service indicator. Tighten the service indicator to a torque of 2 N·m (18 lb in).

i07988074

Engine Air Precleaner - Check/Clean

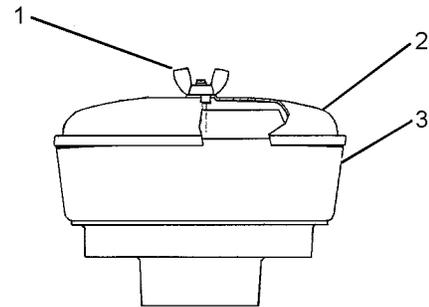


Illustration 58

g01453058

Typical engine air pre-cleaner

- (1) Wing nut
- (2) Cover
- (3) Body

Remove wing nut (1) and cover (2). Check for an accumulation of dirt and debris in body (3). Clean the body, if necessary.

After cleaning the pre-cleaner, install cover (2) and wing nut (1).

Note: When the engine is operated in dusty conditions, more frequent cleaning is required.

Do not tap or strike the air cleaner element.

i02657607

Engine Crankcase Breather - Replace

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

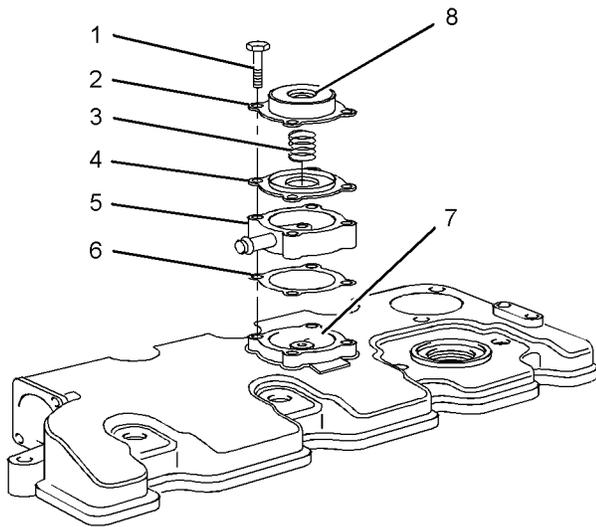


Illustration 59

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.

i05164949

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.

i01907674

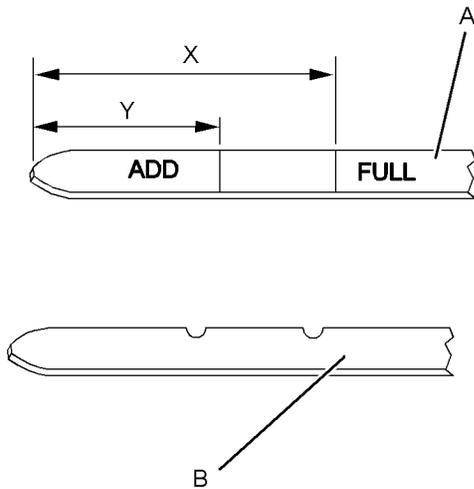


Illustration 60

g03317856

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

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

NOTICE

Perform this maintenance with the engine stopped.

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

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

NOTICE

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

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

Engine Oil Sample - Obtain

The condition of the engine lubricating oil may be checked at regular intervals as part of a preventive maintenance program. Perkins include an oil sampling valve as an option. The oil sampling valve (if equipped) is included in order to regularly sample the engine lubricating oil. The oil sampling valve is positioned on the oil filter head or the oil sampling valve is positioned on the cylinder block.

Perkins recommends using a sampling valve in order to obtain oil samples. The quality and the consistency of the samples are better when a sampling valve is used. The location of the sampling valve allows oil that is flowing under pressure to be obtained during normal engine operation.

Obtain the Sample and the Analysis

WARNING

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

In order to help obtain the most accurate analysis, record the following information before an oil sample is taken:

- The date of the sample
- Engine model
- Engine number
- Service hours on the engine
- The number of hours that have accumulated since the last oil change
- The amount of oil that has been added since the last oil change

Ensure that the container for the sample is clean and dry. Also ensure that the container for the sample is clearly labelled.

To ensure that the sample is representative of the oil in the crankcase, obtain a warm, well mixed oil sample.

To avoid contamination of the oil samples, the tools and the supplies that are used for obtaining oil samples must be clean.

The sample can be checked for the following: the quality of the oil, the existence of any coolant in the oil, the existence of any ferrous metal particles in the oil and the existence of any nonferrous metal particles in the oil.

i08673384

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.

Oil and Filter Change Intervals

The standard engine oil and engine oil filter change period is 500 hours. There are several other factors that can alter the standard engine oil and filter change of 500 hours.

- If the engine is using engine oil analysis to determine oil and filter change period.
- The engine is working in a severe service environment/Load Factor
- Infrequent operation of the engine

Refer to this Operation and Maintenance Manual, "Severe Service Application" for more information on reducing the engine oil and filter change period. For severe service applications the recommended oil and filter change period is 250 hours.

If the engine is operated in severe service conditions, Perkins recommends the use of engine oil sampling. Refer to this Operation and Maintenance Manual, Fluid Recommendations, General Lubricant Information and see section Oil Analysis for more information.

If the engine is operated infrequently less than 500 hours in a 12-month period, then the engine oil and filter change should be conducted yearly.

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:

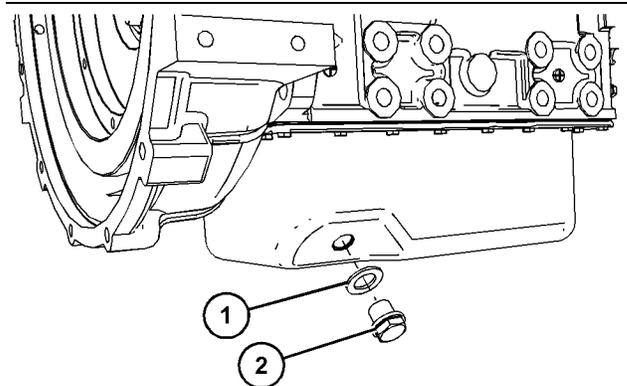


Illustration 61

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)

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 (1) with a suitable tool.

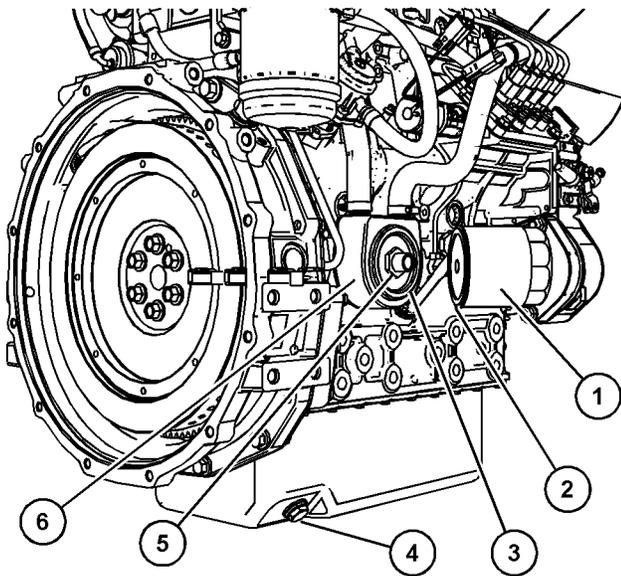


Illustration 62

g06676651

Typical example

- (1) Oil filter
- (2) Oil filter seal
- (3) Oil cooler sealing surface
- (4) Drain plug
- (5) Adapter
- (6) Oil cooler

Note: Oil cooler (6) and adapter (5) are not installed on all engines.

2. Clean the sealing surface of the cylinder block or the surface of the engine oil cooler (3) if equipped.
3. Apply clean engine oil to the new O ring seal (2).

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.

4. Install the new oil filter (1) Tighten the oil filter until the oil filter seal contacts the cylinder block or the oil cooler. Tighten the oil filter by hand according to the instructions that are shown on the oil filter. Do not overtighten the oil filter.

Fill the Engine Crankcase

1. Remove the oil filler cap. Refer to the Operation and Maintenance Manual for more information on lubricant specifications. Fill the crankcase with the correct amount of oil. Refer to the Operation and Maintenance Manual 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 2 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 10 minutes.

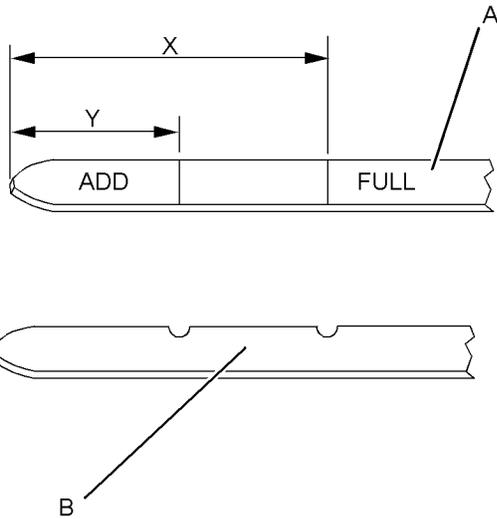


Illustration 63

g03306420

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

(A) Original oil level gauge

(B) Alternative oil level gauge

- Remove the oil level gauge to check the oil level. Maintain the oil level between the "ADD" and "FULL" marks on the oil level gauge.

i06225025

Engine Protective Devices - Check

Visual Inspection

Visually check the condition of all gauges, sensors, and wiring. Look for wiring and components that are loose, broken, or damaged. Damaged wiring or components should be repaired or replaced immediately.

Calibration Check

NOTICE

During testing, abnormal operating conditions must be simulated.

The tests must be performed correctly in order to prevent possible damage to the engine.

Alarms and shutoffs must function correctly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. Determination of the good working order of the engine protective devices is impossible during normal operation. Malfunctions must be simulated in order to test the engine protective devices. To prevent damage to the engine, only authorized service personnel or your Perkins distributor should perform the tests.

Consult your Perkins distributor or refer to the Service Manual for more information.

i06299296

Engine Valve Lash - Check

WARNING

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

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

NOTICE

Only qualified service personnel should perform this maintenance.

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

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

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

- Inlet valve _____ 0.20 mm (0.8 inch)
- Exhaust valve _____ 0.20 mm (0.8 inch)

Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust" for the correct sequence of adjustment.

i08681023

Fan Clearance - Check

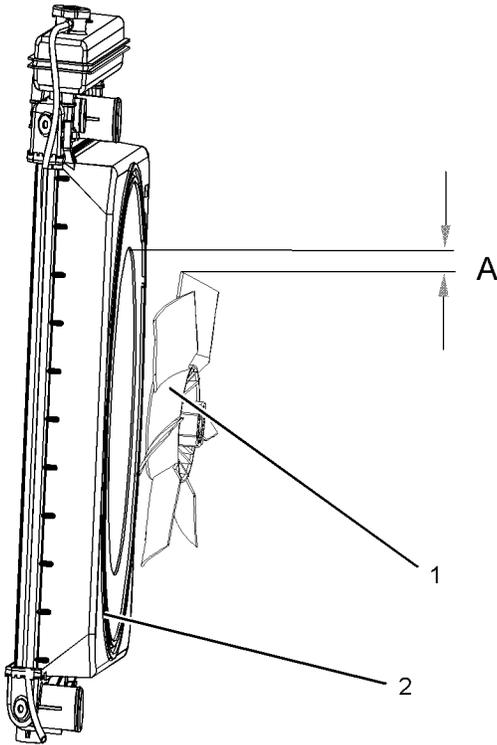


Illustration 64

g03309719

Typical example

Ensure that the engine is stopped. Ensure that the battery disconnect switch is in the OFF position. Ensure that the cooling system is full.

The clearance between the cover (2) and the fan (1) will require checking. The gap between the edge of the cover and the tip of the fan blade (A) must be checked in four equally spaced positions.

Note: The cover is not adjustable.

Three Cylinder

- (A) equals 5 mm (0.19685 inch) for the three cylinder engine

Four Cylinder Turbocharged

- (A) equals 10 mm (0.39370 inch) for the turbocharged engine.

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 any disconnected fuel system components.

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.

i08471258

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.

Use the following procedure to prime the fuel system:

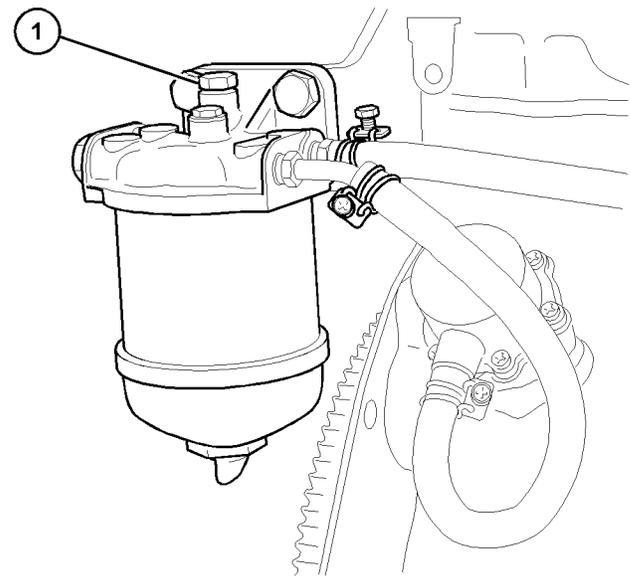


Illustration 65

g06677649

Fuel filter with canister

(1) Vent screw

1. Ensure that the fuel valve is open. 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 (1).

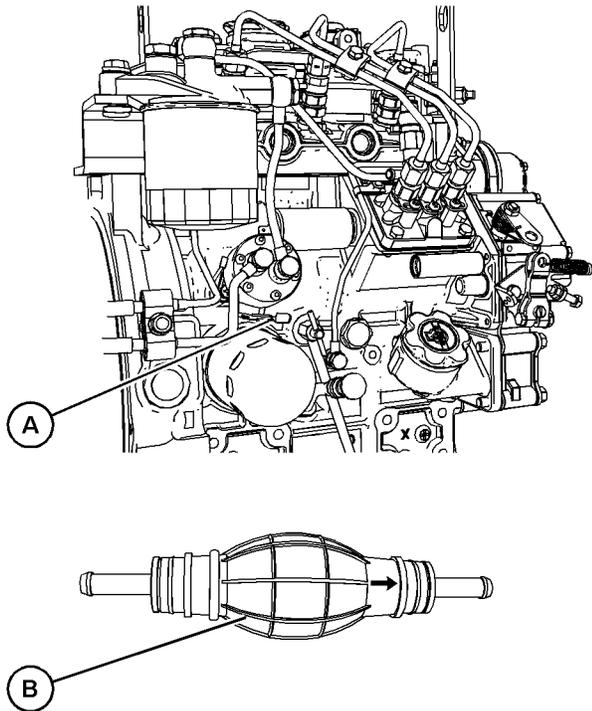


Illustration 66 g06518138

- (A) Lift pump hand priming option (if equipped).
(B) Loose part hand priming option.

3. Operate the hand primer. Refer to illustration 66
4. When fuel free from air flows from the vent screw tighten the vent screw.

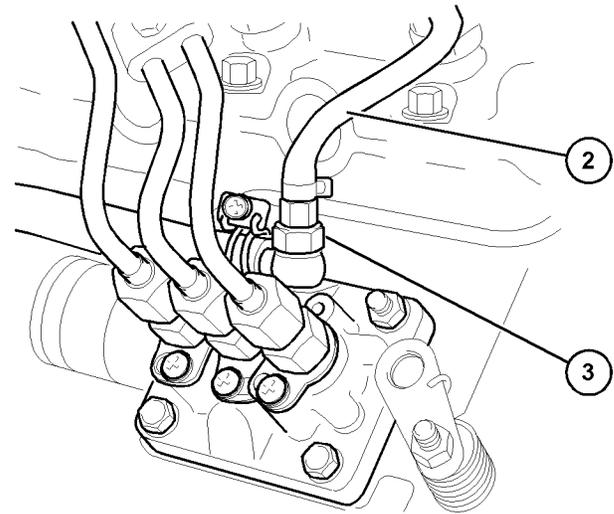


Illustration 67 g06677660

Connector that is installed on 3 cylinder engines

- (2) Fuel return hose for the injector
(3) Connector bolt

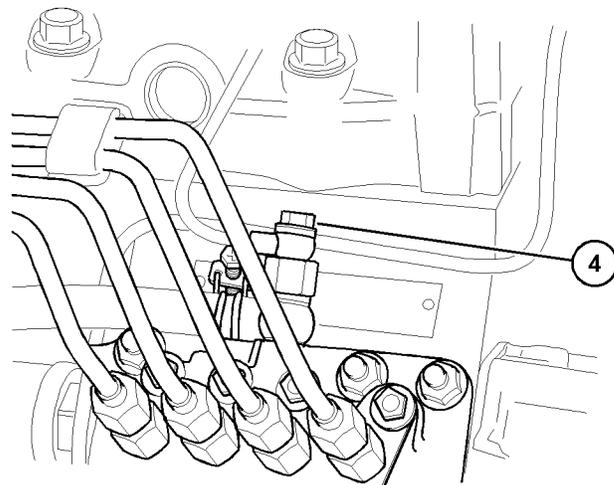


Illustration 68 g06677651

Connector that is installed on 4 cylinder engines

- (4) Connector bolt

5. Loosen the connector (3) or (4) at the fuel injection pump.

Note: For illustration 67, the fuel return hose (2) 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 30 seconds. If the engine does not start after 30 seconds, stop and wait for 2 minutes before trying again.

i08471354

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 any disconnected fuel system components.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Fuel Filter With Canister

1. Close the fuel supply valve.

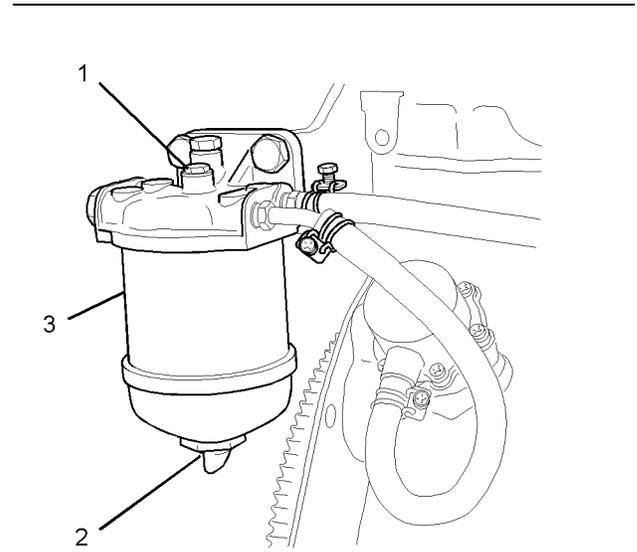


Illustration 69

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).

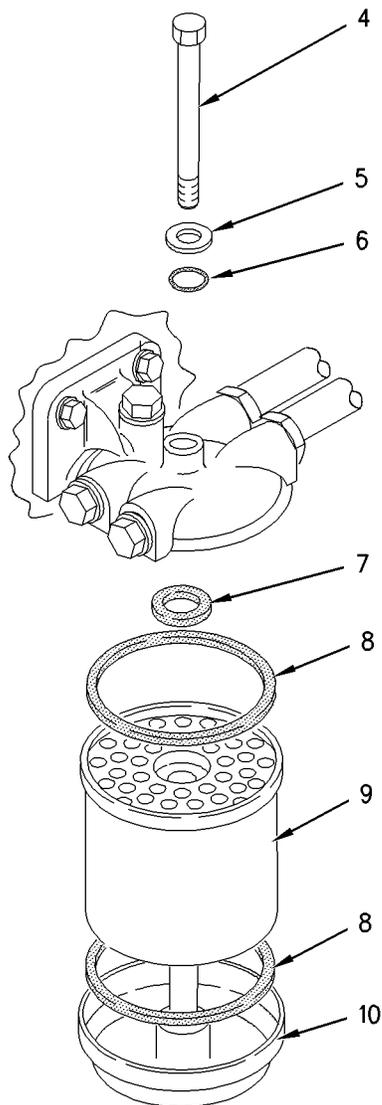


Illustration 70

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".

i08471398

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.

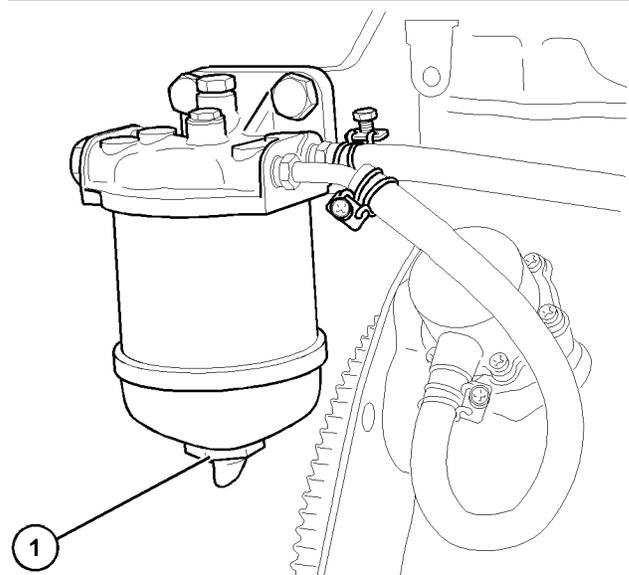


Illustration 71

g06677843

Typical example

1. Open drain (1). Catch the draining fluid in a suitable container. Dispose of the drained fluid correctly.
2. Close drain (1) use hand pressure only.

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.

i02348492

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.

i08254039

Radiator - Clean

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.

The maximum air pressure for cleaning purposes must be reduced to 205 kPa (30 psi) when the air nozzle is deadheaded.

Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This movement 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 both sides.

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

After cleaning, start the engine and bring the engine to high idle. This procedure will help in the removal of debris and drying of the core. 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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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.

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Turbocharger - Inspect

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 damage to the pistons, the valves, and the cylinder head.

Refer to Systems Operation Testing and Adjusting, Air Inlet and Exhaust System - Inspect and Wastegate - Test for more information.

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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.

i02226958

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

The certifying engine manufacturer warrants to the ultimate purchaser and each subsequent purchaser that:

1. New non-road diesel engines and stationary diesel engines less than 10 L per cylinder (including Tier 1 and Tier 2 marine engines < 37 kW, but excluding locomotive and other marine engines) operated and serviced in the United States and Canada, including all parts of their emission control systems ("emission-related components"), are:
 - a. Designed, built, and equipped so as to conform, at the time of sale, with applicable emission standards prescribed by the United States Environmental Protection Agency (EPA) by way of regulation.
 - b. Free from defects in materials and workmanship in emission-related components that can cause the engine to fail to conform to applicable emission standards for the warranty period.
2. New non-road diesel engines (including Tier 1 and Tier 2 marine propulsion engines < 37 kW and Tier 1 through Tier 4 marine auxiliary engines < 37 kW, but excluding locomotive and other marine engines) operated and serviced in the state of California, including all parts of their emission control systems ("emission-related components"), are:
 - a. Designed, built, and equipped so as to conform, at the time of sale, to all applicable regulations adopted by the California Air Resources Board (ARB).
 - b. Free from defects in materials and workmanship which cause the failure of an emission-related component to be identical in all material respects to the component as described in the engine manufacturer's application for certification for the warranty period.
3. New non-road diesel engines installed in construction machines conforming to the South Korean regulations for construction machines manufactured after January 1, 2015, and operated and serviced in South Korea, including all parts of their emission control systems ("emission related components"), are:
 - a. Designed, built, and equipped so as to conform, at the time of sale, with applicable emission standards prescribed in the Enforcement Rule of the Clean Air Conservation Act promulgated by South Korea MOE.
 - b. Free from defects in materials and workmanship in emission-related components that can cause the engine to fail to conform to applicable emission standards for the warranty period.
4. New China non-road 4 mobile diesel engines operated and serviced in China, including all parts of their emission control systems ("emission related components"), are:
 - a. Designed, built, and equipped so as to conform, at the time of manufacture, sale, and import with applicable emission standards promulgated by Ministry of Ecology and Environment (MEE).
 - b. Free from defects in materials and workmanship in emission-related components that can cause the engine to fail to conform to applicable emission standards for the warranty period.

A detailed explanation of the Emission Control Warranty that is applicable to new non-road and stationary diesel engines, including the components covered and the warranty period, is found in "Warranty supplement - Emission warranty parts" available at the Perkins engines website. Consult your authorized Perkins distributor to determine if your engine is subject to an Emission Control Warranty, and to obtain a copy of the applicable warranty publication.

Reference Information Section

www.perkins.com

Reference Materials

i04224089

i05204672

Engine Protection Plans (Extended Service Contract)

Extended Service Contracts-purchased in minutes, protected for years.

Extended Service Contracts (ESC) protect you from the stress that unexpected repair work brings to your life by covering the cost of getting your engine up and running again. Unlike other extended warranties, Perkins Platinum ESC protects you against all component part failures.

Purchase peace of mind from only £0.03 / \$0.05 / euro 0.04 a day and let an ESC make your dreams a reality.

Why buy an Extended Service Contract?

1. No surprises - total protection from unexpected repair cost (parts, labor, and travel).
2. Enjoy longer lasting product support from Perkins global network.
3. Genuine Perkins parts ensure continued engine performance.
4. Highly trained technicians carry out all repairs.
5. Transferable coverage should you sell your machine.

Flexible coverage provides the right level of protection for your Perkins Engine. Coverage can be extended to 2 years/ 1,000 hours right up to 10 year/ 40,000

You can buy an ESC at any time during standard warranty - even the last day!

Each Perkins Distributor has highly trained and experienced Perkins Product Support Service Technicians. The Support Service are equipped, and available around the clock to get your engine running again with the minimum of downtime. Buying an ESC means that you get all this for free.

To purchase an Extended Service Contract, is quick and simple! Contact your local Perkins Distributor now and the distributor can provide you with a quote in minutes. You can locate your nearest Perkins Distributor by visiting:

NOTICE
Dependant upon engine type and application.

Maintenance Records

Perkins recommends the retention of accurate maintenance records. Accurate maintenance records can be used for the following purposes:

- Determine operating costs.
- Establish maintenance schedules for other engines that are operated in the same environment.
- Show compliance with the required maintenance practices and maintenance intervals.

Maintenance records can be used for various other business decisions that are related to engine maintenance.

Maintenance records are a key element of a maintenance program that is correctly managed. Accurate maintenance records can help your Perkins dealer to fine-tune the recommended maintenance intervals in order to meet the specific operating situation. This should result in a lower engine operating cost.

Records should be kept for the following items:

Fuel Consumption – A record of fuel consumption is essential in order to determine when the load sensitive components should be inspected or repaired. Fuel consumption also determines overhaul intervals.

Service Hours – A record of service hours is essential to determine when the speed sensitive components should be inspected or repaired.

Documents – These items should be easy to obtain, and these items should be kept in the engine history file. All of the documents should show this information: date, service hours, fuel consumption, unit number and engine serial number. The following types of documents should be kept as proof of maintenance or repair for warranty:

Keep the following types of documents as proof of maintenance for warranty. Also, keep these types of documents as proof of repair for warranty:

- Dealer work orders and itemized bills
- Owners repair costs
- Owners receipts

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Product and Dealer Information

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

Delivery Date: _____

Product Information

Model: _____

Product Identification Number: _____

Engine Serial Number: _____

Transmission Serial Number: _____

Generator Serial Number: _____

Attachment Serial Numbers: _____

Attachment Information: _____

Customer Equipment Number: _____

Dealer Equipment Number: _____

Dealer Information

Name: _____ Branch: _____

Address: _____

Dealer Contact

Phone Number

Hours

Sales: _____

Parts: _____

Service: _____

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