

Operation and Maintenance Manual

1206E-E70TTA Industrial Engine

BL (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 properly.

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

Do not operate or perform any lubrication, maintenance or repair on this product, until you 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. 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 the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

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.

Table of Contents

Foreword	4
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Safety Section

Safety Messages	5
General Hazard Information	7
Burn Prevention	10
Fire Prevention and Explosion Prevention	11
Crushing Prevention and Cutting Prevention	13
Mounting and Dismounting	13
High Pressure Fuel Lines	13
Before Starting Engine	15
Engine Starting	15
Engine Stopping	15
Electrical System	16
Engine Electronics	17

Product Information Section

Model Views	19
Product Identification Information	27

Operation Section

Lifting and Storage	30
Gauges and Indicators	34
Features and Controls	36
Engine Diagnostics	46
Engine Starting	58
Engine Operation	61
Engine Stopping	66
Cold Weather Operation	68

Maintenance Section

Refill Capacities	72
Maintenance Recommendations	86

Maintenance Interval Schedule	88
-------------------------------------	----

Warranty Section

Warranty Information	125
----------------------------	-----

Reference Information Section

Reference Materials	129
---------------------------	-----

Index Section

Index	130
-------------	-----

Foreword

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 it 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. They 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 its capabilities.

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 extremely 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. We recommend that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

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 should only be carried out by Perkins authorized personnel. Your Perkins dealer or your Perkins distributor offers a variety of 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.

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. Battery posts, terminals and related accessories contain lead and lead compounds. **Wash hands after handling.**

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. Please become familiar with all warning signs.

Ensure that all of 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.

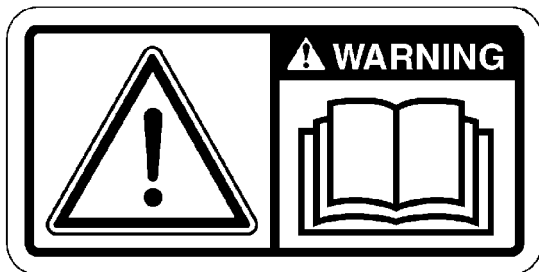


Illustration 1
Typical example

g01154807

The Universal Warning label (1) is located in two positions. The warning labels are located on the front right side of the valve mechanism cover and located on the top of the NOx reduction system NRS.

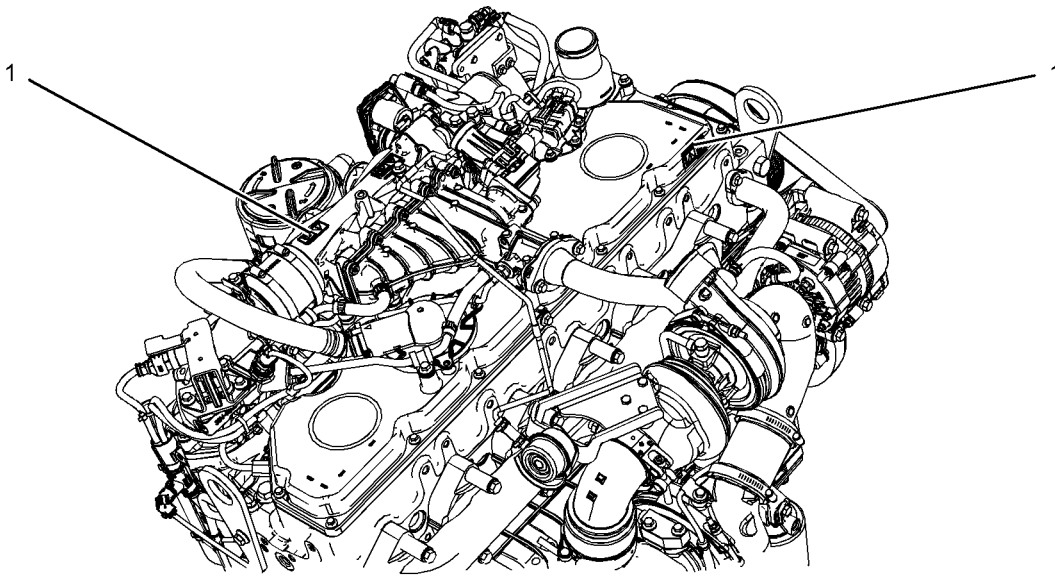


Illustration 2
(1) Universal warning

g02305279

(2) Ether

 **WARNING**

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



Illustration 3
Typical example

g01154809

The ether warning label (2) is located on the top of the reduction system (NRS).

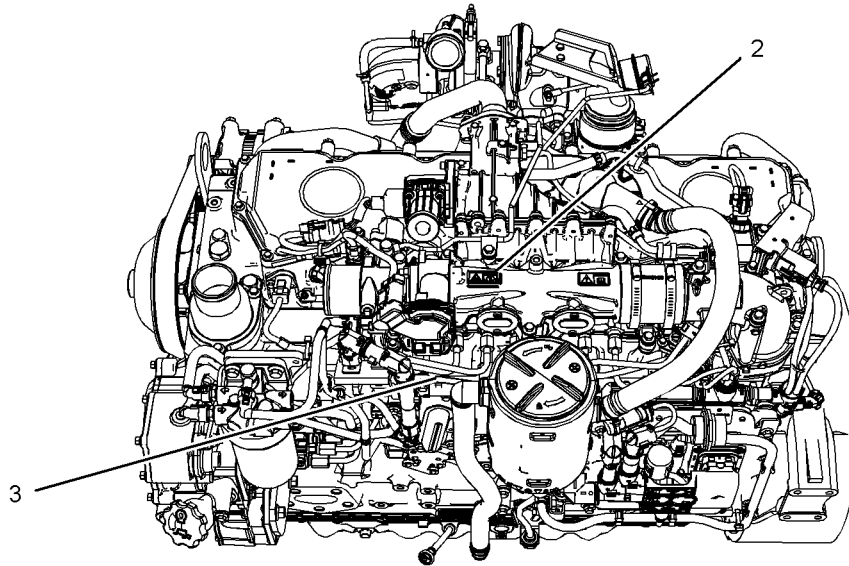


Illustration 4

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(2) Ether

(3) Hand (High Pressure

(3) Hand (High Pressure)

i03566024

⚠ 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.

General Hazard Information



Illustration 5

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Typical example

The warning label for the Hand (High Pressure) (3) is located on a high-pressure fuel line.

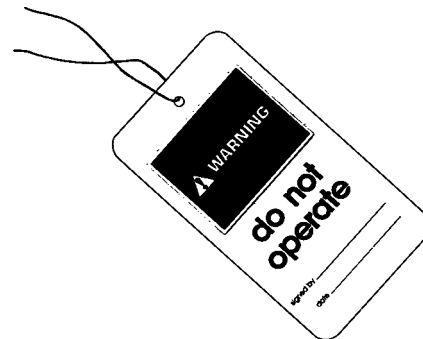


Illustration 6

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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 it is 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 work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- 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 can not 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.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Disconnect the connector for the unit injector that is located on the valve cover base. This 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. This may be accomplished by shutting off the fuel supply and/or the air supply to the engine.
- Start the engine from the operator's station (cab). Never short across the starting motor terminals or the batteries. This could bypass the engine neutral start system and/or the electrical system could be damaged.

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

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

- 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 located at opposite ends of the cover plate or the device. Before removing the last two bolts or nuts, pry the cover loose in order to relieve any spring pressure or other pressure.

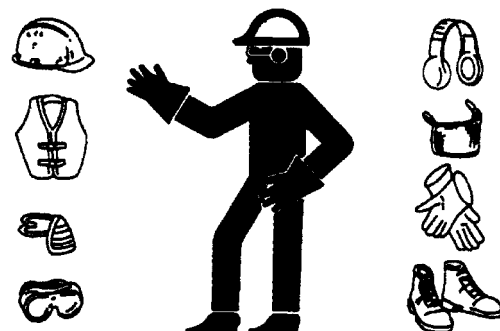


Illustration 7

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- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.

- 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 in order 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 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.

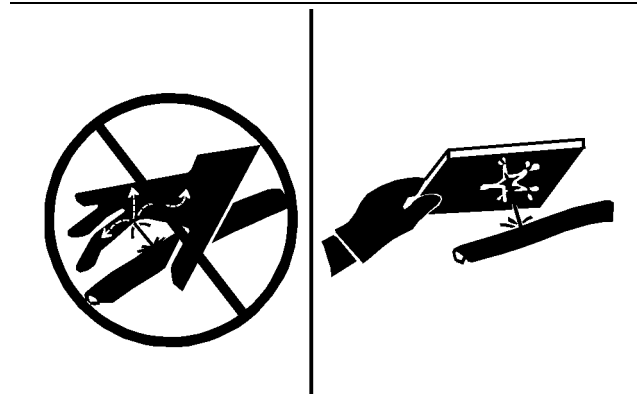


Illustration 8

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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

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.

Asbestos Information

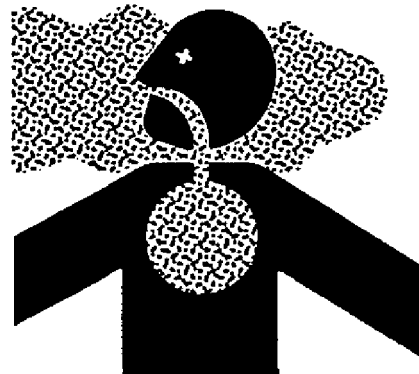


Illustration 9

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Perkins replacement parts that are shipped from Perkins 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 in order 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

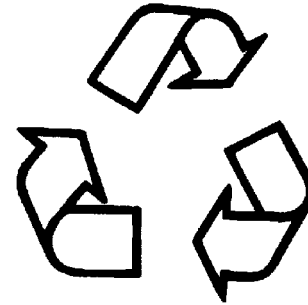


Illustration 10

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Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to 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 system. The engine, the exhaust, and the engine aftertreatment system can reach temperatures as high as 650 °C (1202 °F) under normal operating conditions. If the engine or the engine aftertreatment system unexpectedly fails, the temperature of the gas at the diesel particulate filter (DPF) may increase to 900°C (1652°F).

At idle engine speed and/or zero vehicle speed, an operator can request a manual regeneration. Under this condition, the exhaust gas temperature can reach 650 °C (1202 °F). Otherwise automatic regeneration can produce exhaust gas temperatures as high as 450 °C (842 °F).

Allow the engine system to cool before any maintenance is performed. 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.

⚠ 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.

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed on the engine fuel lines.

Allow the pressure to be purged in the air system, in the hydraulic system, in the lubrication system, or in the cooling system before any lines, fittings, or related items are disconnected.

Induction System**⚠ WARNING**

Sulfuric Acid Burn Hazard may cause serious personal injury or death.

The exhaust gas cooler may contain a small amount of sulfuric acid. The use of fuel with sulfur levels greater than 15 ppm may increase the amount of sulfuric acid formed. The sulfuric acid may spill from the cooler during service of the engine. The sulfuric acid will burn the eyes, skin and clothing on contact. Always wear the appropriate personal protective equipment (PPE) that is noted on a material safety data sheet (MSDS) for sulfuric acid. Always follow the directions for first aid that are noted on a material safety data sheet (MSDS) for sulfuric acid.

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. The aftertreatment regeneration device (ARD) is connected to the coolant system and will contain hot coolant.

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

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

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

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

Oils

Hot oil and hot lubricating components can cause personal injury. Do not allow hot oil to contact the skin. Also, do not allow hot components to contact the skin.

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 11

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

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

After the emergency stop button is operated ensure that you allow 15 minutes, before the engine covers are removed.

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

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

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

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

Do not expose the engine to any flame.

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

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

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

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

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

⚠ 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.

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines.

Ensure that the engine is stopped. Inspect all lines and hoses for wear or for deterioration. The hoses must be correctly routed. The lines and hoses must have adequate support and secure clamps.

Oil filters and fuel filters must be correctly installed. The filter housings must be tightened to the correct torque. Refer to the Disassembly and Assembly manual for more information.



Illustration 12

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



Illustration 13

g00704135

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

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

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

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

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

Fire Extinguisher

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

Lines, Tubes and Hoses

Do not bend high pressure lines. Do not strike high pressure lines. Do not install any lines that are damaged.

Leaks can cause fires. Consult your Perkins dealer or your Perkins distributor for replacement parts.

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

- High pressure fuel line or lines are removed.
- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible part of the hoses are kinked.
- Outer covers have embedded armoring.
- End fittings are displaced.

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

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Crushing Prevention and Cutting Prevention

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

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

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

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

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

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

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Mounting and Dismounting

Do not climb on the engine or the engine aftertreatment. The engine and aftertreatment have not been designed with mounting or dismounting locations.

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

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High Pressure Fuel Lines

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.

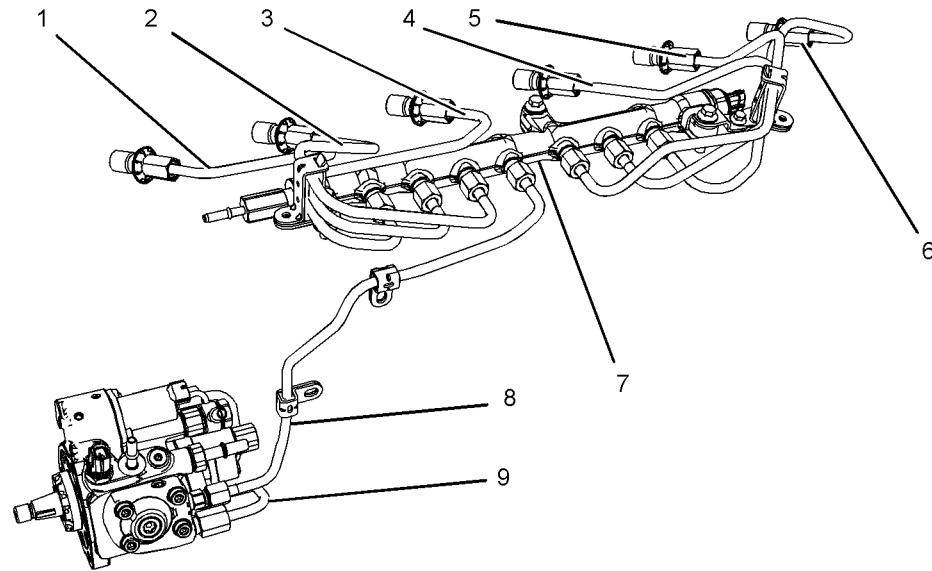


Illustration 14

g01877473

- (1) High pressure line
- (2) High pressure line
- (3) High pressure line

- (4) High pressure line
- (5) High pressure line
- (6) High pressure line

- (7) High pressure fuel manifold (rail)
- (8) High pressure line
- (9) Fuel transfer line that is high pressure

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

This is because of the following items:

- 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.
- The high pressure fuel lines are formed to shape and then strengthened by a special process.

Do not step on the high pressure fuel lines. Do not deflect the high pressure fuel lines. Do not bend or strike the high pressure fuel lines. Deformation or damage of the high pressure fuel lines may cause a point of weakness and potential failure.

Do not check the high pressure fuel lines with the engine or the starting motor in operation. After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines.

Do not loosen the high pressure fuel lines in order to remove air from the fuel system. This procedure is not required.

Visually inspect the high pressure fuel lines before the engine is started. This inspection should be each day.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

- Inspect the high pressure fuel lines for damage, deformation, a nick, a cut, a crease, or a dent.
- Do not operate the engine with a fuel leak. If there is a leak do not tighten the connection in order to stop the leak. The connection must only be tightened to the recommended torque. Refer to Disassembly and Assembly, "Fuel injection lines - Remove and Fuel injection lines - Install".
- If the high pressure fuel lines are torqued correctly and the high pressure fuel lines are leaking the high pressure fuel lines must be replaced.
- Ensure that all clips on the high pressure fuel lines are in place. Do not operate the engine with clips that are damaged, missing or loose.
- Do not attach any other item to the high pressure fuel lines.
- Loosened high pressure fuel lines must be replaced. Also removed high pressure fuel lines must be replaced. Refer to Disassembly and assembly manual, "Fuel Injection Lines - Install".

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Before Starting Engine

Before the initial start-up of an engine that is new, serviced or repaired, make provision to shut the engine off, in order to stop an overspeed. This may be accomplished by shutting off the air and/or fuel supply to the engine.

Overspeed shutdown should occur automatically for engines that are controlled electronically. If automatic shutdown does not occur, press the emergency stop button in order to cut the fuel and/or air to the engine.

Inspect the engine for potential hazards.

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 correctly, if equipped.

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

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

See the Service Manual for repairs and for adjustments.

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Engine Starting

WARNING

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

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

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

Start the engine from the operators compartment or from the engine start switch.

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

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

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

These engines are equipped with a glow plug starting aid in each individual cylinder that heats the intake air in order to improve starting. Some Perkins engines may have a cold starting system that is controlled by the ECM that allows a controlled flow of ether into the engine. The ECM will disconnect the glow plugs before the ether is introduced. This system would be installed at the factory.

i02234873

Engine Stopping

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

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

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

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

i03903127

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

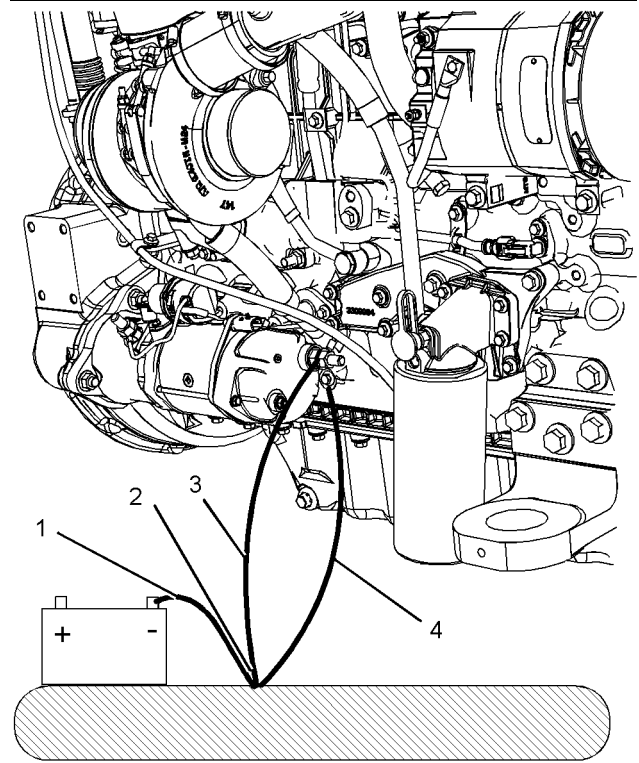


Illustration 15

g02145392

Typical example

- (1) Ground to the battery
- (2) Primary position for grounding
- (3) Ground to the starting motor
- (4) Ground to the engine block

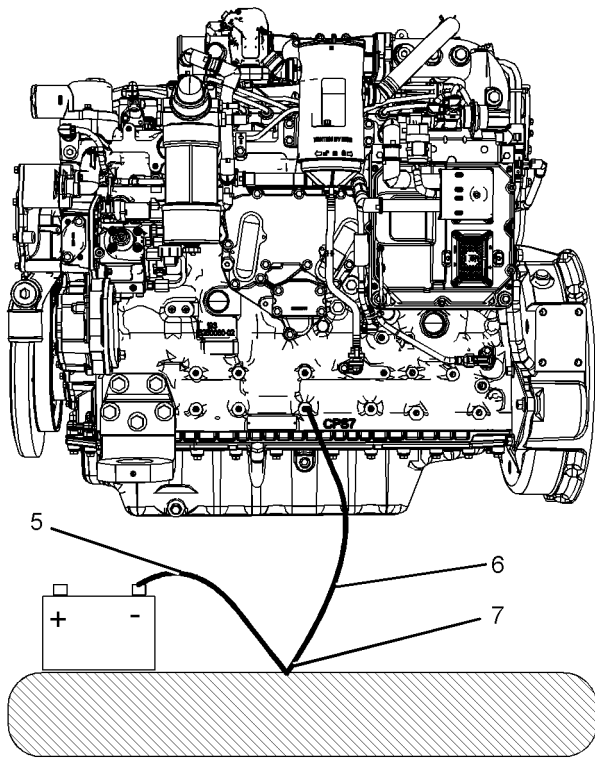


Illustration 16

g02145733

Typical example

- (5) Ground to the battery
- (6) Ground to the engine block
- (7) Primary position for grounding

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.

i03642610

Engine Electronics

! WARNING

Tampering with the electronic system installation or the OEM wiring installation can be dangerous and could result in personal injury or death and/or engine damage.

! WARNING

Electrical Shock Hazard. The electronic unit injectors use DC voltage. The ECM sends this voltage to the electronic unit injectors. Do not come in contact with the harness connector for the electronic unit injectors while the engine is operating. Failure to follow this instruction could result in personal injury or death.

This engine has a comprehensive, programmable Engine Monitoring System. The Electronic Control Module (ECM) has the ability to monitor the engine operating conditions. If any of the engine parameters extend outside an allowable range, the ECM will initiate an immediate action.

The following actions are available for engine monitoring control:

- Warning
- Derate
- Shutdown

The following monitored engine operating conditions have the ability to limit engine speed and/or the engine power:

- Engine Coolant Temperature
- Engine Oil Pressure
- Engine Speed
- Intake Manifold Air Temperature
- Engine Intake Throttle Valve Fault
- Wastegate Regulator

- Supply Voltage to Sensors
- Fuel Pressure in Manifold (Rail)
- NOx Reduction System
- Engine Aftertreatment System

The Engine Monitoring package can vary for different engine models and different engine applications. However, the monitoring system and the engine monitoring control will be similar for all engines.

Note: Many of the engine control systems and display modules that are available for Perkins Engines will work in unison with the Engine Monitoring System. Together, the two controls will provide the engine monitoring function for the specific engine application. Refer to Troubleshooting for more information on the Engine Monitoring System.

Product Information Section

Model Views

i03913230

Model View Illustrations

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

Note: Only major components are identified on the following illustrations.

Engine views

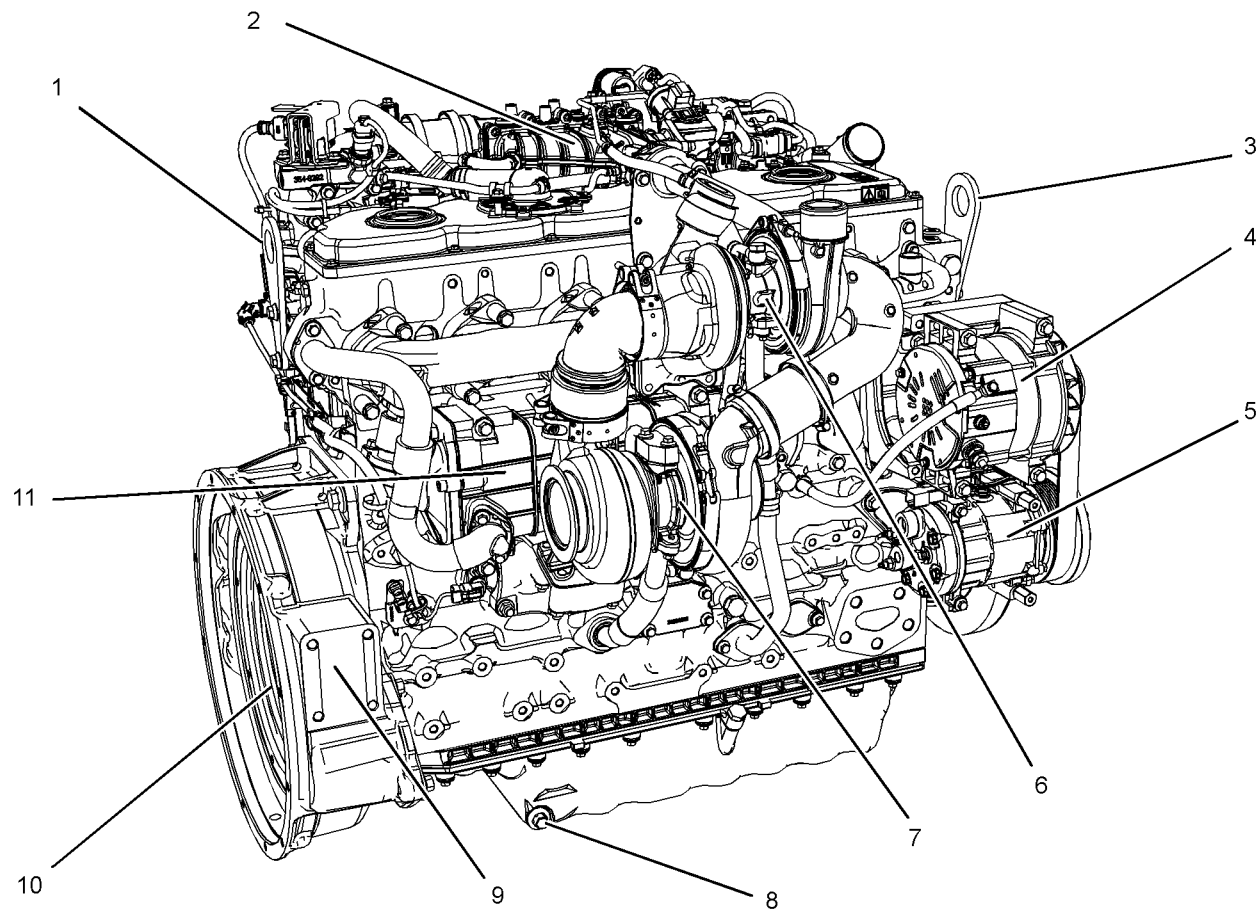


Illustration 17

g02150184

Typical example

- (1) Rear lifting eye
- (2) NOx reduction system NRS
- (3) Front lifting eye
- (4) Alternator

- (5) Refrigerant compressor
- (6) High-pressure turbocharger
- (7) Low-pressure turbocharger
- (8) Engine oil drain

- (9) Flywheel housing
- (10) Flywheel
- (11) NRS cooler

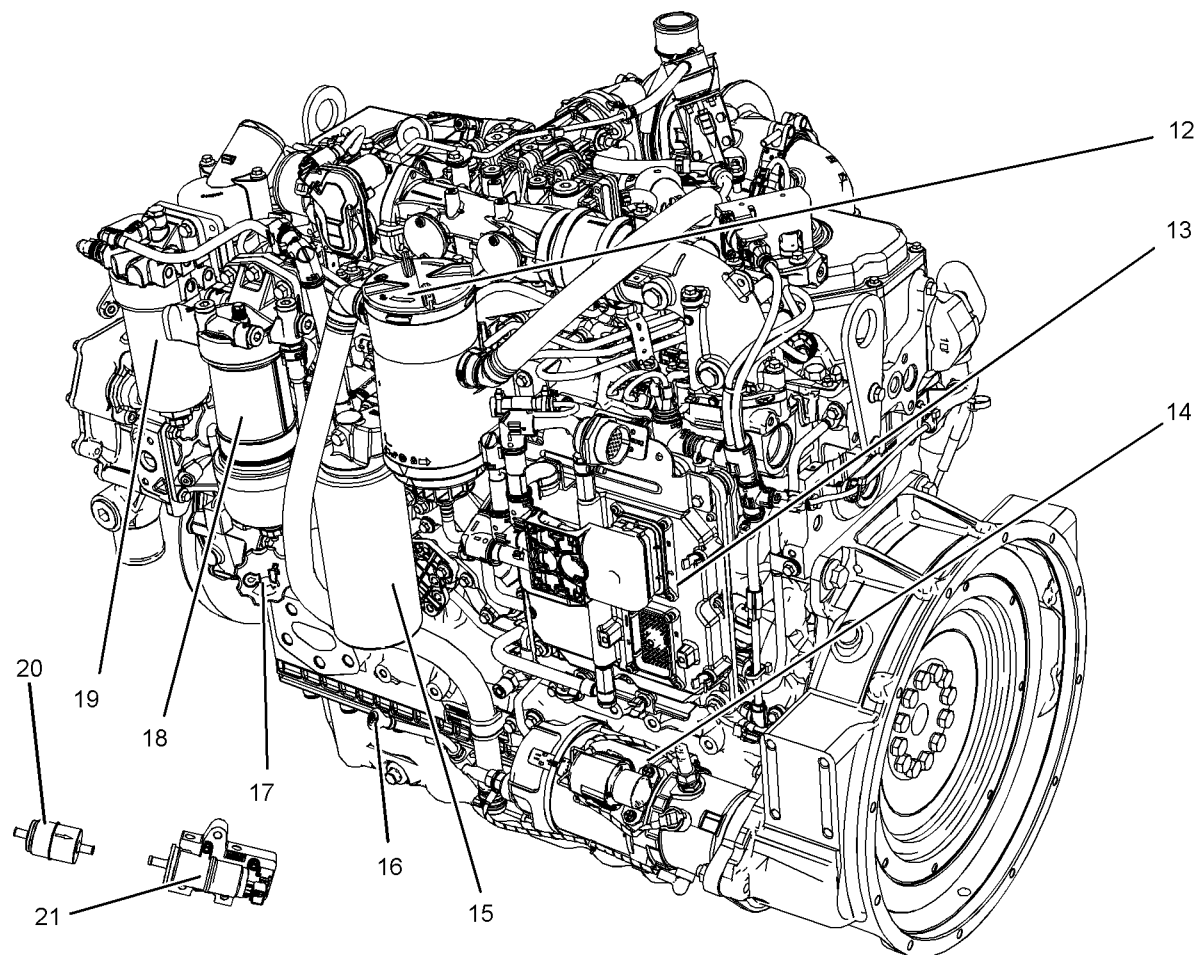


Illustration 18

g02150185

Typical example

(12) Crankcase breather
 (13) Electronic control module (ECM)
 (14) Starting motor
 (15) Oil filter

(16) Oil gauge
 (17) Oil filler
 (18) Primary fuel filter
 (19) Secondary fuel filter

(20) In-line fuel strainer
 (21) Electric fuel priming pump

The location of the in-line fuel strainer (20) and the priming pump (21) will depend on the application.

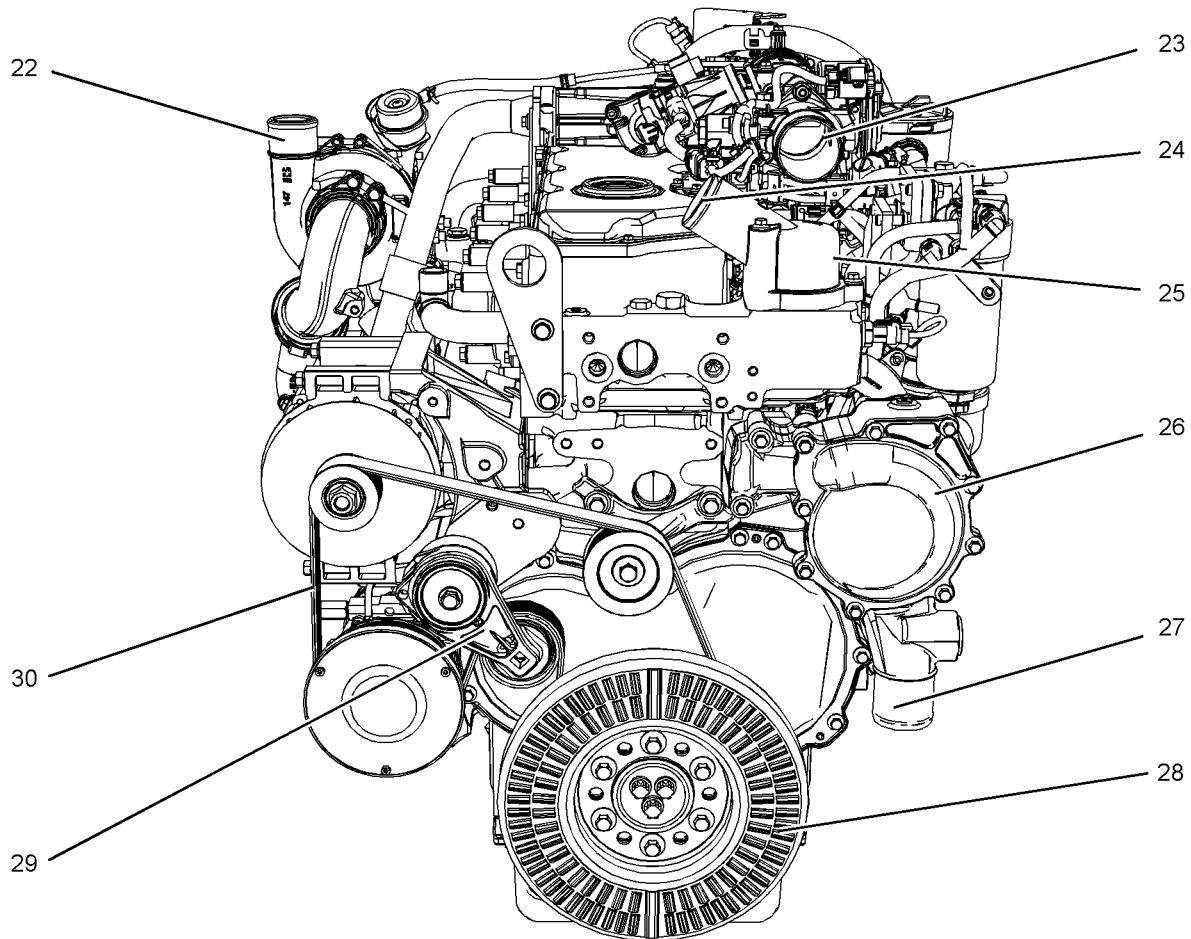


Illustration 19

g02150187

Typical example

(22) Outlet connection to the air to air charge cooler

(23) Connection for the air inlet
(24) Outlet connection for the coolant

(25) Housing for the water temperature regulator

(26) Water pump
(27) Inlet connection for the Coolant

(28) Vibration damper

(29) Belt tensioner
(30) Belt

Engine Aftertreatment System

The following view shows typical features of the engine aftertreatment system. Due to individual applications, your system may appear different from the illustrations.

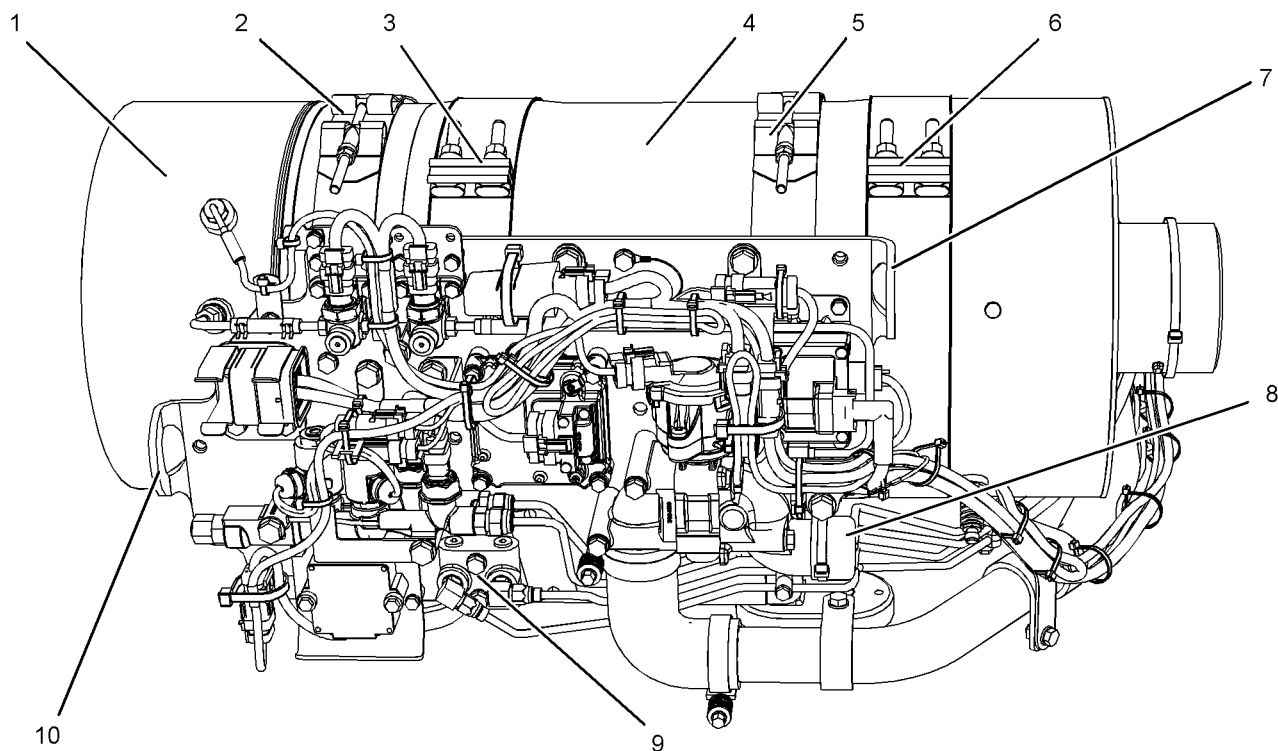


Illustration 20

g02162626

Typical example

- (1) Diesel oxidation catalyst (DOC)
- (2) Securing clamp
- (3) Torca clamp
- (4) Diesel particulate filter (DPF)
- (5) Securing clamp

- (6) Torca clamp
- (7) Lifting eye
- (8) Air inlet for aftertreatment regeneration device (ARD)
- (9) Connections for Coolant manifold

- (10) Lifting eye

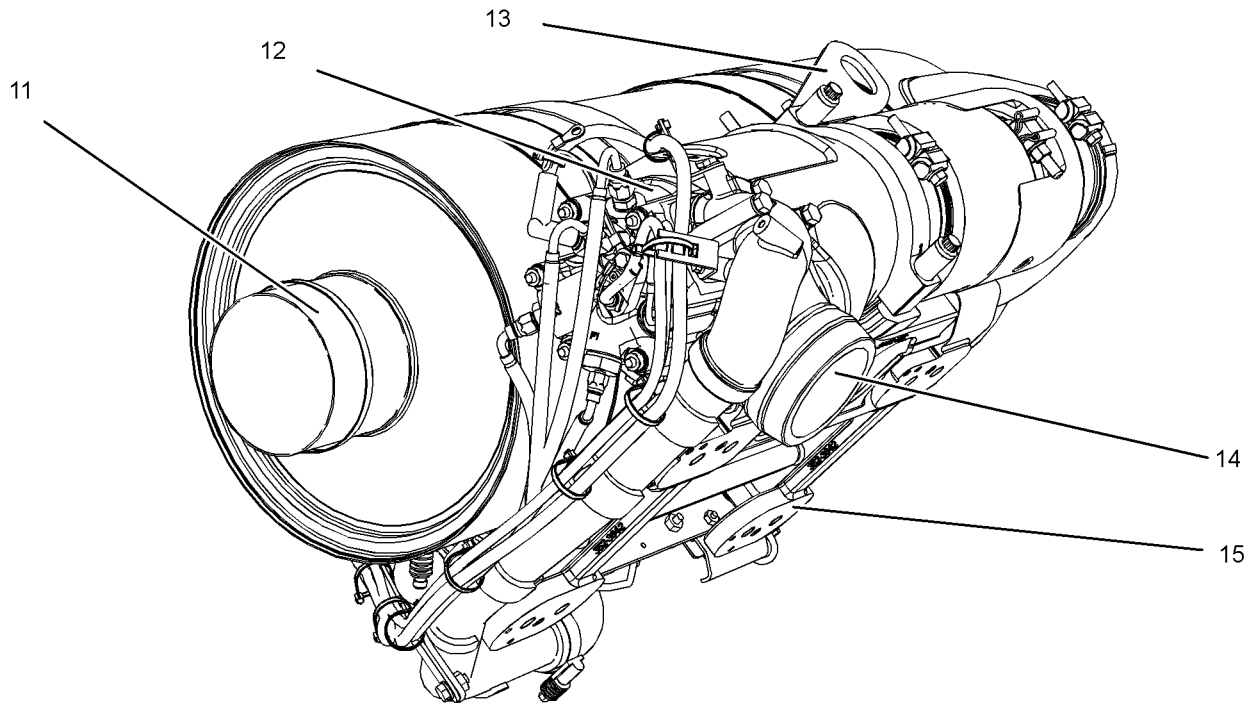


Illustration 21

g02162641

(11) Outlet to exhaust system

(13) Lifting eye

(15) Mounting cradle

(12) Aftertreatment regeneration device

(14) Exhaust Inlet

Fuel Pump for Engine Aftertreatment System

Note: The fuel for the engine aftertreatment system is supplied by a designated fuel pump. The location of this pump can change depending on the application.

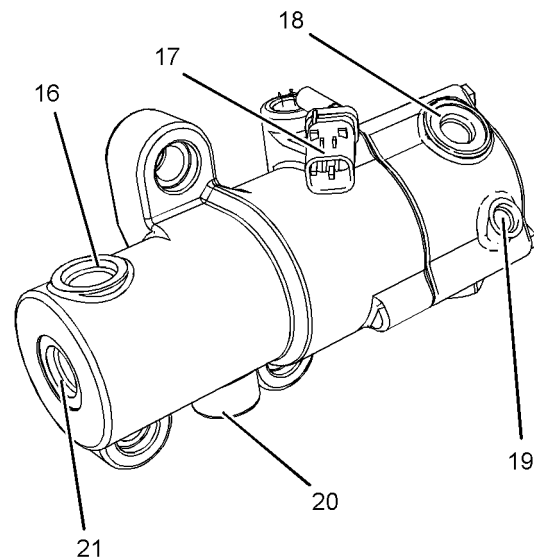


Illustration 22

g02163775

Typical example

(16) Fuel inlet

(17) Electrical connector

(18) Fuel supply line

(19) Return to tank

(20) Fuel inlet

(21) Fuel inlet

i03995541

Engine Description

The Perkins 1206E-E70TTA industrial engine has the following characteristics.

- In-line 6 cylinder
- Four stroke cycle
- Series turbocharged charge cooled

The 1206E-E70TTA industrial engine is equipped with a low-pressure turbocharger and a high-pressure turbocharger.

Engine Specifications

Note: The front end of the engine is opposite the flywheel end of the engine. The left and the right sides of the engine are determined from the flywheel end. The number 1 cylinder is the front cylinder.

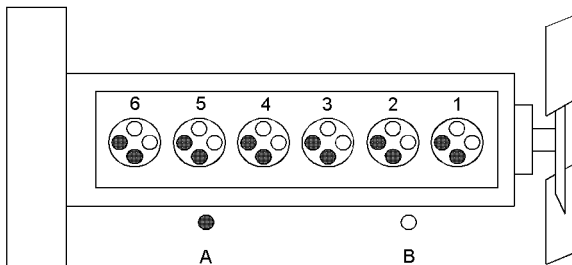


Illustration 23

g01127295

Cylinder and valve location

- (A) Exhaust valves
(B) Inlet valves

Table 1

1206E-E70TTA Engine Specifications	
Operating Range (rpm)	900 to 2800 ⁽¹⁾
Number of Cylinders	6 In-Line
Bore	105 mm (4.13 inch)
Stroke	135 mm (5.31495 inch)
Power	225 kW (301.72 hp)
Aspiration	Turbocharged charge cooled
Compression Ratio	16.5:1
Displacement	7.01 L (428 in ³)
Firing Order	1-5-3-6-2-4
Rotation (flywheel end)	Counterclockwise

⁽¹⁾ The operating rpm is dependent on the engine rating, the application, and the configuration of the throttle.

Electronic Engine Features

The engine operating conditions are monitored. The Electronic Control Module (ECM) controls the response of the engine to these conditions and to the demands of the operator. These conditions and operator demands determine the precise control of fuel injection by the ECM. The electronic engine control system provides the following features:

- Engine monitoring
- Engine speed governing
- Control of the injection pressure
- Cold start strategy
- Automatic air/fuel ratio control
- Torque rise shaping
- Injection timing control
- System diagnostics
- Aftertreatment Regeneration

For more information on electronic engine features, refer to the Operation and Maintenance Manual, "Features and Controls" topic (Operation Section).

Engine Diagnostics

The engine has built-in diagnostics in order to ensure that the engine systems are functioning correctly. The operator will be alerted to the condition by a “Stop or Warning” lamp. Under certain conditions, the engine horsepower and the vehicle speed may be limited. The electronic service tool may be used to display the diagnostic codes.

There are three types of diagnostic codes: active, logged, and event.

Most of the diagnostic codes are logged and stored in the ECM. For additional information, refer to the Operation and Maintenance Manual, “Engine Diagnostics” topic (Operation Section).

The ECM provides an electronic governor that controls the injector output in order to maintain the desired engine rpm.

Engine Cooling and Lubrication

The cooling system and lubrication system consists of the following components:

- Gear-driven centrifugal water pump
- Water temperature regulator which regulates the engine coolant temperature
- Gear-driven rotor type oil pump
- Oil cooler

The engine lubricating oil is supplied by a rotor type oil pump. The engine lubricating oil is cooled and the engine lubricating oil is filtered. The bypass valve can provide unrestricted flow of lubrication oil to the engine if the oil filter element should become plugged.

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.

Engine 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. Reduced hours of operation will increase the length of operating time before an engine overhaul is required.

Aftermarket Products and Perkins Engines

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

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

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.

Aftertreatment System

The aftertreatment system is approved for use by Perkins. In order to be emission-compliant only the approved Perkins aftertreatment system must be used on a Perkins engine.

Product Identification Information

i03567854

Plate Locations and Film Locations

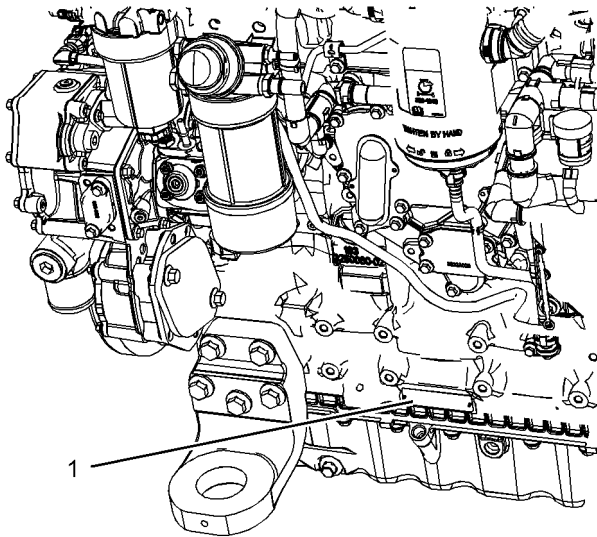


Illustration 24 g01890033
 Location of the serial number plate

Perkins engines are identified by an engine serial number.

An example of an engine number is BL*****U000001J.

***** _____ The list number for the engine

BL _____ Type of engine

U _____ Built in the United Kingdom

000001 _____ Engine Serial Number

J _____ Year of Manufacture

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

The numbers for fuel setting information for electronic engines are stored within the flash file. These numbers can be read by using the electronic service tool.

Serial Number Plate (1)

The engine serial number plate is located on the left side of the cylinder block to the rear of the front engine mounting.



Illustration 25 g01094203
 Serial number plate

i03976148

Plate Locations and Film Locations (Engine Aftertreatment System)

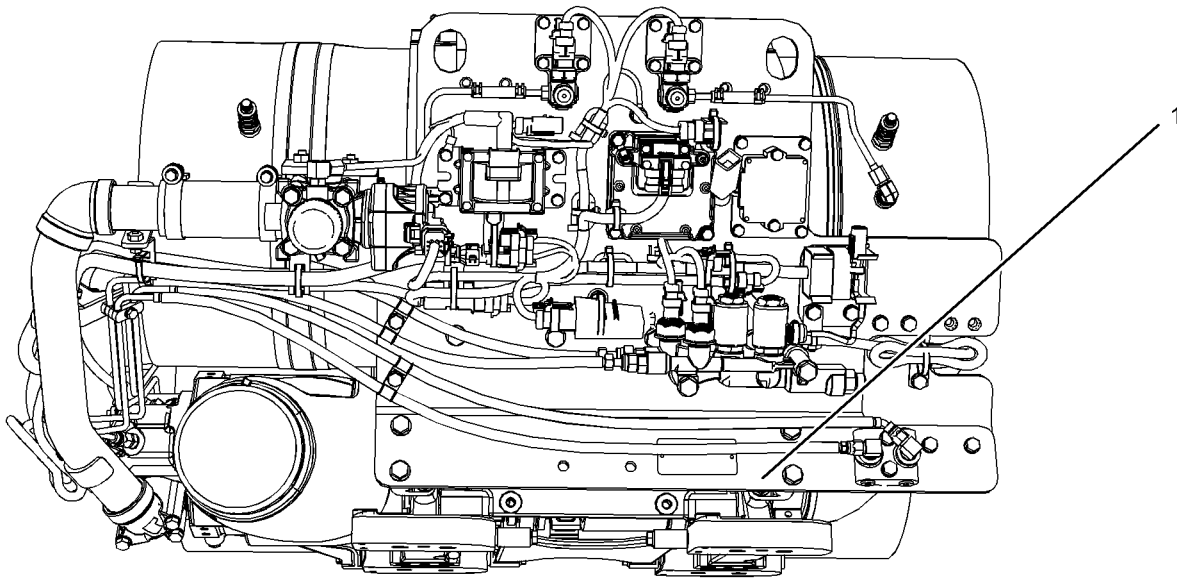


Illustration 26
 Typical example

g02151573

The module arrangement exhaust plate is installed on the mounting plate (1). The location of the arrangement plate mounting plate can alter depending on the application.

i03867276

Reference Numbers

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

Record for Reference

Engine Model _____

Engine Serial number _____

Engine Low Idle rpm _____

Engine Full Load rpm _____

Primary Fuel Filter _____

Water Separator Element _____

Secondary Fuel Filter Element _____

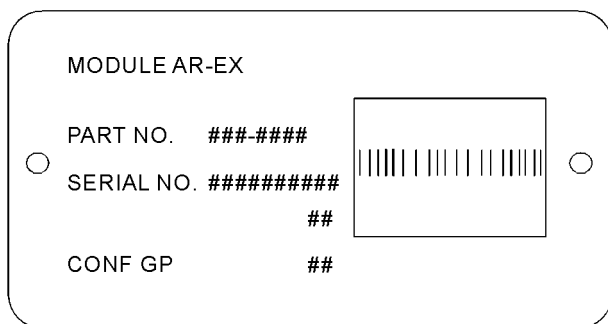


Illustration 27
 Module Arrangement Exhaust Plate

g02109493

Record the information that is on the plate. This information identifies the engine aftertreatment system. This information will be required by your Perkins dealer.

Lubrication Oil Filter Element _____

Auxiliary Oil Filter Element _____

Total Lubrication System Capacity _____

Total Cooling System Capacity _____

Air Cleaner Element _____

Drive Belt _____

Engine Aftertreatment System

Part Number _____

Serial Number _____


i03977815

Emissions Certification Film

Label for compliant engines

An emission label is installed on the front gear cover.

Note: A second emission label may be supplied with the engine. If necessary, the second emission label may be installed on the application by the original equipment manufacturer.

IMPORTANT ENGINE INFORMATION		Perkins	Engine Type
Engine Family: #####13#### #####12#### EPA Family: #####12####		 120R-###6## e11 97/68## #####16#####	Factory Reset if Setting Applicable <input type="checkbox"/> #####9#### <input type="checkbox"/> <input type="checkbox"/> #####9#### <input type="checkbox"/> <input type="checkbox"/> #####9#### <input type="checkbox"/> <input type="checkbox"/> #####9#### <input type="checkbox"/> <input type="checkbox"/> #####9#### <input type="checkbox"/>
EPA Family Max. Values	Advertised kW: ##5## Fuel Rate: ##5##mm ³ /stk Init Timing: #####11####		Settings are to be made with engine at normal operating temperature with transmission in neutral. This engine conforms to ##4# U.S. EPA Regulations for large non-road and stationary C.I. engines and California off-road C.I. engines. Certified to operate on commercially available diesel fuel.
Emissions Control System: #####10#####	Wetto Lash Acid (Lack): Exhaust #8588 Islet #8588	FEL (g/kWh): NOx+EMC: 24588 PM: 04588	Use service tool to verify current engine settings
Hangar No #3#	Position ##4#	LABEL No. 3181A081	

Operation Section

Lifting and Storage

Product Lifting (Engine)

i03977851

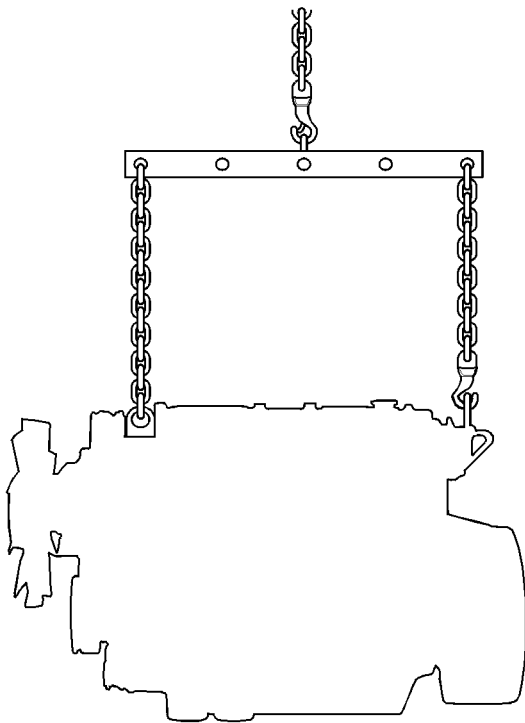


Illustration 29

g01097527

NOTICE

Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

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

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

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

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

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

i03977852

Product Lifting (Clean Emission Module)

NOTICE

Never bend the eyebolts and the brackets. Only load the eyebolts and the brackets under tension. Remember that the capacity of an eyebolt is less as the angle between the supporting members and the object becomes less than 90 degrees.

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

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

Some removals may require lifting the fixtures in order to obtain proper balance and safety.

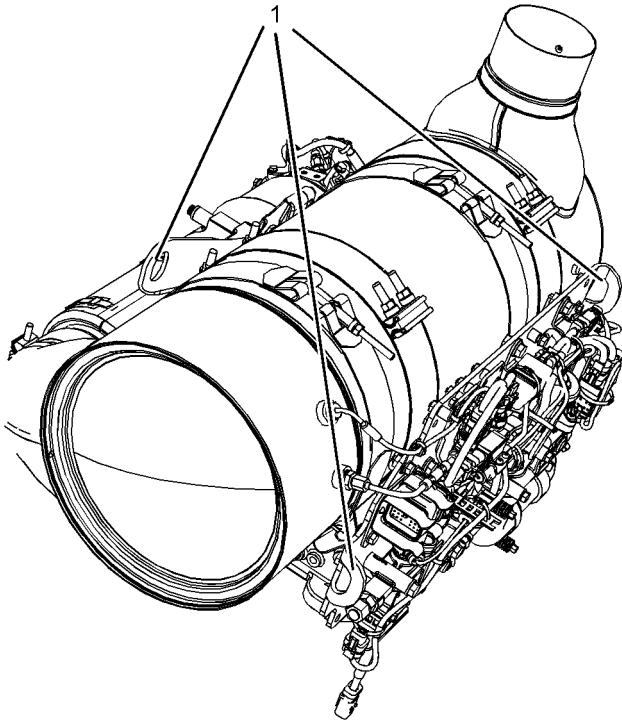


Illustration 30

g02293733

Typical example

To remove the Clean Emission Module (CEM), use lifting eyes (1). Lifting eyes are designed and installed for the specific CEM arrangement. Do not use the lifting eyes for any other purpose than lifting the CEM.

Alterations to the lifting eyes and/or the CEM make the lifting eyes and the lifting fixtures obsolete. If alterations are made, ensure that proper lifting devices are provided. Consult your Perkins dealer, or your Perkins distributor for information regarding fixtures for proper CEM lifting.

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Product Lifting

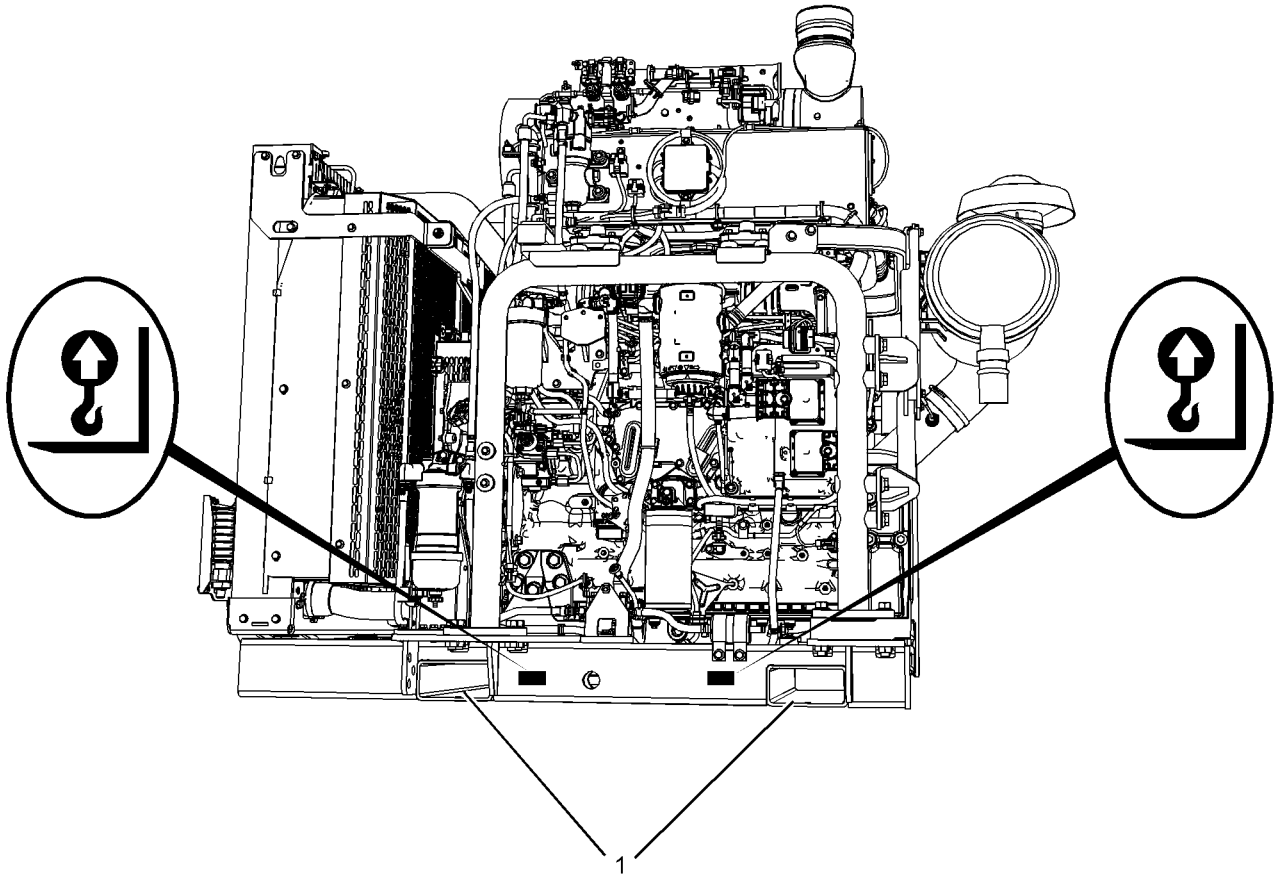


Illustration 31
Typical example

g02354678

The lifting points (1) are for the application shown. A suitable lift truck will be required in order to lift the application.

The lifting eyes on the application will have blanking devices (2) installed.

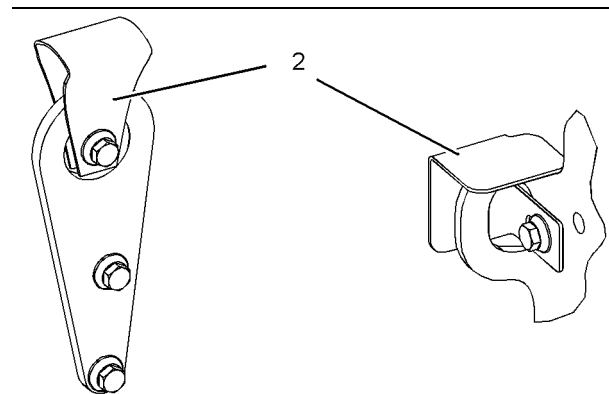


Illustration 32
(A) Typical engine lifting eye
(B) Typical CEM lifting eye

g02354717

In order to lift the clean emission module, refer to this Operation and Maintenance Manual, "Product Lifting (Clean Emission Module)". In order to lift the engine, refer to this Operation and Maintenance Manual, "Product Lifting (Engine)".

i04084189

Product Storage (Engine and Aftertreatment)

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

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

Condition for Storage

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

Storage Period

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

Storage Procedure

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

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

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

3. The engine oil will not need to be drained in order to store the engine. Provided the correct specification of engine oil is used the engine can be stored for up to 6 months. For the correct specification of engine oil refer to this Operation and Maintenance Manual, "Fluid recommendations".
4. Remove the 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 ref to this Operation and Maintenance Manual.

Aftertreatment

No special procedures are required. The exhaust outlet of the aftertreatment should be capped. Before storing, the engine and the aftertreatment must be enclosed in a cover.

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 and aftertreatment.

Ensure that the engine and aftertreatment are covered completely before storage. Log the procedure in the record for the engine.

Gauges and Indicators

i03979889

Gauges and Indicators

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

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

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 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 SAE10W40 is 350 to 450 kPa (50 to 65 psi) at rated rpm.

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

1. Remove the load.
2. Stop the engine.
3. Check and maintain the oil level.



Jacket Water Coolant Temperature – Typical temperature range is 82° to 94°C (179.6° to 169.2°F). This temperature range will vary according to engine load and the ambient temperature.

A 100 kPa (14.5 psi) radiator cap must be installed on the cooling system. The maximum temperature for the cooling system is 108° C (226.4° F). This temperature is measured at the outlet for the water temperature regulator. The engine coolant temperature is regulated by the engine sensors and the engine ECM. This programming cannot be altered. An engine derate can occur if the maximum engine coolant temperature is exceeded.

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 and the engine rpm.
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 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).



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
- Wait to start lamp
- Low oil pressure 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.

The function of the low oil pressure lamp is controlled by the engine ECM. 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.

All lamps will illuminate for 2 seconds in order to check that the lamps are functioning when the keyswitch is turned to the ON position. If any of the lamps stay illuminated, the reason for illumination should be investigated immediately.

Aftertreatment Lamps

For information on the aftertreatment lamp, refer to this Operation and Maintenance Manual, “Diesel Particulate Filter Regeneration”.

Features and Controls

i03552521

Monitoring System (Engine)

Table 2

Warning Lamp	Shutdown Lamp	Lamp Status	Description of Lamp Status	Engine Status
ON	ON	Lamp check	When the engine start switch is turned to the "ON" position both lamps will illuminate for 2 seconds only.	The engine has not been started.
OFF	OFF	No faults	There are no active diagnostic faults.	The engine is running normally.
ON	OFF	Active diagnostic fault	An active diagnostic fault has been detected.	The engine is running normally.
ON	FLASHING	Active diagnostic fault	A serious active diagnostic fault has been detected and an engine derate has been invoked.	The engine is running but the engine has been derated.
FLASHING	OFF	Derate and warning	One or more of the engine protection values has been exceeded.	The engine is running but the engine has been derated.
FLASHING	ON	Engine shutdown	One or more of the engine protection values has been exceeded or a serious active diagnostic fault has been detected.	The engine is shutdown or shutdown is imminent.

i03979949

Monitoring System (Engine)



If the Shutdown mode has been selected and the warning indicator activates, engine shutdown may take as little as 20 seconds from the time the warning indicator is activated. Depending on the application, special precautions should be taken to avoid personal injury. The engine can be restarted following shutdown for emergency maneuvers, if necessary.

NOTICE

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

The following parameters are monitored:

- Coolant temperature
- Intake manifold air temperature
- Intake manifold air pressure
- Oil pressure
- Pressure in the fuel rail
- Fuel temperature
- Fuel filter differential pressure
- Water in fuel
- Engine speed/timing
- Atmospheric pressure (Barometric pressure)
- The Inlet pressure and outlet pressure of the NOx reduction system
- The differential pressure within the NOx reduction system

- Temperature of the NOx reduction system
- The amount of soot in the Diesel particulate filter

Programmable Options and Systems Operation

WARNING

If the Warning/Derate/Shutdown mode has been selected and the warning indicator activates, bring the engine to a stop whenever possible. Depending on the application, special precautions should be taken to avoid personal injury.

The engine can be programmed to the following modes:

“Warning”

The “Warning” lamp and the warning signal (orange lamp) turn “ON” and the warning signal is activated continuously in order to alert the operator that one or more of the engine parameters is not within normal operating range.

“Warning/Derate”

The “Diagnostic” lamp turns “ON” and the warning signal (red lamp) is activated. After the warning, the engine power will be derated. The warning lamp will begin to flash when the derating occurs.

The engine will be derated if the engine exceeds preset operational limits. The engine derate is achieved by restricting the amount of fuel that is available for each injection. The amount of reduction of fuel is dependent on the severity of the fault that has caused the engine derate, typically up to a limit of 50%. This reduction in fuel results in a predetermined reduction in engine power.

“Warning/Derate/Shutdown”

The “Diagnostic” lamp turns “ON” and the warning signal (red lamp) is activated. After the warning, the engine power will be derated. The engine will continue at the rpm of the set derate until a shutdown of the engine occurs. The engine can be restarted after a shutdown for use in an emergency.

A shutdown of the engine may occur in as little as 20 seconds. The engine can be restarted after a shutdown for use in an emergency. However, the cause of the initial shutdown may still exist. The engine may shut down again in as little as 20 seconds.

If there is a signal for low oil pressure or for coolant temperature, there will be a two second delay in order to verify the condition.

For each of the programmed modes, refer to Troubleshooting Guide, “Indicator Lamps” for more information on Indicator Lamps.

For more information or assistance for repairs, consult your Perkins distributor or your Perkins dealer.

Instrument panels and Displays

In order to monitor the engine a wide variety of instrument panels are available. These instrument panels can contain the aftertreatment lamps and the indicator lamps and the gauges for the application. The regeneration switch can be incorporate within the panel.

Also available are mini power displays and performance monitors. These displays and monitors can show the operator the following engine information.

- The system configuration parameters
- The customer specified parameters
- Diagnostic codes
- Event codes
- Coolant temperature
- Oil temperature
- Oil pressure
- Intake temperature
- Intake pressure
- Atmospheric pressure
- Fuel temperature

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Sensors and Electrical Components

Sensor Locations

The illustration within the section shows the typical locations of the sensors for a 1206E-70 Industrial Engine. Specific engines may appear different from the illustration due to differences in applications.

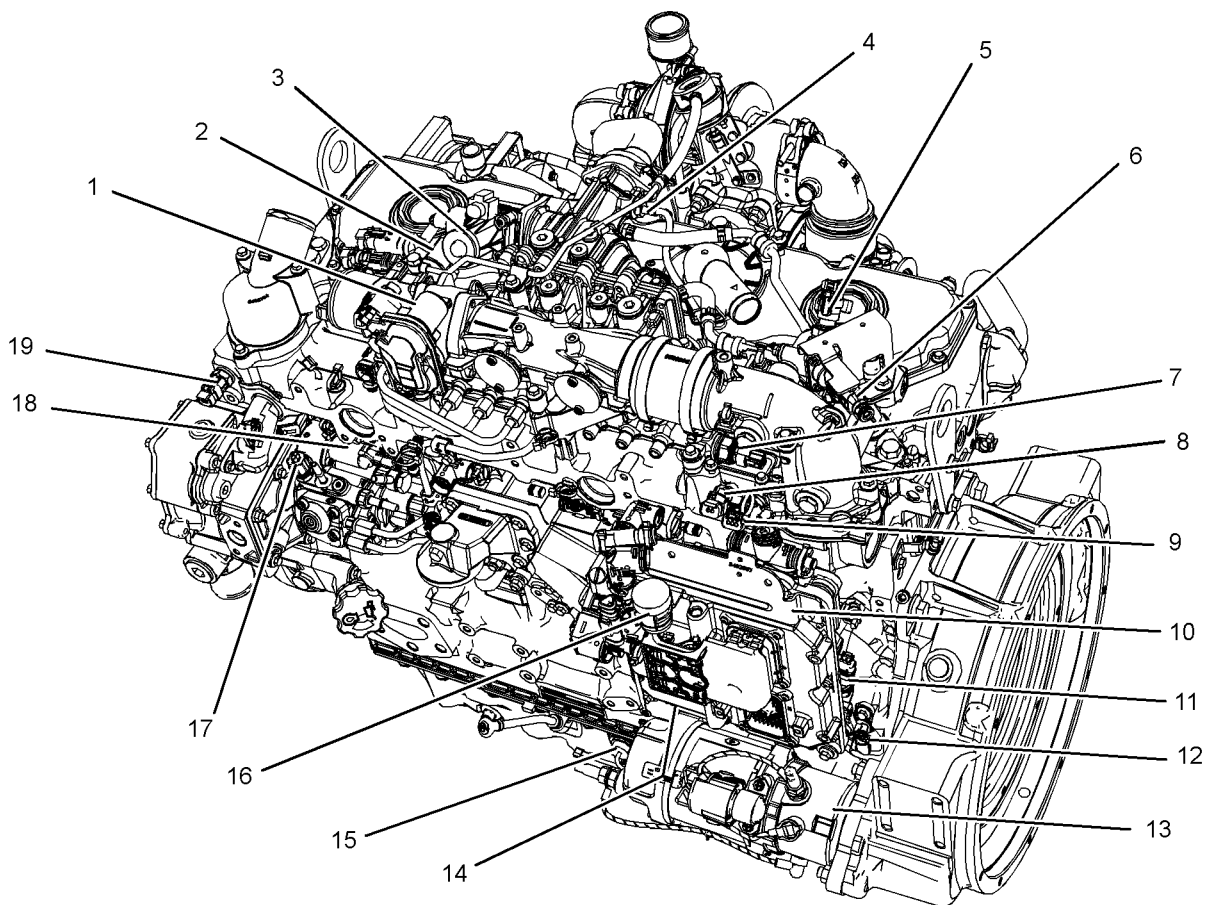


Illustration 33

g02150593

- | | | |
|---|---|---|
| (1) Engine Intake Throttle Valve | (7) Fuel Pressure Sensor (Fuel Rail Pressure Sensor) | (15) Oil level Switch (if Equipped) |
| (2) Wastegate Regulator | (8) Intake Manifold Air Temperature Sensor | (16) Diagnostic Connector |
| (3) Control Valve for the NOx Reduction System (NRS) | (9) Intake Manifold Pressure Sensor | (17) Fuel Temperature Sensor |
| (4) Temperature Sensor for the NOx Reduction System | (10) Electronic Control Module (ECM) | (18) Solenoid for the High Pressure Fuel Pump |
| (5) Intake Pressure Sensor for the NOx Reduction System (NRS) | (11) Atmospheric Pressure Sensor (Barometric Pressure Sensor) | (19) Coolant Temperature Sensor |
| (6) Differential Pressure Sensor for the NOx Reduction System (NRS) | (12) Primary Speed/Timing Sensor | |
| | (13) Starting Motor | |
| | (14) Oil Pressure Sensor | |

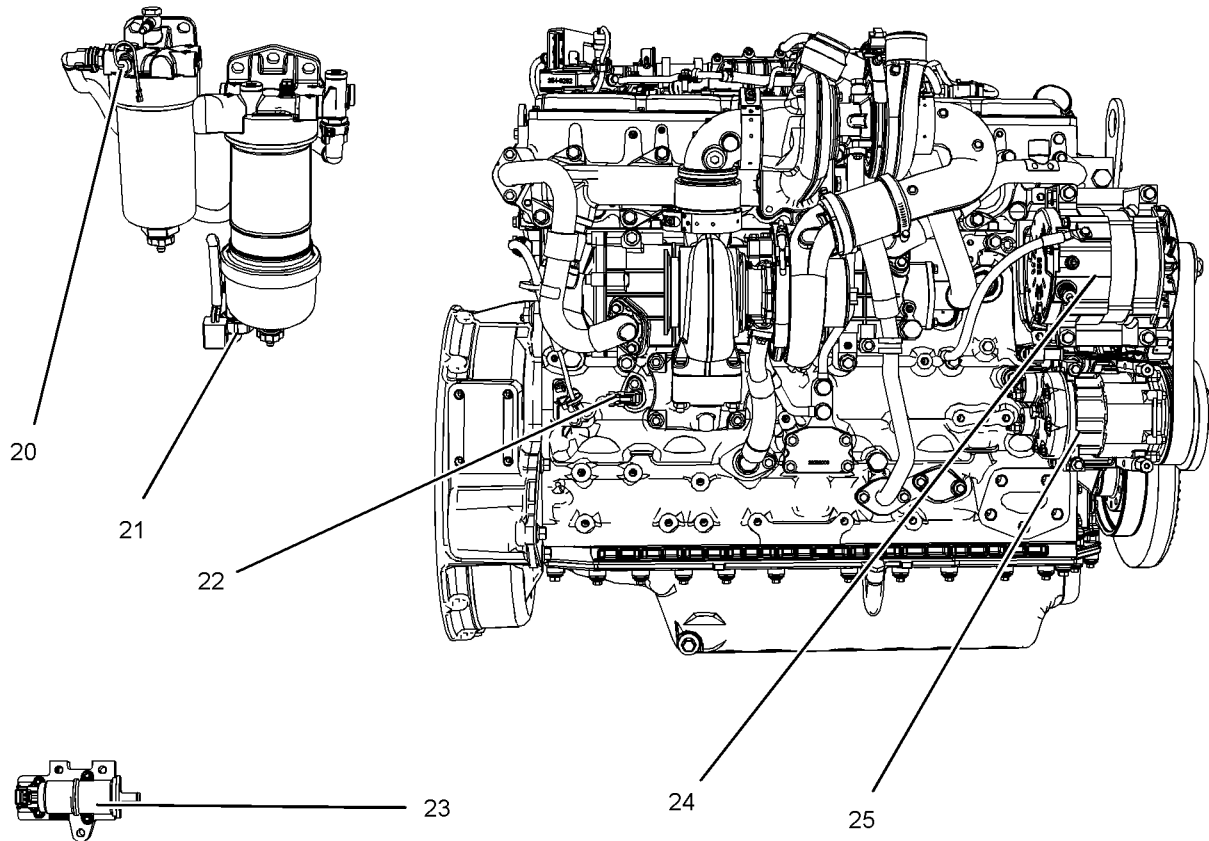


Illustration 34

g02150594

The location of the fuel filters will depend on the application.

(20) Differential Pressure Switch for the
Secondary Fuel Filter
(21) Water in Fuel Switch

(22) Secondary Speed/Timing Sensor
(23) Fuel Priming Pump
(24) Alternator

(25) Refrigerant Compressor (if equipped)

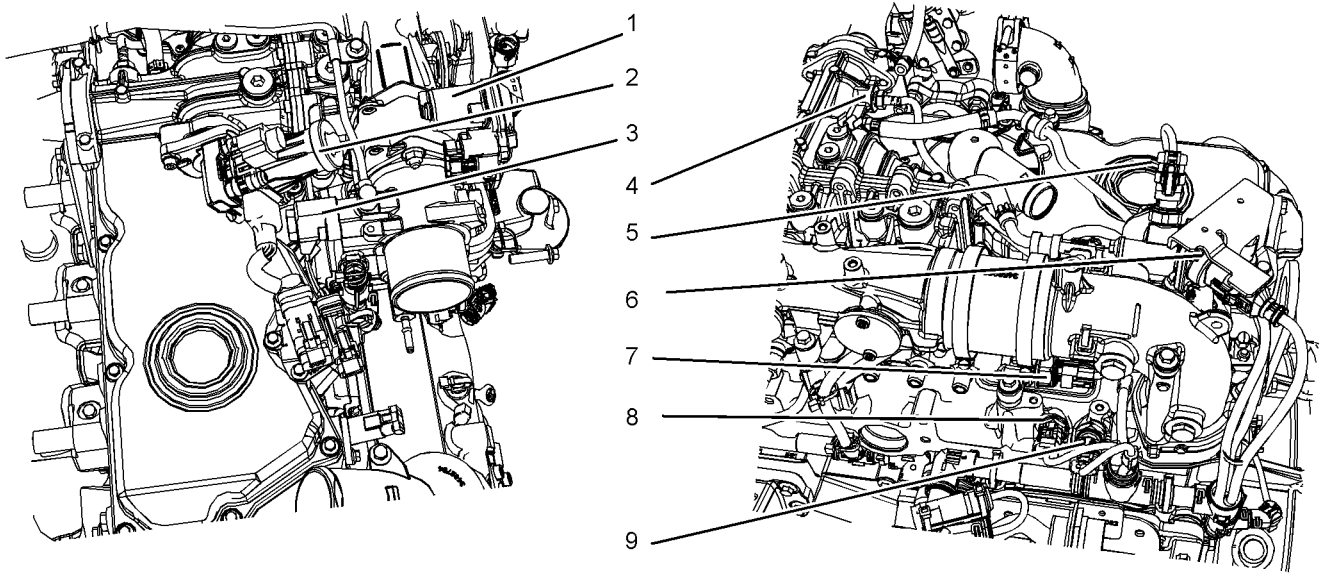


Illustration 35

g02151173

- | | | |
|------------------------------------|--|--|
| (1) Engine Intake Throttle Valve | (5) Intake Pressure Sensor for the NRS | (8) Intake Manifold Air Temperature Sensor |
| (2) Wastegate Regulator | (6) Differential Pressure Sensor for the NRS | (9) Intake Manifold Pressure Sensor |
| (3) Control Valve for the NRS | (7) Fuel Pressure Sensor (Fuel Rail Pressure Sensor) | |
| (4) Temperature Sensor for the NRS | | |

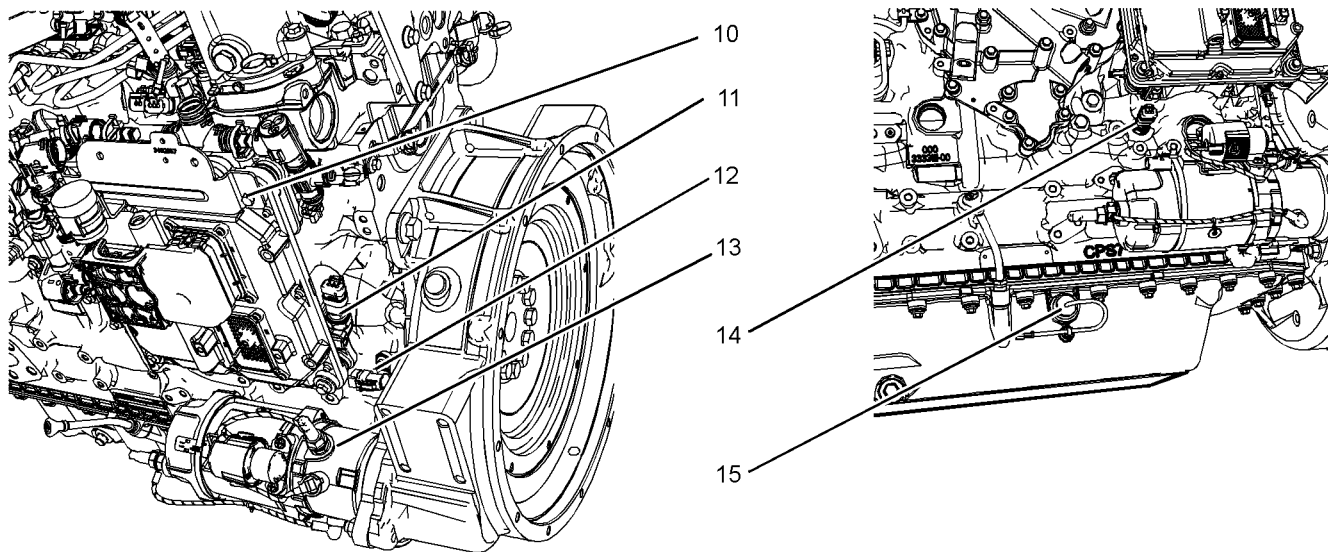


Illustration 36

g02151174

- | | | |
|---|----------------------------------|-------------------------------------|
| (10) Electronic Control Module (ECM) | (12) Primary Speed/Timing Sensor | (15) Oil Level Switch (if Equipped) |
| (11) Atmospheric Pressure Sensor (Barometric Pressure Sensor) | (13) Starting Motor | |
| | (14) Oil Pressure Sensor | |

The oil level switch (15) will only operate with the application on level ground and the power in the ON position. The engine must be at zero RPM. A coolant level switch can be installed, this switch only operates at key on, and the application must be on level ground.

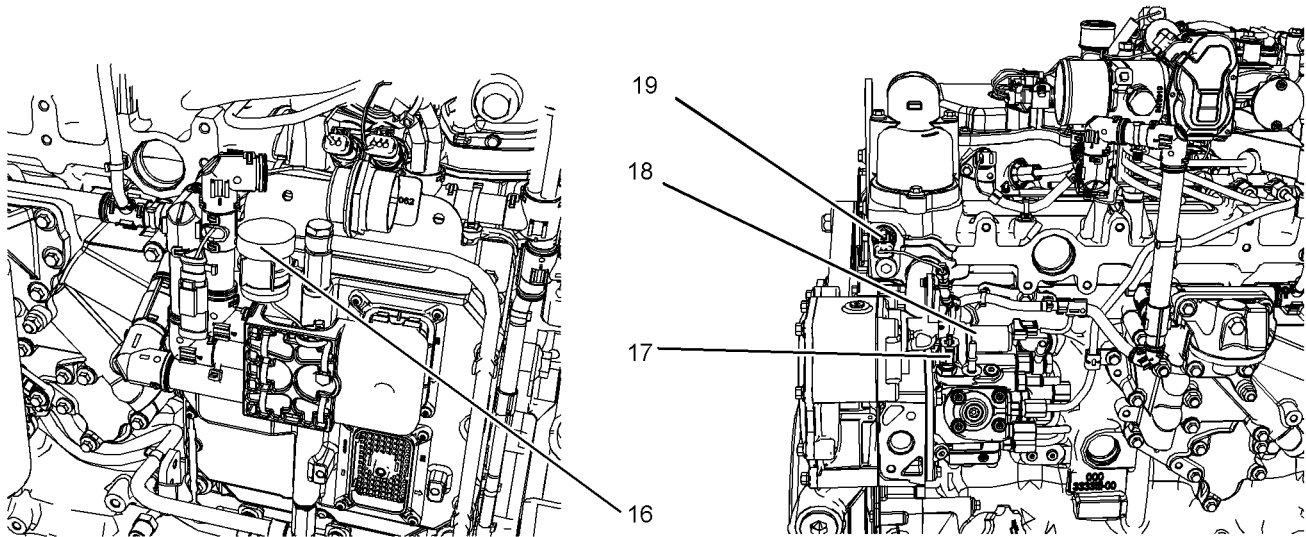


Illustration 37

g02151327

(16) Diagnostic Connector
(17) Fuel Temperature Sensor

(18) Solenoid for the High Pressure Fuel
Pump

(19) Coolant Temperature Sensor

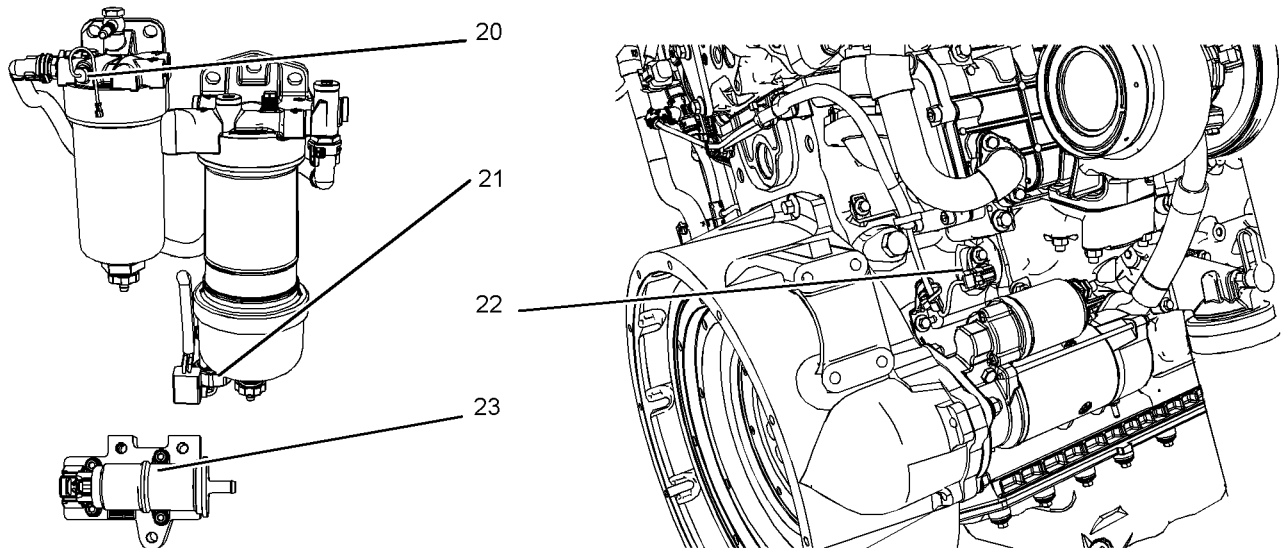


Illustration 38

g02151177

(20) Differential Pressure Switch for the
Secondary Fuel Filter

(21) Water in Fuel Switch
(22) Secondary Speed/Timing Sensor

(23) Fuel Priming Pump

Programmable Monitoring System (PMS)

The Programmable Monitoring System determines the level of action that is taken by the Engine Control Module (ECM) (10). In response to a condition that can damage the engine. These conditions are identified by the ECM from the signals that are produced from the following sensors.

- Coolant Temperature Sensor
- Intake Manifold Air Temperature Sensor
- Intake Manifold Pressure Sensor
- Fuel Pressure Sensor
- Engine Oil Pressure Sensor
- Primary Speed/Timing Sensor
- Secondary Speed/Timing Sensor

-
- Fuel Temperature Sensor
 - Temperature Sensor for the NRS
 - Intake Pressure Sensor for the NRS
 - Differential Pressure Sensor for the NRS

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Sensors and Electrical Components (Aftertreatment)

The following view shows typical features of the engine aftertreatment system. Due to individual applications, your system may appear different from the illustrations.

- **Glossary**
- ARD Aftertreatment Regeneration Device
- DOC Diesel Oxidation Catalyst

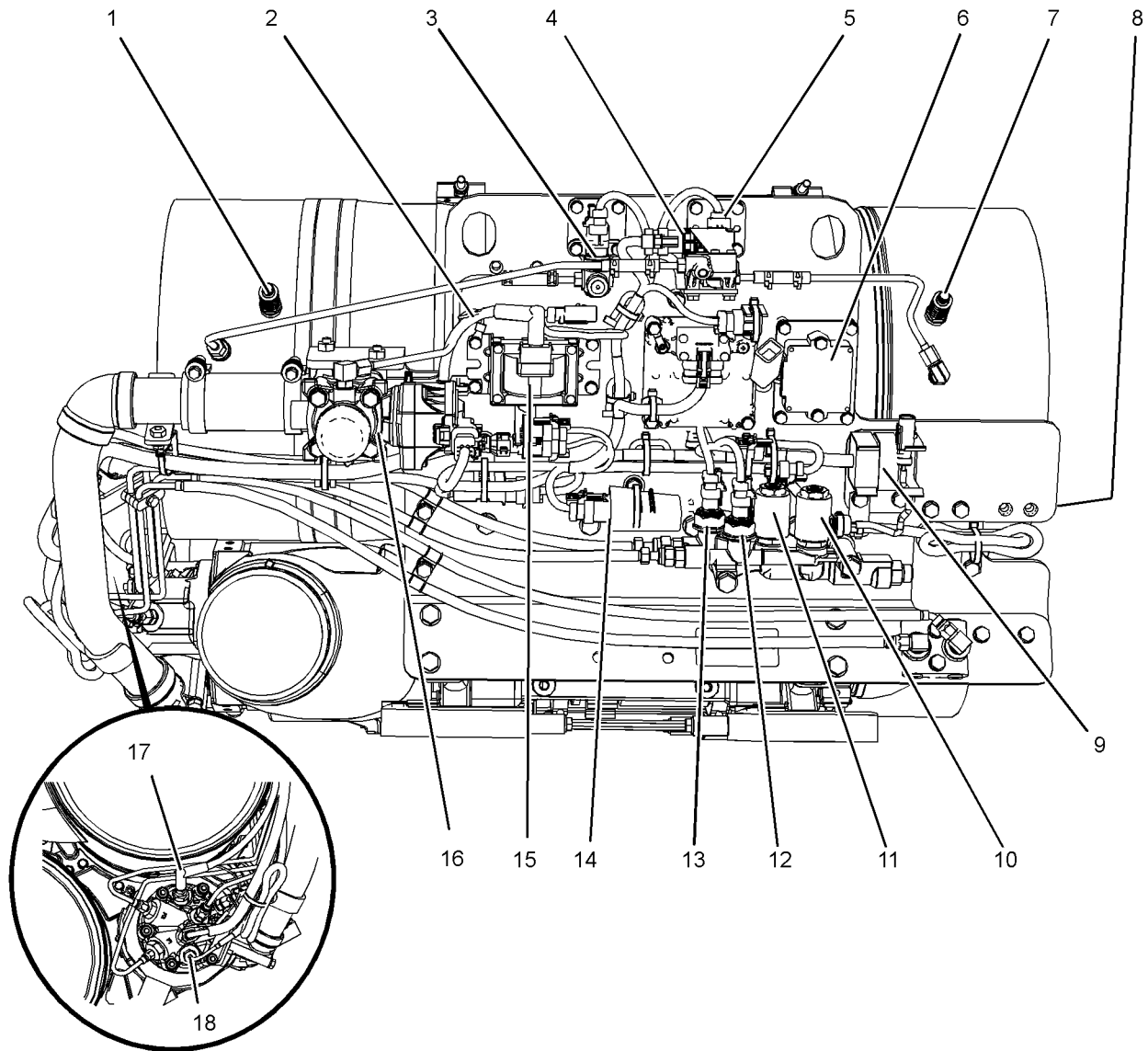


Illustration 39

g02313693

Typical example

- (1) Soot sensor connection
- (2) Spark plug lead
- (3) ARD air pressure sensor
- (4) DOC pressure sensor
- (5) Pressure differential sensor
- (6) Relay
- (7) Soot sensor connection
- (8) DOC Temperature sensor (not shown)
- (9) Harness connector
- (10) Main fuel valve (If equipped)
- (11) Pilot fuel valve
- (12) Fuel pressure sensor (if equipped)
- (13) Fuel pressure sensor (pilot)
- (14) Aftertreatment device ID
- (15) Coil for spark plug
- (16) ARD air control valve
- (17) Location of spark plug
- (18) ARD exhaust gas temperature sensor

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Engine Shutoffs and Engine Alarms

Shutoffs

The shutoffs are electrically operated or mechanically operated. The electrically operated shutoffs are controlled by the ECM.

Shutoffs are set at critical levels for the following items:

- Operating temperature
- Operating pressure
- Operating level
- 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

The alarms are electrically operated. The operations of the alarms are controlled by the ECM.

The alarm is operated by a sensor or by a switch. When the sensor or the switch is activated, a signal is sent to the ECM. An event code is created by the ECM. The ECM will send a signal in order to illuminate the lamp.

Your engine may be equipped with the following sensors or switches:

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

Intake manifold air temperature – The intake manifold air temperature sensor indicates high intake air temperature.

Intake manifold pressure – The intake manifold pressure sensor checks the rated pressure in the engine manifold.

Fuel rail pressure – The fuel rail pressure sensor checks for high pressure or low pressure in the fuel rail.

Engine oil pressure – The engine oil pressure sensor indicates when oil pressure drops below rated system pressure, at a set engine speed.

Engine overspeed – If, the engine rpm exceeds the overspeed setting the alarm will be activated.

Air filter restriction – The switch checks the air filter when the engine is operating.

User-defined switch – This switch can shut down the engine remotely.

Water in fuel switch – This switch checks for water in the primary fuel filter when the engine is operating.

Fuel temperature – The fuel temperature sensor monitors the pressurized fuel in the high-pressure fuel pump.

Fuel differential pressure – This switch checks the pressure across the fuel filter.

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.

Note: If installed, the coolant level switch and the oil level switch are indicators. Both switches operate when the application is on level ground and the engine RPM at zero.

Testing

Turning the keyswitch to the ON position will check the indicator lights on the control panel. All the indicator lights will be illuminated for 2 seconds after the keyswitch is operated. Replace suspect bulbs immediately.

Refer to Troubleshooting, KENR9106 for more information.

i03554501

Overspeed

- ECM _____ Electronic Control Module
- RPM _____ Revolutions Per Minute

An overspeed is detected by the speed/timing sensors.

The default setting for an overspeed is 3000 rpm. The ECM will cut the power to the electronic unit injectors, until the rpm drops below 200 rpm of the overspeed setting. A diagnostic fault code will be logged into the ECM memory and a warning lamp will indicate a diagnostic fault code.

An overspeed can be set from 2600 rpm to 3000 rpm. This setting depends on the application.

Engine Diagnostics

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Self-Diagnostics

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Perkins electronic engines have the capability to perform a self-diagnostics test. When the system detects an active problem, a diagnostic lamp is activated. Diagnostic codes will be stored in permanent memory in the Electronic Control Module (ECM). The diagnostic codes can be retrieved by using the electronic service tool. Refer to Troubleshooting , “Electronic Service Tools” for further information.

Some installations have electronic displays that provide direct readouts of the engine diagnostic codes. Refer to the manual that is provided by the OEM for more information on retrieving engine diagnostic codes. Alternatively refer to Troubleshooting , “Indicator Lamps” for further information.

Active codes represent problems that currently exist. These problems should be investigated first.

Logged codes represent the following items:

- Intermittent problems
- Recorded events
- Performance history

The problems may have been repaired since the logging of the code. These codes do not indicate that a repair is needed. The codes are guides or signals when a situation exists. Codes may be helpful to troubleshoot problems.

When the problems have been corrected, the corresponding logged fault codes should be cleared.

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Diagnostic Lamp

A diagnostic lamp is used to indicate the existence of an active fault. Refer to Troubleshooting , “Indicator Lamps” for more information. A fault diagnostic code will remain active until the problem is repaired. The diagnostic code may be retrieved by using the electronic service tool. Refer to Troubleshooting , “Electronic Service Tools” for more information.

Diagnostic Flash Code Retrieval

In order to read the diagnostic flash codes through the diagnostic lamp, cycle the key switch from off to on twice within 3 seconds.

The codes will be flashing in sequence. For example if the flash code equals 133, the diagnostic lamp will flash once, pause, flash three times, pause, and flash three times.

After the complete code has flashed, a 3 second pause will take place before the next code will begin to flash (if another code is present).

Note: For more information refer to Troubleshooting manual.

Table 3

CDL Code	Description	J1939 Code	Flash Code
N/A	No Diagnostic Code Detected	N/A	551
1-2	Cylinder #1 Injector data incorrect	651-2	111
1-5	Cylinder #1 Injector current below normal	651-5	
1-6	Cylinder #1 Injector current above normal	651-6	
2-2	Cylinder #2 Injector data incorrect	652-2	112
2-5	Cylinder #2 Injector current below normal	652-5	
2-6	Cylinder #2 Injector current above normal	652-6	
3-2	Cylinder #3 Injector data incorrect	653-2	113
3-5	Cylinder #3 Injector current below normal	653-5	
3-6	Cylinder #3 Injector current above normal	653-6	
4-2	Cylinder #4 Injector data incorrect	654-2	114
4-5	Cylinder #4 Injector current below normal	654-5	
4-6	Cylinder #4 Injector current above normal	654-6	
5-2	Cylinder #5 Injector data incorrect	655-2	115
5-5	Cylinder #5 Injector current below normal	655-5	
5-6	Cylinder #5 Injector current above normal	655-6	
6-2	Cylinder #6 Injector data incorrect	656-2	116
6-5	Cylinder #6 Injector current below normal	656-5	
6-6	Cylinder #6 Injector current above normal	656-6	
18-5	Fuel Control Valve current below normal	1076-5	-
18-6	Fuel Control Valve current above normal	1076-6	-
41-3	8 Volt DC Supply voltage above normal	678-3	517
41-4	8 Volt DC Supply voltage below normal	678-4	
91-2	Throttle Position Sensor erratic, intermittent, or incorrect	91-2	154
91-3	Throttle Position Sensor voltage above normal	91-3	
91-4	Throttle Position Sensor voltage below normal	91-4	
91-8	Throttle Position Sensor abnormal frequency, pulse width, or period	91-08	
100-3	Engine Oil Pressure Sensor voltage above normal	100-3	157
100-4	Engine Oil Pressure Sensor voltage below normal	100-4	
100-21	Engine Oil Pressure Sensor data drifted low	100-21	
110-3	Engine Coolant Temperature Sensor voltage above normal	110-3	168
110-4	Engine Coolant Temperature Sensor voltage below normal	110-4	
168-2	Electrical System Voltage erratic, intermittent, or incorrect	168-2	511
168-3	Electrical System Voltage voltage above normal	168-3	
168-4	Electrical System Voltage voltage Below normal	168-4	
172-3	Intake Manifold Air Temperature Sensor voltage above normal	105-3	133
172-4	Intake Manifold Air Temperature Sensor voltage below normal	105-4	

(continued)

(Table 3, contd)

CDL Code	Description	J1939 Code	Flash Code
174-3	Fuel Temperature Sensor voltage above normal	174-3	165
174-4	Fuel Temperature Sensor voltage below normal	174-4	
190-8	Engine Speed Sensor abnormal frequency, pulse width, or period	190-8	141
247-9	SAE J1939 Data Link abnormal update rate	-	514
253-2	Personality Module erratic, intermittent, or incorrect	631-2	415
261-11	Engine Timing Offset fault	637-11	143
262-3	5 Volt Sensor DC Power Supply voltage above normal	3509-3	516
262-4	5 Volt Sensor DC Power Supply voltage below normal	3509-4	
268-2	Programmed Parameter Fault erratic, intermittent, or incorrect	630-2	527
274-3	Atmospheric Pressure Sensor voltage above normal	108-3	152
274-4	Atmospheric Pressure Sensor voltage below normal	108-4	
274-13	Atmospheric Pressure Sensor calibration required	108-13	
274-21	Atmospheric Pressure Sensor data drifted low	108-21	
342-8	Secondary Engine Speed Sensor abnormal frequency, pulse width, or period	723-8	142
526-5	Turbo Wastegate Drive current below normal	1188-5	177
526-6	Turbo Wastegate Drive current above normal	1188-6	
535-3	Exhaust Temperature Sensor voltage above normal	3241-3	185
535-4	Exhaust Temperature Sensor voltage below normal	3241-4	
774-2	Secondary Throttle Position Sensor erratic, intermittent, or incorrect	29-2	155
774-3	Secondary Throttle Position Sensor voltage above normal	29-3	
774-4	Secondary Throttle Position Sensor voltage below normal	29-4	
774-8	Secondary Throttle Position Sensor abnormal frequency, pulse width, or period	29-8	
993-2	DPF Active Regeneration Inhibited Due to Inhibit Switch	3703-31	-
1262-2	Engine Throttle Actuator 1 Control Command not responding properly	3464-7	-
1634-2	Idle Validation Switch #1 erratic, intermittent or incorrect	558-2	245
1635-2	Idle Validation Switch #2 erratic, intermittent or incorrect	2970-2	246
1639-9	Machine Security System Module abnormal update rate	1196-9	
1743-2	Engine Operation Mode Selector Switch erratic, intermittent, or incorrect	2882-2	144
1785-3	Intake Manifold Pressure Sensor voltage above normal	3563-3	197
1785-4	Intake Manifold Pressure Sensor voltage below normal	3563-4	
1785-13	Intake Manifold Pressure Sensor calibration required	3563-13	
1785-21	Intake Manifold Pressure Sensor data drifted low	3563-21	
1797-3	Fuel Rail Pressure Sensor voltage above normal	157-3	159
1797-4	Fuel Rail Pressure Sensor voltage below normal	157-4	
1797-7	Fuel Rail Pressure Sensor not responding properly	157-7	
1834-2	Ignition Key Switch loss of signal	158-2	429
2131-3	5 Volt Sensor DC Power Supply #2 voltage above normal	3510-3	528
2131-4	5 Volt Sensor DC Power Supply #2 voltage below normal	3510-4	

(continued)

(Table 3, contd)

CDL Code	Description	J1939 Code	Flash Code
2246-6	Glow Plug Start Aid Relay current above normal	676-6	199
2417-5	Ether Injection Control Solenoid current below normal	626-5	233 233
2417-6	Ether Injection Control Solenoid current above normal	626-6	
2452-3	DPF #1 Intake Temperature Sensor voltage above normal	3242-3	224
2452-4	DPF #1 Intake Temperature Sensor voltage below normal	3242-4	224
2458-3	DPF #1 Differential Pressure Sensor : voltage above normal	3251-3	222
2458-4	DPF #1 Differential Pressure Sensor : voltage below normal	3251-4	222
2460-3	ARD Fuel Pressure #1 Sensor voltage above normal	3480-3	219
2460-4	ARD Fuel Pressure #1 Sensor voltage below normal	3480-4	219
2461-5	ARD Fuel Pressure #1 Control current below normal	3479-5	216
2461-6	ARD Fuel Pressure #1 Control current above normal	3479-6	
2465-5	Aftertreatment #1 Ignition Transformer Primary current below normal	3484-5	243
2465-6	Aftertreatment #1 Ignition Transformer Primary current above normal	3484-6	
2489-5	ARD Air Pressure Control Actuator current below normal	3487-5	211
2489-6	ARD Air Pressure Control Actuator current above normal	3487-6	
2490-3	ARD Air Pressure Control Actuator Position Sensor voltage above normal	3488-3	212
2490-4	ARD Air Pressure Control Actuator Position Sensor voltage below normal	3488-4	
2498-3	ARD Supply Air Pressure Sensor voltage above normal	3837-3	-
2498-4	ARD Supply Air Pressure Sensor voltage below normal	3837-4	-
2498-13	ARD Supply Air Pressure Sensor calibration required	3837-13	-
2498-21	ARD Supply Air Pressure Sensor data drifted low	3837-21	-
2526-3	Air Inlet Temperature Sensor voltage above normal	172-3	232
2526-4	Air Inlet Temperature Sensor voltage below normal	172-4	232
3180-5	Aftertreatment #1 Ignition Transformer Secondary current below normal	4265-5	244
3180-6	Aftertreatment #1 Ignition Transformer Secondary current above normal	4265-6	
3182-5	Aftertreatment #1 Fuel Injector #1 Heater current below normal	5425-5	215
3182-6	Aftertreatment #1 Fuel Injector #1 Heater current above normal	5425-6	
3385-3	Engine Exhaust Gas Recirculation Intake Pressure Sensor voltage above normal	3358-3	231
3385-4	Engine Exhaust Gas Recirculation Intake Pressure Sensor voltage below normal	3358-4	
3385-13	Engine Exhaust Gas Recirculation Intake Pressure Sensor calibration required	3358-13	
3385-21	Engine Exhaust Gas Recirculation Intake Pressure Sensor data drifted low	3358-21	
3386-3	Engine Exhaust Gas Recirculation Intake Pressure Sensor voltage above normal	412-3	227
3386-4	Engine Exhaust Gas Recirculation Intake Pressure Sensor voltage below normal	412-4	

(continued)

(Table 3, contd)

CDL Code	Description	J1939 Code	Flash Code
3397-2	DPF #1 Soot Loading Sensor : Erratic, Intermittent, or Incorrect	4783-2	226
3397-3	DPF #1 Soot Loading Sensor : Voltage Above Normal	4783-3	
3397-4	DPF #1 Soot Loading Sensor : Voltage Below Normal	4783-4	
3397-9	DPF #1 Soot Loading Sensor abnormal update rate	4783-9	
3397-12	DPF #1 Soot Loading Sensor failure	4783-12	
3397-13	DPF #1 Soot Loading Sensor calibration required	4783-13	
3397-19	DPF #1 Soot Loading Sensor data error	4783-19	
3397-21	DPF #1 Soot Loading Sensor data drifted low	4783-21	
3405-5	Engine Exhaust Gas Recirculation Valve Control current below normal	2791-5	228
3405-6	Engine Exhaust Gas Recirculation Valve Control current above normal	2791-6	229
3407-3	Engine Exhaust Gas Recirculation Valve Position Sensor voltage above normal	27-3	
3407-4	Engine Exhaust Gas Recirculation Valve Position Sensor voltage below normal	27-4	
3427-5	Aftertreatment Fuel Pump Relay current below normal	5423-5	218
3427-6	Aftertreatment Fuel Pump Relay current above normal	5423-6	218
3464-3	DPF #1 Intake Pressure Sensor voltage above normal	3609-3	223
3464-4	DPF #1 Intake Pressure Sensor voltage below normal	3609-4	
3464-13	DPF #1 Intake Pressure Sensor calibration required	3609-13	
3464-21	DPF #1 Intake Pressure Sensor data drifted low	3609-21	
3468-2	Aftertreatment #1 Identification Number Module erratic, intermittent, or incorrect	5576-2	-
3468-8	Aftertreatment #1 Identification Number Module abnormal frequency, pulse width, or period	5576-8	-
3468-14	Aftertreatment #1 Identification Number Module special instruction	5576-14	-
3511-3	Engine Exhaust Gas Recirculation Outlet Pressure Sensor voltage above normal	5019-3	247
3511-4	Engine Exhaust Gas Recirculation Outlet Pressure Sensor voltage below normal	5019-4	
3511-13	Engine Exhaust Gas Recirculation Outlet Pressure Sensor calibration required	5019-13	
3511-21	Engine Exhaust Gas Recirculation Outlet Pressure Sensor data drifted low	5019-21	
3514-5	Engine Throttle Actuator Control Command current below normal	3464-5	-
3514-6	Engine Throttle Actuator Control Command current above normal	3464-6	-
3515-3	Engine Throttle Valve Position Sensor voltage above normal	51-3	252
3515-4	Engine Throttle Valve Position Sensor voltage below normal	51-4	
Event Codes			
E172-1	High Air Filter Restriction - Warning	107-15	151
E232-1	High Fuel/Water Separator Water Level - Warning	97-17	-
E360-1	Low Engine Oil Pressure - Warning	100-17	157
E360-3	Low Engine Oil Pressure - Shutdown	100-01	

(continued)

(Table 3, contd)

CDL Code	Description	J1939 Code	Flash Code
E361-1	High Engine Coolant Temperature - Warning	110-15	168
E361-2	High Engine Coolant Temperature - Derate	110-16	
E361-3	High Engine Coolant Temperature - Shutdown	110-0	
E362-1	Engine Overspeed - Warning	190-15	141
E363-1	High Fuel Supply Temperature - Warning	174-15	165
E363-2	High Fuel Supply Temperature - Derate	174-16	
E396-2	High Fuel Rail Pressure - Warning	157-16	159
E398-2	Low Fuel Rail Pressure - Warning	157-18	
E499-3	Fuel Rail #1 Pressure Leak - Shutdown	1239-0	
E539-1	High Intake Manifold Air Temperature - Warning	105-15	133
E539-2	High Intake Manifold Air Temperature - Derate	105-16	
E593-2	Aftertreatment Insufficient Temperature to Complete Regeneration - Derate	3711-31	214
E991-3	DPF Active Regeneration Inhibited Due to Permanent System Lockout - Shutdown	3715-31	-
E992-3	DPF Active Regeneration Inhibited Due to Temporary System Lockout - Shutdown	3714-31	-
E995-2	High DPF #1 Soot Loading - Derate	3719-16	226
E995-3	High DPF #1 Soot Loading - Shutdown	3719-0	
E997-1	High DPF #1 Ash Loading - Warning	3720-15	-
E997-2	High DPF #1 Ash Loading - Derate	3720-16	-
E1008-2	High DPF #1 Intake Temperature - Derate	3242-16	224
E1014-2	Low DPF #1 Intake Temperature - Derate	3242-18	224
E1022-1	Low ARD Fuel Pressure #1 - Warning	3480-17	219
E1022-2	Low ARD Fuel Pressure #1 - Derate	3480-18	
E1025-2	Aftertreatment #1 Loss of Ignition - Derate	3473-31	244
E1026-2	Aftertreatment #1 Loss of Combustion - Derate	3474-31	-
E1041-2	ARD Air Pressure Control Actuator Not Responding To Command - Derate	3487-7	211
E1044-2	High Intake Manifold Pressure - Derate	102-16	197
E1045-2	Low Intake Manifold Pressure - Derate	102-18	
E1050-1	High Aftertreatment #1 Fuel Pressure #1 - Warning	3480-15	219
E1050-2	High Aftertreatment #1 Fuel Pressure #1 - Derate	3480-16	
E1070-1	Aftertreatment Fuel Injector #1 not responding - Warning	3556-7	-
E1092-1	High Engine Exhaust Gas Recirculation Temperature - Warning	412-15	227
E1092-2	High Engine Exhaust Gas Recirculation Temperature - Derate	412-16	227
E1121-2	Engine Exhaust Gas Recirculation Valve Control Not Responding to Command - Derate	2791-7	228
E1154-2	Low DPF #1 Intake Pressure - Warning	3609-18	223
E1156-1	High DPF #1 Intake Pressure - Warning	3609-15	
E1170-2	Low Aftertreatment #1 Secondary Air Pressure - Derate	3837-18	-

(continued)

(Table 3, contd)

CDL Code	Description	J1939 Code	Flash Code
E1264-3	High Pressure Common Rail Fuel Pressure Relief Valve Active - Shutdown	5571-0	159
E1305-1	Initial Assembly Aftertreatment #1 Regeneration Required - Warning	3483-11	-
E1319-2	Engine Exhaust Gas Recirculation Mass Flow Rate Not Responding - Derate	2659-7	-
E2143-3	Low Engine Coolant Level - Shutdown	111-01	169

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Fault Logging

The system provides the capability of Fault Logging. When the Electronic Control Module (ECM) generates an active diagnostic code, the code will be logged in the memory of the ECM. The codes that have been logged by the ECM can be identified by the electronic service tool. The active codes that have been logged will be cleared when the fault has been rectified or the fault is no longer active. The following logged faults can not be cleared from the memory of the ECM without using a factory password: Overspeed, low engine oil pressure, and high engine coolant temperature.

Engine Operation with Active Diagnostic Codes

If a diagnostic lamp illuminates during normal engine operation, the system has identified a situation that is not within the specification. Use electronic service tools to check the active diagnostic codes.

Note: If the customer has selected “DERATE” and if there is a low oil pressure condition, the Electronic Control Module (ECM) will limit the engine power until the problem is corrected. If the oil pressure is within the normal range, the engine may be operated at the rated speed and load. However, maintenance should be performed as soon as possible.

The active diagnostic code should be investigated. The cause of the problem should be corrected as soon as possible. If the cause of the active diagnostic code is repaired and there is only one active diagnostic code, the diagnostic lamp will turn off.

Operation of the engine and performance of the engine can be limited as a result of the active diagnostic code that is generated. Acceleration rates may be significantly slower. Refer to the Troubleshooting Guide for more information on the relationship between these active diagnostic codes and engine performance.

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Engine Operation with Intermittent Diagnostic Codes

If a diagnostic lamp illuminates during normal engine operation and the diagnostic lamp shuts off, an intermittent fault may have occurred. If a fault has occurred, the fault will be logged into the memory of the Electronic Control Module (ECM).

In most cases, it is not necessary to stop the engine because of an intermittent code. However, the operator should retrieve the logged fault codes and the operator should reference the appropriate information in order to identify the nature of the event. The operator should log any observation that could have caused the lamp to light.

- Low power
- Limits of the engine speed
- Excessive smoke, etc

This information can be useful to help troubleshoot the situation. The information can also be used for future reference. For more information on diagnostic codes, refer to the Troubleshooting Guide for this engine.

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Configuration Parameters

The engine electronic control module (ECM) has two types of configuration parameters. The system configuration parameters and the customer specified parameters.

The electronic service tool is required in order to alter the configuration parameters.

System Configuration Parameters

System configuration parameters affect the emissions of the engine or the power of the engine. System configuration parameters are programmed at the factory. Normally, system configuration parameters would never require changing through the life of the engine. System configuration parameters must be reprogrammed if an ECM is replaced. System configuration parameters do not require reprogrammed if the ECM software is changed. Factory passwords are required to change these parameters.

Table 4

System Configuration Parameters	
Configuration Parameters	Record
Engine Serial Number	
Delayed Engine Shutdown	
Factory Installed Aftertreatment #1 Identification Number	
DPF #1 Soot Loading Sensing System Configuration Code	
Limp Home Engine Speed Ramp Rate	
System Operating Voltage Configuration	
Rating Number	
CAN Communication Protocol Write Security	

Customer Specified Parameters

Customer specified parameters allow the engine to be configured to the exact needs of the application.

The electronic service tool is required in order to alter the customer configuration parameters.

Customer parameters may be changed repeatedly as operational requirements change.

Table 5

Customer Specified Parameters	
Specified Parameters	Record
Throttle Type Channel 1	
Throttle Type Channel 2	
Continuous Position Throttle Configuration 1	
Continuous Position Throttle Configuration 2	
Multi Position Throttle Switch Configuration	
Throttle Arbitration	
Equipment ID	
Low Idle Speed	
Ether Solenoid Configuration	
Engine Idle Shutdown Minimum Ambient Air Temperature	
Engine Idle Shutdown Maximum Ambient Air Temperature	
Engine Idle Shutdown Enable Status	
Engine Idle Shutdown Delay Time	
Engine Idle Shutdown Ambient Temperature Override Enable Status	
Delayed Engine Shutdown Maximum Time	
High Soot Load Aftertreatment Protection Enable Status	
Key off regen enable status	
Key Off Aftertreatment Regeneration Maximum Time	

(continued)

(Table 5, contd)

Multiple Engines on J1939	
Air Shutoff	
ARD Auto Regeneration Enable Status	
Throttle Lock Feature Installation Status	
PTO Mode	
Throttle Lock Engine Set Speed #1	
Throttle Lock Engine Set Speed #2	
Throttle Lock Increment Speed Ramp Rate	
Throttle Lock Decrement Speed Ramp Rate	
Throttle Lock Engine Set Speed Increment	
Throttle Lock Engine Set Speed Decrement	
Monitoring Mode Shutdowns	
Monitoring Mode Derates	
Limp Home Desired Engine Speed	
Engine Acceleration Rate	
Engine Speed Decelerating Ramp Rate	
Intermediate Engine Speed	
Fan	
Engine Fan Control	
Engine Fan Type Configuration	
Engine Cooling Fan Pulley Ratio	
Engine Cooling Fan Temperature Error Increasing Hysteresis	
Engine Cooling Fan Temperature Error Decreasing Hysteresis	
Engine Cooling Fan Current Ramp Rate	
Engine Cooling Fan Speed	
Top Engine Fan Speed	
Minimum Desired Engine Cooling Fan Speed	
Engine Cooling Fan Solenoid Minimum Current	
Engine Cooling Fan Solenoid Maximum Current	
Engine cooling Fan solenoid Dither Frequency	
Engine Cooling Fan Solenoid Dither Amplitude	
Fan Temperatures	
Engine Fan Control Charge Air Cooler Outlet Temperature Input Enable	
Engine Cooling Fan Maximum Air Flow Charge Air Cooler Outlet Temperature	
Engine Cooling Fan Minimum Air Flow Charge Air Cooler Outlet Temperature	
Engine Cooling Fan Control Coolant Temperature Input Enable Status	
Engine Cooling Fan Maximum Air Flow Coolant Temperature	

(continued)

(Table 5, contd)

Engine Cooling Fan Minimum Air Flow Coolant Temperature	
Engine Cooling Fan Control Transmission Oil Temperature Input Enable Status	
Engine Cooling Fan Maximum Air Flow Transmission Oil Temperature	
Engine Cooling Fan Minimum Air Flow Transmission Oil Temperature	
Engine Cooling Fan Control Hydraulic Oil Temperature Input Enable Status	
Engine Cooling Fan Maximum Air Flow Hydraulic Oil Temperature	
Engine Cooling Fan Minimum Air Flow Hydraulic Oil Temperature	
Engine Cooling Fan Control Auxiliary #1 Temperature Input Enable Status	
Engine Cooling Fan Maximum Air Flow Auxiliary #1 Temperature	
Engine Cooling Fan Minimum Air Flow Auxiliary #1 Temperature	
Engine Cooling Fan Control Auxiliary #2 Temperature Input Enable Status	
Engine Cooling Fan Maximum Air Flow Auxiliary #2 Temperature	
Engine Cooling Fan Minimum Air Flow Auxiliary #2 Temperature	
Reversing Fan	
Engine Fan Reversing Feature	
Engine Fan Reverse Operation Early Termination Enable Status	
Engine Fan Manual Purge	
Engine Fan Suspend Purge	
Engine Fan Purge Cycle Interval	
Engine Fan Purge Cycle Duration	
Other Parameters	
Maintenance Indicator Mode	
Maintenance Level 1 Cycle Interval Hours	
Coolant Level Sensor	
Air Filter Restriction Switch Installation Status	
Air Filter Restriction Switch Configuration	
Fuel/Water Separator Switch Installation Status	
User Defined Switch Installation Status	
Auxiliary Temperature Sensor Installation Status	
Auxiliary Pressure Sensor Installation Status	
Engine Overspeed Setpoint	
Fuel Filter Differential Pressure Switch Config	
Diesel Particulate Filter Regeneration Force/ Inhibit Switch Installation	
Diesel Particulate Filter Regeneration Inhibit Indicator Installation	
Diesel Particulate Filter Soot Loading Indicator Installation	
High Exhaust System Temperature Indicator Installation	
Auxiliary Temp #2	

(continued)

(Table 5, contd)

Remote Torque Speed Control Enable Status	
Number of Engine Operating Mode Switches	
Engine Operating Mode Configuration	

Engine Starting

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Before Starting Engine

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

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

NOTICE

All valves in the fuel return line must be open and fuel supply lines must be open. Damage to the fuel system can occur if fuel lines are closed with the engine in operation.

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

WARNING

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

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

Starting the Engine

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

Starting the Engine

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

Note: During the key on, the indicator lamps will be illuminated for 2 seconds in order to check lamp operation. If any of the lamps do not illuminate, replace the bulb.

3. When the warning light for the glow plugs is extinguished, turn the keyswitch to the START position in order 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 temperature of the engine.

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.

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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.

Startability will be improved at temperatures below -18°C (0°F) 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.

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

1. Disengage any driven equipment.
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.

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.

3. When the warning light for the glow plugs is extinguished turn the keyswitch to the START position in order 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 temperature of the engine.

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" in order to speed up the warm up process.

6. Allow the engine to idle for three to five 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 from 1000 to 1200 rpm. This 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. Allow the white smoke to disperse before proceeding with normal operation.

7. Operate the engine at low load until all systems reach operating temperature. Check the gauges during the warm-up period.

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Starting with Jump Start Cables

WARNING

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

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

Note: If it is 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

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 engine's accessories.
2. Connect one positive end of the jump start cable to the positive cable terminal of the discharged battery. Connect the other positive end of the jump start cable to the positive cable terminal of the electrical source.

3. Connect one negative end of the jump start cable to the negative cable terminal of the electrical source. Connect the other negative end of the jump start cable to the engine block or to the chassis ground. This procedure helps to prevent potential sparks from igniting the combustible gases that are produced by some batteries.

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

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

After jump starting, the alternator may not be able to fully recharge batteries that are severely discharged. The batteries must be replaced or charged to the proper voltage with a battery charger after the engine is stopped. Many batteries which are considered unusable are still rechargeable. Refer to Operation and Maintenance Manual, "Battery - Replace" and Testing and Adjusting Manual, "Battery - Test".

After Starting Engine

Note: In ambient temperatures from 0 to 60°C (32 to 140°F), the warm-up time is approximately three 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 high pressure fuel lines with the engine or the starting motor in operation. If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

- Check for any fluid or for any air leaks at idle rpm and at one-half full rpm (no load on the engine) before operating the engine under load. This is not possible in some applications.
- Allow the engine to idle for three to five minutes, or allow the engine to idle until the water temperature indicator begins to rise. Check all gauges during the warm-up period.

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

Engine Operation

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Engine Operation

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

The time that is needed for the engine to reach normal operating temperature can be less than the time taken for a walk-around inspection of the engine.

The engine can be operated at the rated rpm after the engine is started and 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.

Avoid excess idling. Excessive idling causes carbon buildup, engine slobber, and soot loading of the Diesel Particulate Filter (DPF). This is harmful to the engine.

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.

Reduction of Particulate Emissions

The Diesel Particulate Filter (DPF) and the Aftertreatment Regeneration Device (ARD) work together in order to reduce particulate emissions. The DPF collects the soot and any ash that is produced by the combustion in the engine. During regeneration, the soot is converted into a gas which is released into the atmosphere. The Ash remains in the DPF until the ash is cleaned out of the DPF.

The temperature of the DPF must be above a particular value in order for regeneration to occur. The exhaust gas provides heat for the regeneration process. There are two types of regeneration:

Passive Regeneration – Is a chemical reaction within the system and the engine provides sufficient exhaust gas temperature for regeneration.

Active Regeneration – The engines duty cycle does not provide sufficient exhaust temperature for passive regeneration. The ARD operates in order to raise the temperature of the exhaust gas. When the regeneration process is complete, the ARD turns off.

The operator will receive information on the status of the ARD from dash lamps and the driver will be able to request a regeneration by using a switch. Refer to this Operation and Maintenance Manual, “Monitoring System” for more information.

Engine Operation and Active Regeneration

Your ARD may perform an active regeneration while your engine is at idle. During this active regeneration of the DPF, the engine may operate at idle for periods longer than 5 minutes.

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Diesel Particulate Filter Regeneration

WARNING

The temperature of the exhaust gas and the temperature of the exhaust system components can reach up to 650 °C (1202 °F) during regeneration. An unexpected failure of the engine or an unexpected failure of the aftertreatment system may increase temperature at the diesel particulate filter to as high as 900 °C (1652 °F) gas temperature. This may result in fire, burn, or explosion hazards, which may result in personal injury or death. Do not expose flammable material or explosive atmospheres to exhaust gas or to exhaust system components during regeneration.

Regeneration

Regeneration is the removal of soot from the Diesel Particulate Filter (DPF). The Aftertreatment Regeneration Device (ARD) is used to regenerate the DPF. The DPF traps both soot and ash. The ash is removed through a manual cleaning process. Refer to Operation and Maintenance Manual, “Diesel Particulate Filter - Clean” for more information on the service of the DPF.

Types of Regeneration

Passive Regeneration – Is a chemical reaction within the system and the engine will create enough heat in order to regenerate the DPF.

Active Regeneration – The engine does not create enough heat in order to regenerate the DPF. The ARD must be used to create the heat necessary to regenerate the DPF.

Lamps

Five dash lamps can be affected by the DPF regeneration. Also, the horn can be used in order to alter the operator.



High Exhaust System Temperature Lamp (HEST) – The lamp is illuminated when the ARD is activated and the exhaust temperature is greater than 450 °C (842 °F).



DPF Lamp – This lamp provides a general indication of the soot load. The lamp is off when the soot load is normal. The lamp will operate at level 2.

Note: In some situations, the DPF lamp may stay illuminated when the soot load is below 90%. The illuminated DPF lamp indicates that a complete regeneration has **not** been performed. A complete regeneration is when the soot level is reduced to 0%. If the DPF lamp stays illuminated, perform a regeneration without interruption until the soot level is reduced to 0%. A complete regeneration will reset the DPF lamp.



Amber or yellow Warning Lamp – This lamp indicates that the soot load has increased. Regeneration is required. This lamp will be illuminated at level 3 soot load and the lamp will flash if regeneration is not activated. Also, the DPF lamp will be illuminated.

Note: Amber or yellow Warning Lamp can be used as a diagnostic lamp. For more information refer to this Operation and Maintenance Manual, “Diagnostic Lamp”.



Red Stop Lamp – This lamp indicates that the soot load is extremely high. The soot load is at level 3. The engine will derate and may shut down. Also, the DPF lamp will be illuminated.



DPF Disable Lamp – This lamp is illuminated whenever the ARD disable switch is activated or the system has been disabled by the engine ECM.

Modes of Regeneration

- Low speed automatic
- Enhanced automatic regeneration

- Forced regeneration

Low speed automatic regeneration and enhanced automatic regeneration are controlled by the engine ECM. During this regeneration the operator will see the high exhaust system temperature lamp (HEST) illuminated.

Low speed automatic – Low speed automatic regeneration allows for the DPF regeneration to start automatically with the engine speed in a low idle condition or near low idle condition. In order for a low speed automatic regeneration to occur, the following conditions must be met:

- Soot level must be between level 1 and level 3 on the soot level monitor (if equipped).
- Engine speed must be below 1400 rpm.
- The interlocks for the application will raise the RPM to the required engine speed in order for the regeneration to occur. The engine RPM will be from 1000 to 1400 RPM.
- Refer to the OEM for the applications interlocks required to be engaged before regeneration can take place.

Enhanced automatic regeneration – This mode of DPF regeneration allows for regeneration to take place at higher engine rpm and higher engine loads. In order for enhanced automatic regenerations to occur, the following conditions must be met:

- Soot level must be between level 2 and level 3 on the soot level monitor (if equipped).
- Engine speed must be greater than 1400 rpm.
- Minimum engine idle speed input must be set. Setting the input will not allow engine speed to fall below 1000 rpm during enhanced automatic regeneration. If minimum low idle speed input is not available, regeneration will stop if engine speed drops below 1000 rpm.
- Refer to the OEM for the applications interlocks required to be engaged before regeneration can take place.

Forced regeneration – A forced regeneration is initiated by pressing the regeneration switch. A forced regeneration is allowed during normal operation up to level 3. A forced regeneration can be performed in the low speed automatic window or the enhanced automatic regeneration window.

Regeneration Switch

Note: The MIDDLE position of the regeneration switch is the default position for automatic modes of regeneration.

Note: Some OEMs may use other means of activating a forced regeneration such as touch screen interfaces.



Force Regeneration – Press in the top of the switch for 2 seconds in order to begin regeneration. An indicator light on the switch will become active showing that the regeneration is active. The HEST lamp will become active showing that the regeneration is active. The high exhaust temperature indicator will deactivate after regeneration is completed or the regeneration has been disabled.



Disable Regeneration – Press in the bottom of the switch for 2 seconds in order to disable regeneration. An indicator light on the switch will become active. The disable indicator lamp will illuminate. The indicator will deactivate after the disable regeneration is completed.

Note: To re-enable the regeneration, cycle the engine start switch key or press and hold down the force regeneration switch for 2 seconds.

Note: If the engine start switch key is cycled while the regeneration system is disabled via the disable regeneration switch, press and hold the disable regeneration switch for 2 seconds to reinitiate the disable regeneration.

Soot Level Monitoring and Indicator Lamps

During the normal working cycle of the engine the ECM will control when the regeneration will occur. Operation of the engine is not recommended with the amber warning light flashing, or the red lamp illuminated. Operation of the engine at this level could damage the DPF.

Table 6

Lamp Operation			Action Required
HEST Lamp	On	The ARD is activated and the exhaust temperature is greater than 450 °C (842 °F)	None
DPF Lamp	On	The lamp provides a general indication of the soot load. The lamp is off when the soot load is normal. The lamp will operate at level 2 and above.	A regeneration is required. In automatic mode the ECM will decide when to allow the regeneration. If the DPF lamp stays illuminated allow a regeneration without interruption. An uninterrupted regeneration will reset the DPF lamp.
Amber Warning Lamp	On	The lamp indicates that the soot load has increased. Regeneration is required.	A regeneration is required. Perform a forced regeneration, or allow the ECM control.
Amber Warning Lamp	Lamp is now flashing	The flashing lamp will indicate that the engine has continued to be operated, regeneration is required.	An urgent regeneration is required. If a regeneration is not allowed, the DPF could be damage.
Red Stop Lamp	On	The engine could be derated or the engine could be shut down.	Once the engine enters into shutdown mode you must contact your Perkins dealer or your Perkins distributor. Your dealer or distributor will need to perform a service level regeneration. The DFP may need to be replaced.

Some applications will be equipped with a monitoring gauge. Illustration 40 is an example of the levels of soot loading on a gauge.

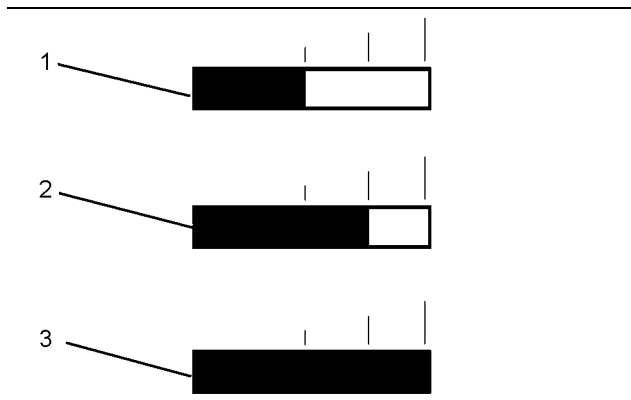


Illustration 40 g02153650

- (1) Normal operation level 1
- (2) Level 2 with DPF lamp illuminated
- (3) level 3 with DPF lamp illuminated and amber warning lamp illuminated.

During the normal working cycle of the engine the ECM will control when the regeneration will occur. Regeneration will take place by low speed automatic regeneration or by enhanced automatic regeneration. Operation of the engine at level 3 and not allowing a regeneration to be performed could damage the DFP.

Soot Level and Engine Loading

Illustration 41 is a guide to show engine RPM engine load and when regeneration can occur.

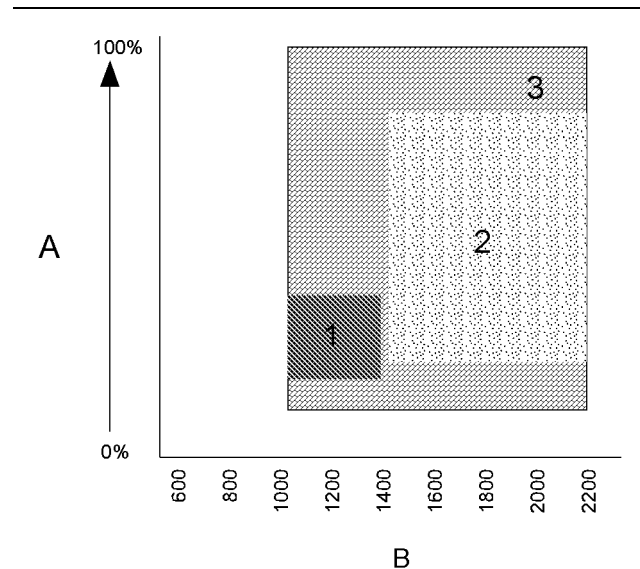


Illustration 41 g02237313

- (A) Engine load factor
- (B) Engine RPM
- (1) Low speed automatic regeneration
- (2) High speed automatic regeneration (60-80% soot load)
- (3) High speed automatic regeneration (80-100% soot load)

In some circumstances high speed regeneration cannot occur. Allow the application to operate at a lower load factor in order to allow low speed regeneration to occur.

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Fuel Conservation Practices

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

- Avoid spilling fuel.

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

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

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

- Observe the service indicator frequently. Keep the air cleaner elements clean.
- Ensure that the turbocharger is operating correctly. For more information refer to this Operation and Maintenance Manual, "Turbocharger - Inspect"
- Maintain a good electrical system.

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

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

Engine Stopping

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Stopping the Engine

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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 turbocharger shaft and bearing life.

Note: Individual applications will have different control systems. Ensure that the shutoff procedures are understood. Use the following general guidelines in order 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 five minutes in order to cool the engine.
2. Stop the engine after the cool down period according to the shutoff system on the engine and turn the ignition key switch to the OFF position. If necessary, refer to the instructions that are provided by the OEM.

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Emergency Stopping

NOTICE

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

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

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

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.

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.

- After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems. Replace any high pressure fuel line that has leaked. Refer to Disassembly and assembly Manual, "Fuel Injection Lines - Install".
- Check the crankcase oil level. Maintain the oil level between the "MIN" mark and the "MAX" mark on the engine oil level gauge.
- 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.

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.

- Allow the engine to cool. Check the coolant level.

- Check the coolant for correct antifreeze protection and the correct corrosion protection. Add the correct coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. This maintenance is outlined in the instructions from the OEM.

Cold Weather Operation

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Cold Weather Operation

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

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

This section will cover the following information:

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

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

- Weather conditions
- Engine applications

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

Hints for Cold Weather Operation

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

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

Recommendations for the Coolant

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

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

Engine Block Heaters

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

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

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

Idling the Engine

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

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

Recommendations for Coolant Warm Up

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

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

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

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

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

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

The Water Temperature Regulator and Insulated Heater Lines

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

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

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

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

Recommendation for Crankcase Breather Protection

Crankcase ventilation gases contain a large quantity of water vapor. This water vapor can freeze in cold ambient conditions and can plug or damage the crankcase ventilation system. If the engine is operated in temperatures below -25°C (-13°F), measures must be taken to prevent freezing and plugging of the breather system. Insulated hoses and a heated canister assembly should be installed.

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

Fuel and the Effect from Cold Weather

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

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

- Glow plugs (if equipped)
- Engine coolant heaters, which may be an OEM option
- Fuel heaters, which may be an OEM option
- Fuel line insulation, which may be an OEM option

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

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

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

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

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

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

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Fuel Related Components in Cold Weather

Fuel Tanks

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

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

Some fuel tanks use supply pipes that allow water and sediment to settle below the end of the fuel supply pipe.

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

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

Fuel Filters

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

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

Fuel Heaters

Note: The OEM may equip the application with fuel heaters. If this is the case, the temperature of the fuel must not exceed 73 °C (163 °F) at the fuel transfer pump.

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

Maintenance Section

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Refill Capacities

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Refill Capacities

Lubrication System

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

Table 7

Engine Refill Capacities		
Compartment or System	Minimum	Maximum
Crankcase Oil Sump ⁽¹⁾	13.5 L (3.56 US gal)	16.5 L (4.36 US gal)

⁽¹⁾ These values are the approximate capacities for the crankcase oil sump (aluminum) which includes the standard factory installed oil filters. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter. The design of the oil pan can change the oil capacity of the oil pan.

Cooling System

Refer to the OEM specifications for the External System capacity. This capacity information will be needed in order to determine the amount of coolant/antifreeze that is required for the Total Cooling System.

Table 8

Engine Refill Capacities	
Compartment or System	Liters
Engine Only	15 L (3.96 US gal)
External System Per OEM ⁽¹⁾	

⁽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.

Fluid Recommendations

General Coolant Information

NOTICE

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

NOTICE

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

NOTICE

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

Clean the cooling system for the following reasons:

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

NOTICE

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

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

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

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

Water

Water is used in the cooling system in order to transfer heat.

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

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

If distilled water or deionized water is not available, use water with the properties that are listed in Table 9.

Table 9

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. Overconcentration of additives can cause the inhibitors to drop out-of-solution. The deposits can enable the following problems to occur:

- Formation of gel compounds
- Reduction of heat transfer
- Leakage of the water pump seal

- Plugging of radiators, coolers, and small passages

Glycol

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

- Boiling
- Freezing
- Cavitation of the water pump

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

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

Note: 100 percent pure glycol will freeze at a temperature of -23 °C (-9 °F).

Most conventional 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 10 and refer to table 11.

Table 10

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

NOTICE

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

Table 11

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

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

Coolant Recommendations

- ELC _____ Extended Life Coolant
- SCA _____ Supplement Coolant Additive

- ASTM _____ American Society for Testing and Materials

The following two coolants are used in Perkins diesel engines:

Preferred – Perkins ELC

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

NOTICE

The 1200 series industrial engines must be operated with a 1:1 mixture of water and glycol. This 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.

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

A mixture of SCA inhibitor and water is acceptable but will not give the same level of 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. Water which has the recommended properties may be used

Table 12

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 One Year
Commercial Heavy-Duty Antifreeze that meets “ASTM D6210”	3000 Service Hours or Two Years
Perkins POWERPART SCA inhibitor	3000 Service Hours or Two Years
Commercial SCA inhibitor and Water	3000 Service Hours or One Year

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

ELC

Perkins provides ELC for use in the following applications:

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

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

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

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

ELC Cooling System Maintenance

Correct additions to the Extended Life Coolant

NOTICE

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

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

In order 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. This will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

NOTICE

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

Do not use standard supplemental coolant additive (SCA).

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

ELC Cooling System Cleaning

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

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

Before the cooling system is filled, the heater control (if equipped) must be set to the hot position. Refer to the OEM in order 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 in order 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. Flush the system with clean water in order to remove any debris.
4. Use Perkins cleaner to clean the system. Follow the instruction on the label.

5. Drain the cleaner into a suitable container. Flush the cooling system with clean water.
 6. Fill the cooling system with clean water and operate the engine until the engine is warmed to 49° to 66°C (120° to 150°F).
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NOTICE

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

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

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

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

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

ELC Cooling System Contamination**NOTICE**

Mixing ELC with other products reduces the effectiveness of the ELC and shortens the ELC service life. Use only Perkins Products for premixed or concentrate coolants. 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 clean water. Fill the system with the Perkins ELC.
- Drain a portion of the cooling system into a suitable container according to local regulations. Then, fill the cooling system with premixed ELC. This procedure should lower the contamination to less than 10 percent.

- Maintain the system as a conventional Heavy-Duty Coolant. Treat the system with an SCA. Change the coolant at the interval that is recommended for the conventional Heavy-Duty Coolant.

Commercial Heavy-Duty Antifreeze and SCA

NOTICE

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

NOTICE

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

Check the antifreeze (glycol concentration) in order 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.

Refer to Table 13 for part numbers and for quantities of SCA.

Table 13

Perkins Liquid SCA	
Part Number	Quantity
21825735	10

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

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

Use the equation that is in Table 14 to determine the amount of Perkins SCA that is required when the cooling system is initially filled.

Table 14

Equation For Adding The SCA To The Heavy-Duty Coolant At The Initial Fill
$V \times 0.045 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 15 is an example for using the equation that is in Table 14.

Table 15

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)	× 0.045	0.7 L (24 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). Test the concentration of SCA.

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

Use the equation that is in Table 16 to determine the amount of Perkins SCA that is required, if necessary:

Table 16

Equation For Adding The SCA To The Heavy-Duty Coolant For Maintenance
$V \times 0.014 = X$
V is the total volume of the cooling system.
X is the amount of SCA that is required.

Table 17 is an example for using the equation that is in Table 16.

Table 17

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)	× 0.014	0.2 L (7 oz)

Cleaning the System of Heavy-Duty Antifreeze

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

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

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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 (ACEA) 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.

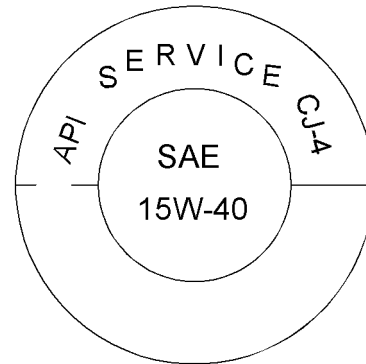


Illustration 42
Typical API symbol

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Terminology

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

Engine Oil

Commercial Oils

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 18

Classifications for the 1200 Series Industrial Engine
Oil Specification
API CJ-4 ACEA E9 ECF-3

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

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

The chemical limits were developed in order 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 18 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 in order to collect this particulate matter. There is a very 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 18 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 in order to monitor the condition of the engine oil. Use oil analysis also in order to determine the oil change interval that is optimum.

Note: 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 43 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to illustration 43 (maximum temperature) in order 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.

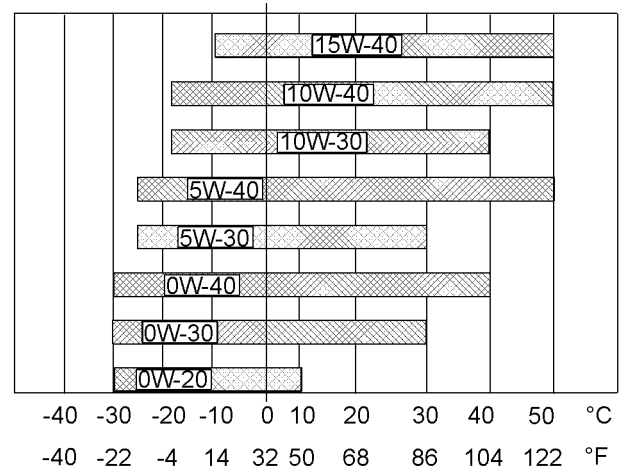


Illustration 43

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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. It is not necessary to use aftermarket additives in order 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 in order 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 43 in order 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 in order 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

- **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

General Information

NOTICE

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

NOTICE

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

Diesel Fuel Requirements

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

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

Satisfactory engine performance is dependent 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 19.

NOTICE

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

Table 19

Perkins Specification for Distillate Diesel Fuel ⁽¹⁾				
Property	UNITS	Requirements	“ASTM”Test	“ISO”Test
Aromatics	%Volume	35% maximum	D1319	“ISO”3837
Ash	%Weight	0.01% maximum	D482	“ISO”6245
Carbon Residue on 10% Bottoms	%Weight	0.35% maximum	D524	“ISO”4262
Cetane Number ⁽²⁾	-	40 minimum	D613/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
Density at 15 °C (59 °F) ⁽³⁾	Kg / M ³	801 minimum and 876 maximum	No equivalent test	“ISO 3675” “ISO 12185”
Distillation	°C	10% at 282 °C (539.6 °F) maximum 90% at 360 °C (680 °F) maximum	D86	“ISO”3405
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 ⁽¹⁾	%mass	0.0015	D5453/D26222	“ISO 20846” “ISO 20884”
Kinematic Viscosity ⁽⁴⁾	“MM” ² /S (cSt)”	The viscosity of the fuel that is delivered to the fuel injection pump. “1.4 minimum/4.5 maximum”	D445	“ISO”3405
Water and sediment	% weight	0.1% maximum	D1796	“ISO”3734
Water	% weight	0.1% 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

(continued)

(Table 19, contd)

Lubricity corrected wear scar diameter at 60 °C (140 °F). ⁽⁶⁾	mm	0.52 maximum	D6079	“ISO”12156-1
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- (1) This specification includes the requirements for Ultra Low Sulfur Diesel (ULSD). ULSD fuel will have ≤ 15 ppm (0.0015%) sulfur. Refer to “ASTM D5453”, “ASTM D2622”, or “ISO 20846, ISO 20884” test methods.
- (2) A fuel with a higher cetane number is recommended in order to operate at a higher altitude or in cold weather.
- (3) “Via standards tables, the equivalent API gravity for the minimum density of 801 kg / m³ (kilograms per cubic meter) is 45 and for the maximum density of 876 kg / m³ is 30”.
- (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 in order 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 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.

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.

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, deposits in the combustion chamber, and reduced service life of the engine.

NOTICE

The Perkins 1200 series of diesel engine must be operated using Ultra Low Sulfur Diesel. The sulphur content of this fuel must be lower than 15 PPM. This fuel complies with the emissions regulations that are prescribed by the Environmental Protection Agency of the United States.

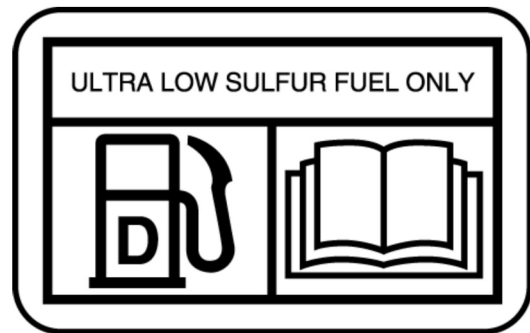


Illustration 44

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Illustration 44 is a representation of the label that will be installed by the fuel filler cap on the fuel tank of the application.

The fuel specifications that are listed in the table 20 are released as acceptable to use on all 1200 series of engine.

Table 20

Acceptable Fuel Specification for the 1200 Series of Engines ⁽¹⁾	
Fuel Specification	Comments
EN590	European Automotive Diesel Fuel (DERV)
“ASDM 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.

Cetane numbers in excess of 45 are normally expected from current diesel fuel. However, a cetane number of 40 may be experienced in some territories. The United States of America is one of the territories that can have a low cetane value. A minimum cetane value of 40 is required during average starting conditions. A fuel with higher cetane number is recommended for operations at high altitudes or in cold-weather operations.

Fuel with a low cetane number can be the root cause of problems during a cold start.

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 in order 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 in order 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 in order 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 1200 series diesel engines have been designed to operate only with ULSD. By using the test methods “ASTM D5453, ASTM D2622, or ISO 20846 ISO 20884”, the content of sulfur in ULSD fuel must be below 15 PPM (mg/kg) or 0.0015% mass.

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 their 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 in order 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 light weight hydrocarbons can affect the characteristics of combustion.

Recommendation for Biodiesel

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 feedstock. The most commonly available biodiesel in Europe is Rape Methyl Ester (REM). 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. In order 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 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 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 of 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 currently unknown.
- Perkins recommend the use of oil analysis in order 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 T400012 Fuel Cleaner 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".

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, while 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.

Perkins strongly recommended 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. It is therefore essential to 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.

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

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. 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 19.

Perkins Diesel Fuel System Cleaner

Perkins T400012 Fuel Cleaner 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 in order 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".

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.

Details instruction on the rate of which the fuel cleaner must be use 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.

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.

The engine can have the ability to auto start. Ensure that the power supply is isolated before any service or repair is performed.

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

Fuel System

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

High Pressure Fuel Lines

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

This is because of the following 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 in order to remove air from the fuel system.

Engine Oil

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

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Welding on Engines with Electronic Controls

NOTICE

Because the strength of the frame may decrease, some manufacturers do not recommend welding onto a chassis frame or rail. Consult the OEM of the equipment or your Perkins dealer regarding welding on a chassis frame or rail.

Proper welding procedures are necessary in order to avoid damage to the engines ECM, sensors, and associated components. When possible, remove the component from the unit and then weld the component. If removal of the component is not possible, the following procedure must be followed when you weld on a unit equipped with an Electronic Engine. The following procedure is considered to be the safest procedure to weld on a component. This procedure should provide a minimum risk of damage to electronic components.

NOTICE

Do not ground the welder to electrical components such as the ECM or sensors. Improper grounding can cause damage to the drive train bearings, hydraulic components, electrical components, and other components.

Clamp the ground cable from the welder to the component that will be welded. Place the clamp as close as possible to the weld. This will help reduce the possibility of damage.

Note: Perform the welding in areas that are free from explosive hazards.

1. Stop the engine. Turn the switched power to the OFF position.

2. Ensure that the fuel supply to the engine is turned off.
3. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.
4. Disconnect all electronic components from the wiring harnesses. Include the following components:
 - Electronic components for the driven equipment
 - ECM
 - Sensors
 - Electronically controlled valves
 - Relays
 - Aftertreatment ID module

NOTICE

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

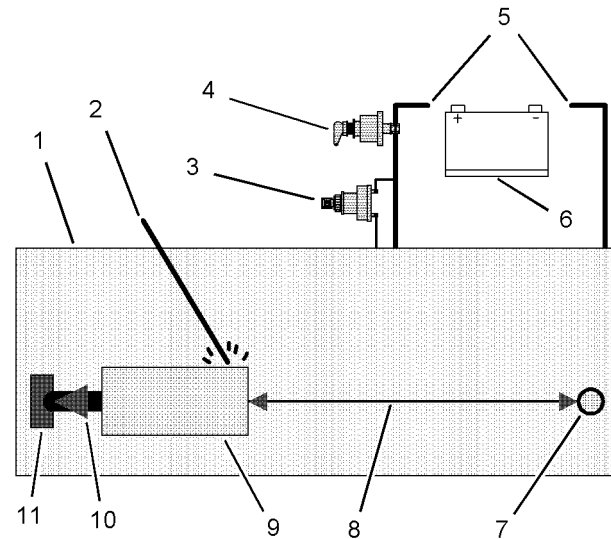


Illustration 45

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

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

5. Connect the welding ground cable directly to the part that will be welded. Place the ground cable as close as possible to the weld in order to reduce the possibility of welding current damage to the following components. Bearings, hydraulic components, electrical components, and ground straps.

Note: If electrical/electronic components are used as a ground for the welder, or electrical/electronic components are located between the welder ground and the weld, current flow from the welder could severely damage the component.

6. Protect the wiring harness from welding debris and spatter.
7. Use standard welding practices to weld the materials.

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Maintenance Interval Schedule

When Required

Battery - Replace	90
Battery or Battery Cable - Disconnect	91
Engine - Clean	101
Engine Air Cleaner Element (Dual Element) - Clean/Replace	101
Engine Air Cleaner Element (Single Element) - Inspect/Replace	103
Engine Oil Sample - Obtain	108
Fuel System - Prime	111
Severe Service Application - Check	119

Daily

Cooling System Coolant Level - Check	97
Driven Equipment - Check	100
Engine Air Cleaner Service Indicator - Inspect ...	104
Engine Air Precleaner - Check/Clean	104
Engine Oil Level - Check	108
Fuel System Primary Filter/Water Separator - Drain	114
Walk-Around Inspection	122

Every Week

Hoses and Clamps - Inspect/Replace	117
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Every 50 Service Hours or Weekly

Fuel Tank Water and Sediment - Drain	116
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Every 500 Service Hours

Belt - Inspect	92
Engine Oil and Filter - Change	109
Fan Clearance - Check	110

Every 500 Service Hours or 1 Year

Battery Electrolyte Level - Check	91
Cooling System Supplemental Coolant Additive (SCA) - Test/Add	98
Crankshaft Vibration Damper - Inspect	99
Engine Air Cleaner Element (Dual Element) - Clean/Replace	101
Engine Air Cleaner Element (Single Element) - Inspect/Replace	103
Fuel System Primary Filter (Water Separator) Element - Replace	112
Fuel System Secondary Filter - Replace	115
Radiator - Clean	118

Every 1000 Service Hours

Water Pump - Inspect	123
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Every 1500 Service Hours

Engine Crankcase Breather Element - Replace ..	105
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Every 2000 Service Hours

Aftercooler Core - Inspect	89
Engine Mounts - Inspect	107
Starting Motor - Inspect	120
Turbocharger - Inspect	120

Every 3000 Service Hours

Alternator - Inspect	90
Alternator and Fan Belts - Replace	90
Belt Tensioner - Inspect	92
Radiator Pressure Cap - Clean/Replace	119

Every 3000 Service Hours or 2 Years

Cooling System Coolant (Commercial Heavy-Duty) - Change	93
Cooling System Water Temperature Regulator - Replace	99

Every 4000 Service Hours

Aftercooler Core - Clean/Test	89
-------------------------------------	----

Every 4500 Service Hours

ARD Spark Plug - Clean/Inspect/Replace	89
--	----

Every 5000 Service Hours

Diesel Particulate Filter - Clean	100
---	-----

Every 12 000 Service Hours or 6 Years

Cooling System Coolant (ELC) - Change	95
---	----

Commissioning

Fan Clearance - Check	110
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ARD Spark Plug - Clean/Inspect/Replace

- ARD Aftertreatment Regeneration Device

NOTICE

If the engine is running, or the keyswitch is in the ON position the ARD spark plug will continue to fire. Turn the keyswitch to the OFF position before servicing the ARD spark plug.

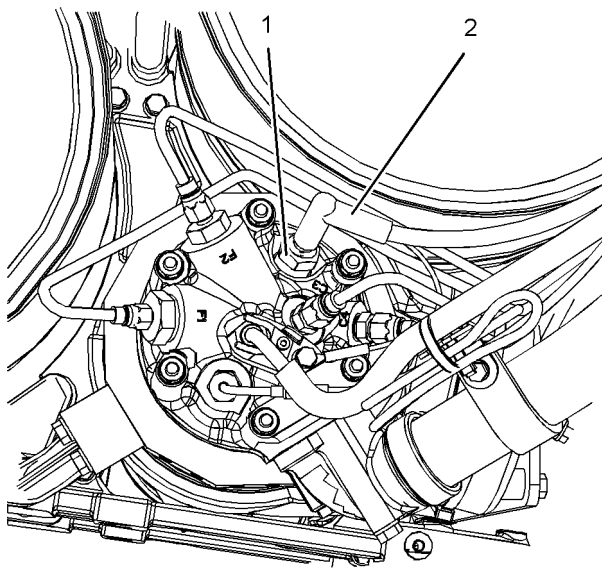


Illustration 46

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1. Ensure that the power is in the "OFF" position and that the engine was stopped. Remove any dirt or debris from the area around the spark plug. Remove wire harness (2) from spark plug (1).
2. Use a T40006 Socket in order to remove the spark plug. Loosen the spark plug and use the socket to remove the spark plug by hand in order to detect problems with the threads. Discard the spark plug.

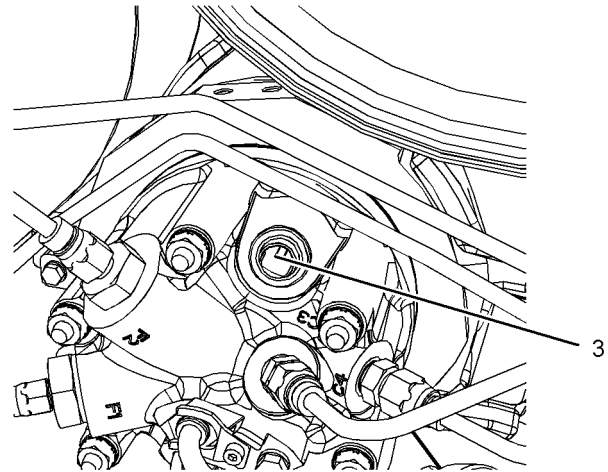


Illustration 47

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3. Use T400005 Plug Bore Brush in order to clean the ground electrode (3).
4. Install the new spark plug by hand. Tighten the spark plug to a torque of 47 N·m (34 lb ft).
5. Connect the wiring harness (2).

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Aftercooler Core - Clean/Test (Air-To-Air Aftercooler)

The air-to-air aftercooler is OEM installed in many applications. Please refer to the OEM specifications for information that is related to the aftercooler.

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Aftercooler Core - Inspect

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

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

For air-to-air aftercoolers, use the same methods that are used for cleaning radiators.

 **WARNING**

Personal injury can result from air pressure.

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

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

After cleaning, start the engine and accelerate the engine to high idle rpm. This will help in the removal of debris and drying of the core. Stop the engine. Use a light bulb behind the core in order to inspect the core for cleanliness. Repeat the cleaning, if necessary.

Inspect the fins for damage. Bent fins may be opened with a "comb".

Note: If parts of the aftercooler system are repaired or replaced, a leak test is highly recommended.

Inspect these items for good condition: Welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

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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.

i02680137

Alternator and Fan Belts - Replace

Refer to Disassembly and Assembly Manual , "Alternator Belt - Remove and Install".

i03559623

Battery - Replace

 **WARNING**

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

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

 **WARNING**

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

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

1. Switch the engine to the OFF position. Remove all electrical loads.
2. Turn off any battery chargers. Disconnect any battery chargers.
3. Ensure that the battery disconnect switch is in the OFF position.
4. Disconnect the NEGATIVE "-" cable from the NEGATIVE "-" battery terminal.
5. Disconnect the POSITIVE "+" cable from the POSITIVE "+" battery terminal.

Note: Always recycle a battery. Never discard a battery. Dispose of 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 battery disconnect switch is in the OFF position.

8. Connect the POSITIVE “+” cable to the POSITIVE “+” battery terminal.
9. Connect the NEGATIVE “-” cable to the NEGATIVE “-” battery terminal.
10. Turn the battery disconnect switch to the ON position.

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.

i02323088

Battery or Battery Cable - Disconnect

WARNING

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

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

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

i03973719

i03557440

Belt - Inspect

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

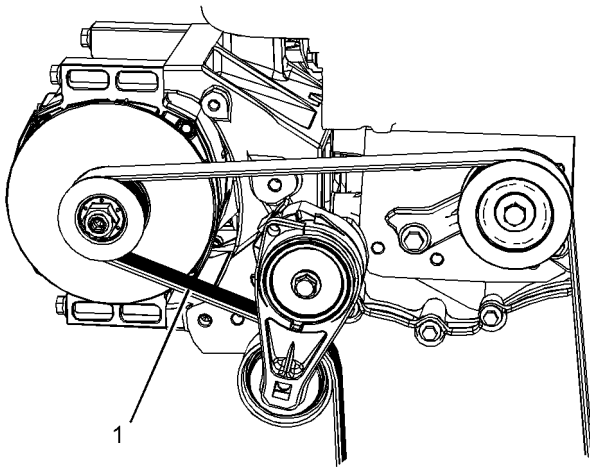


Illustration 48

g01906354

Typical example

To maximize the engine performance, inspect the belt (1) for wear and for cracking. Replace the belt if the belt is worn or damaged.

- Inspect the belt for cracks, splits, glazing, grease, displacement of the cord and evidence of fluid contamination.

The belt must be replaced if the following conditions are present.

- The belt has a crack in more than one rib.
- More than one section of the belt is displaced in one rib of a maximum length of 50.8 mm (2 inch).

To replace the belt, refer to Disassembly and Assembly, "Alternator Belt - Remove and Install". If necessary, replace the belt tensioner. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install" for the correct procedure.

Belt Tensioner - Inspect

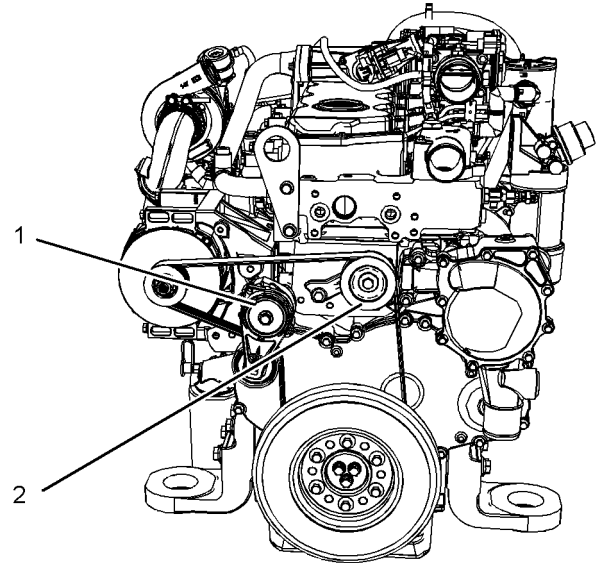


Illustration 49

g01880953

Typical example

Remove the belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".

Ensure that the belt tensioner is securely installed. Visually inspect the belt tensioner (1) for damage. Check that the pulley on the tensioner rotates freely and that the bearing is not loose. Some engines have an idler pulley (2). Ensure that the idler pulley is securely installed. Visually inspect the idler pulley for damage. Ensure that the idler pulley can rotate freely and that the bearing is not loose. If necessary, replace damaged components.

Install the belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".

i04155927

Cooling System Coolant (Commercial Heavy-Duty) - Change

NOTICE

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

Dispose of all fluids according to Local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

- The engine overheats frequently.
- Foaming of the coolant 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.

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.

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 in order to relieve any pressure. Remove the cooling system filler cap.

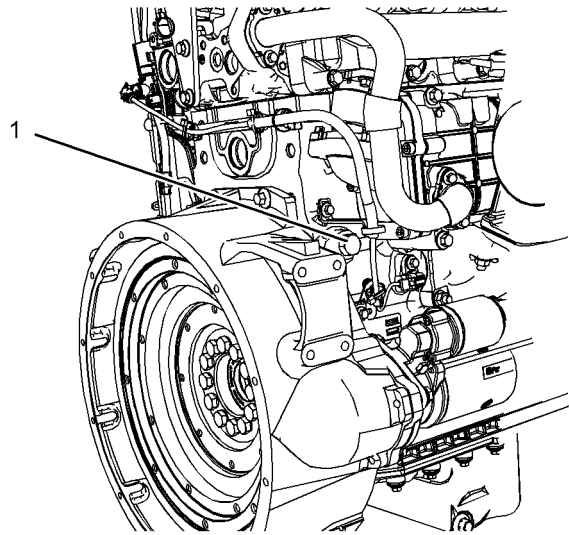


Illustration 50
Typical example

g02350782

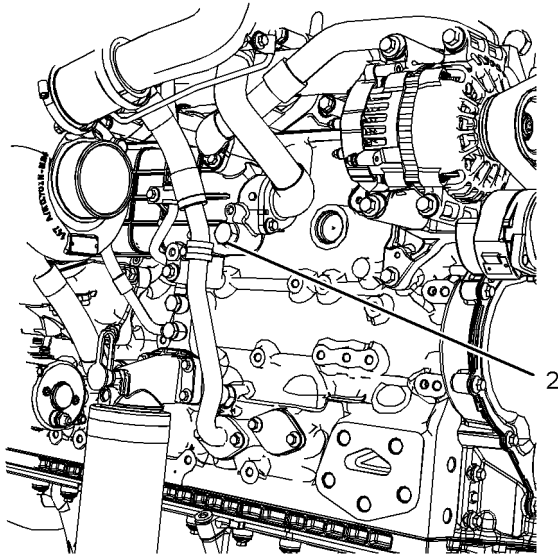


Illustration 51 g02350785
Typical example

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

Allow the coolant to drain.

NOTICE

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

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

Flush

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

NOTICE

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

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water. Install the cooling system filler cap.

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

Fill

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

NOTICE

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

Cooling system air locks may result in engine damage.

2. 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.
3. Start and run the engine at low idle. Increase the engine rpm to high idle. Operate the engine in order to open the engine thermostat. This will allow any air in the system to be purged. Decrease the engine speed to low idle. Stop the engine.
4. Maintain the coolant level at the maximum mark that is correct for your application.

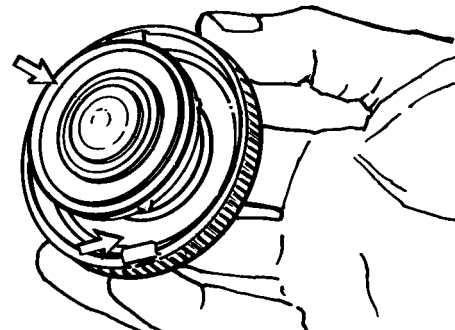


Illustration 52
Filler cap

g00103639

5. 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.
6. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i04155851

Cooling System Coolant (ELC) - Change

NOTICE

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

Dispose of all fluids according to Local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

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

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

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

NOTICE

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

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 in order to relieve any pressure. Remove the cooling system filler cap.

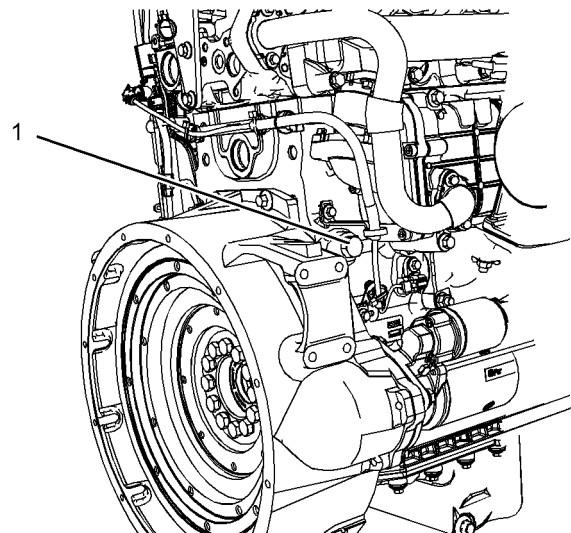


Illustration 53

Typical example

g02350782

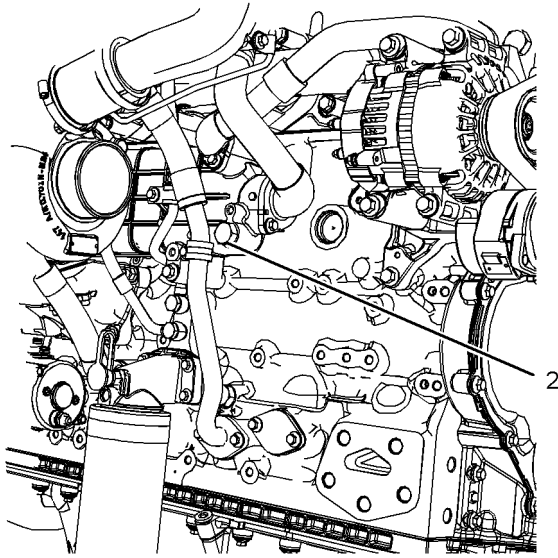


Illustration 54

g02350785

Typical example

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

Allow the coolant to drain.

NOTICE

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

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

Flush

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

NOTICE

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

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water. Install the cooling system filler cap.

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

Fill

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

NOTICE

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

Cooling system air locks may result in engine damage.

2. Fill the cooling system with Extended Life Coolant (ELC). Refer to the Operation and Maintenance Manual, "Fluid Recommendations" topic (Maintenance Section) for more information on cooling system specifications. Do not install the cooling system filler cap.
3. Start and run the engine at low idle. Increase the engine rpm to high idle. Operate the engine in order to open the engine thermostat. This procedure will allow any air in the system to be purged. Decrease the engine speed to low idle. Stop the engine.
4. Maintain the coolant level at the maximum mark that is correct for your application.

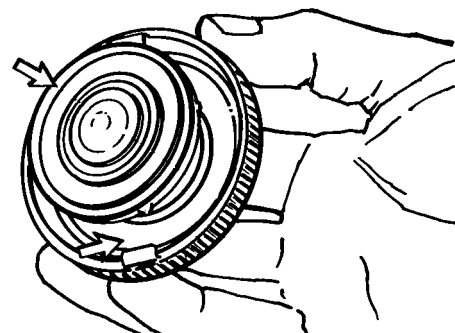


Illustration 55

g00103639

Filler cap

5. 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.
6. Start the engine. Inspect the cooling system for leaks and for correct operating temperature.

i03576064

Cooling System Coolant Level - Check

Engines With a Coolant Recovery Tank

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

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

NOTICE

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

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

WARNING

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

2. Loosen filler cap slowly in order to relieve any pressure. Remove the filler cap.

3. Pour the correct coolant mixture into the tank. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for information on the correct mixture and type of coolant. Refer to the Operation and Maintenance Manual, "Refill Capacities and Recommendations" for the cooling system capacity. Do not fill the coolant recovery tank above "COLD FULL" mark.

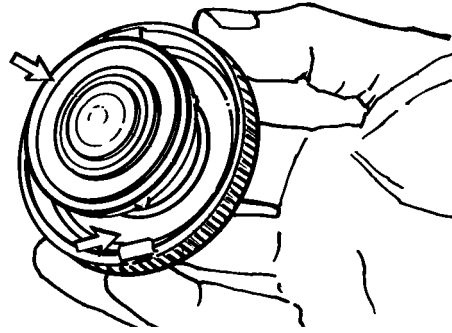


Illustration 56

g00103639

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

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

Engines Without a Coolant Recovery Tank

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

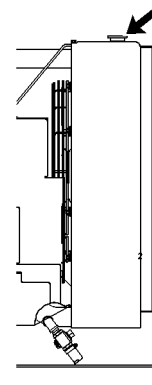


Illustration 57

g00285520

Cooling system filler cap

WARNING

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

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

i03644948

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

WARNING

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

Test for SCA Concentration

Heavy-Duty Coolant/Antifreeze and SCA

NOTICE

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

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

Add the SCA, If Necessary

NOTICE

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

WARNING

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

NOTICE

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

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.

i04020355

Cooling System Water 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. Refer to this Operation and Maintenance Manual, "Maintenance Interval Schedule" for the proper maintenance interval.

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 two articles in the Disassembly and Assembly Manual, "Water Temperature Regulators - Remove and Water Temperature Regulators - 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.

i03634651

Crankshaft Vibration Damper - Inspect

Viscous Damper

The viscous damper has an inertia weight that is located inside a fluid filled case. The inertia weight moves in the case in order to limit torsional vibration.

Visually inspect the crankshaft damper. Ensure that the cooling fins (1) on the crankshaft damper are clean and free from dirt.

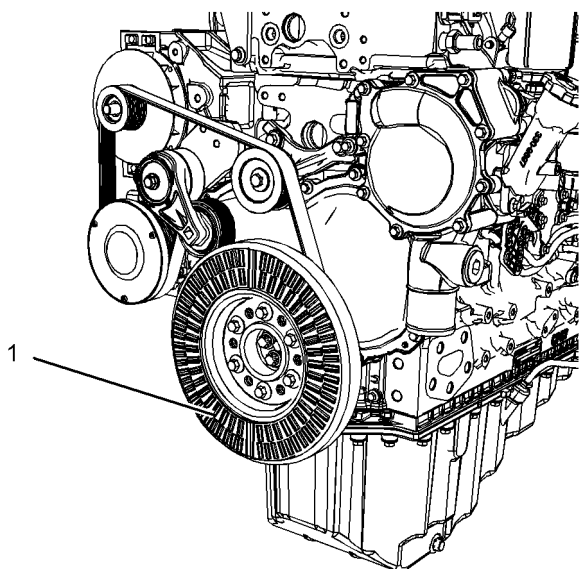


Illustration 58

g01950241

Typical example

Inspect the damper and replace the damper for any of the following reasons:

- The damper is dented, cracked, or leaking.

For information on removal of the crankshaft damper, refer to Disassembly and Assembly, "Vibration Damper and Pulley - Remove and Install".

i04087370

Diesel Particulate Filter - Clean

WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

WARNING

The muffler, catalytic converter/muffler, and diesel particulate filter will become extremely hot during engine operation. A hot muffler, catalytic converter/muffler and diesel particulate filter can cause serious burns. Allow adequate cooling time before working on or near the muffler, catalytic converter/muffler and diesel particulate filter.

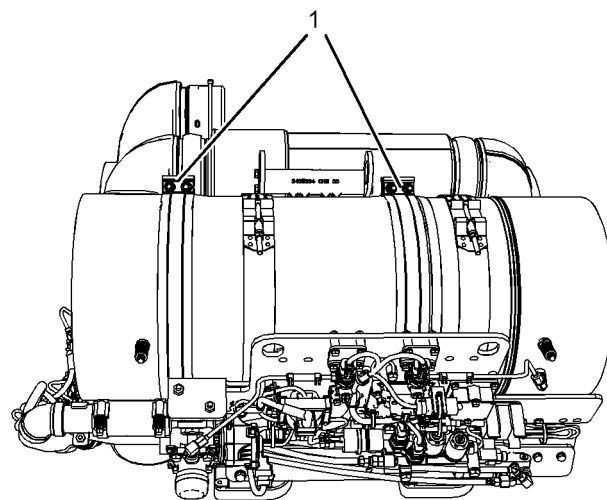


Illustration 59

g01949226

Typical example

- DPF _____ Diesel Particulate Filter

Contact your Perkins dealer, or your Perkins distributor. New torca clamps (1) must be installed on the DPF.

For information on removal of the DPF, refer to Disassembly and Assembly, "DPF - Remove". Also, refer to System Operation Testing and Adjusting, "Diesel Particulate Filter - Clean".

- Only ultra low sulfur diesel fuel can be used in an application that has an aftertreatment regeneration device. The use of other fuel will damage your engine system.
- The engine must be operated on CJ-4 specification of engine oil.

i02151646

Driven Equipment - Check

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

- Inspection
- Adjustment
- Lubrication
- Other maintenance recommendations

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

i03991933

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 in order to prevent electrical components from being damaged by excessive water when the engine is cleaned. Pressure washers and steam cleaners should not be directed at any electrical connectors or the junction of cables into the rear of the connectors. Avoid electrical components such as the alternator, the starter, and the ECM. Protect the fuel injection pump from fluids in order to wash the engine.

Aftertreatment

During the engine cleaning process, ensure that water or cleaning fluids cannot enter the aftertreatment system. If cleaning fluids enters the aftertreatment system, damage could occur.

i02334355

Engine Air Cleaner Element (Dual Element) - Clean/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 air-borne 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 precleaner (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. This replacement should be performed regardless of the number of cleanings.

Replace the dirty air cleaner elements with clean air cleaner elements. Before installation, the 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.

Dual Element Air Cleaners

The dual element air cleaner contains a primary air cleaner element and a secondary air cleaner element.

The primary air cleaner element can be used up to six times if the element is properly cleaned and properly inspected. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

The secondary air cleaner element is not serviceable. Refer to the OEM information for instructions in order to replace the secondary air cleaner element.

When the engine is operating in environments that are dusty or dirty, air cleaner elements may require more frequent replacement.

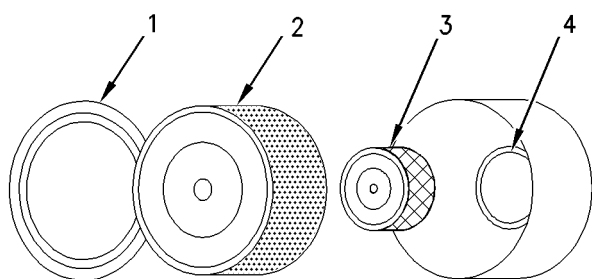


Illustration 60

g00736431

- (1) Cover
- (2) Primary air cleaner element
- (3) Secondary air cleaner element
- (4) Air inlet

1. Remove the cover. Remove the primary air cleaner element.
 2. The secondary air cleaner element should be removed and discarded for every three cleanings of the primary air cleaner element.
- Note:** Refer to “Cleaning the Primary Air Cleaner Elements”.
3. Cover the air inlet with tape in order to keep dirt out.
 4. Clean the inside of the air cleaner cover and body with a clean, dry cloth.
 5. Remove the tape from the air inlet. Install the secondary air cleaner element. Install a primary air cleaner element that is new or cleaned.
 6. Install the air cleaner cover.
 7. Reset the air cleaner service indicator.

Cleaning the Primary Air Cleaner Elements

Refer to the OEM information in order to determine the number of times that the primary filter element can be cleaned. When the primary air cleaner element is cleaned, check for rips or tears in the filter material. The primary air cleaner element should be replaced at least one time per year. This replacement should be performed regardless of the number of cleanings.

NOTICE

Do not tap or strike the air cleaner element.

Do not wash the primary air cleaner element.

Use low pressure (207 kPa; 30 psi maximum) pressurised air or vacuum cleaning to clean the primary air cleaner element.

Take extreme care in order to avoid damage to the air cleaner elements.

Do not use air cleaner elements that have damaged pleats, gaskets or seals.

Refer to the OEM information in order to determine the number of times that the primary air cleaner element can be cleaned. Do not clean the primary air filter element more than three times. The primary air cleaner element must be replaced at least one time per year.

Cleaning the air filter element will not extend the life of the air filter element.

Visually inspect the primary air cleaner element before cleaning. Inspect air cleaner elements for damage to the pleats, the seals, the gaskets and the outer cover. Discard any damaged air cleaner element.

Two methods may be used in order to clean the primary air cleaner element:

- pressurized air
- Vacuum cleaning

Pressurized Air

WARNING

Personal injury can result from air pressure.

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

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

Pressurized air can be used to clean primary air cleaner elements that have not been cleaned more than three times. Use filtered, dry air with a maximum pressure of 207 kPa (30 psi). Pressurized air will not remove deposits of carbon and oil.

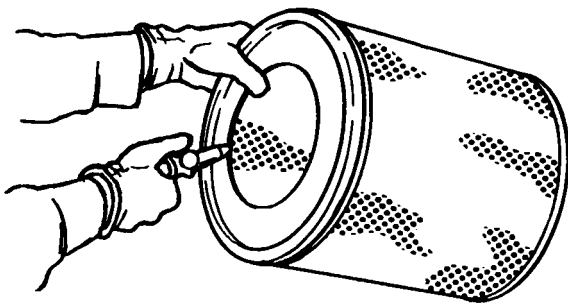


Illustration 61

g00281692

Note: When the primary air cleaner elements are cleaned, always begin with the clean side (inside) in order to force dirt particles toward the dirty side (outside).

Aim the air hose so that air flows along the length of the filter. Follow the direction of the paper pleats in order to prevent damage to the pleats. Do not aim the air directly at the face of the paper pleats.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Vacuum Cleaning

Vacuum cleaning is a good method for removing accumulated dirt from the dirty side (outside) of a primary air cleaner element. Vacuum cleaning is especially useful for cleaning primary air cleaner elements which require daily cleaning because of a dry, dusty environment.

Cleaning from the clean side (inside) with pressurized air is recommended prior to vacuum cleaning the dirty side (outside) of a primary air cleaner element.

Note: Refer to “Inspecting the Primary Air Cleaner Elements”.

Inspecting the Primary Air Cleaner Elements

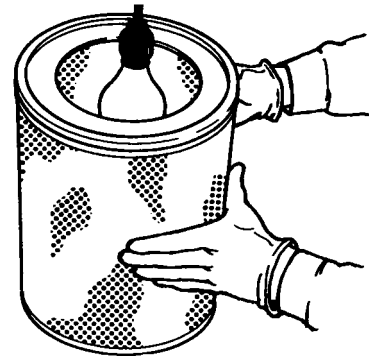


Illustration 62

g00281693

Inspect the clean, dry primary air cleaner element. Use a 60 watt blue light in a dark room or in a similar facility. Place the blue light in the primary air cleaner element. Rotate the primary air cleaner element. Inspect the primary air cleaner element for tears and/or holes. Inspect the primary air cleaner element for light that may show through the filter material. If it is necessary in order to confirm the result, compare the primary air cleaner element to a new primary air cleaner element that has the same part number.

Do not use a primary air cleaner element that has any tears and/or holes in the filter material. Do not use a primary air cleaner element with damaged pleats, gaskets or seals. Discard damaged primary air cleaner elements.

i02152042

Engine Air Cleaner Element (Single Element) - Inspect/Replace

Refer to Operation and Maintenance Manual, “Engine Air Cleaner Service Indicator-Inspect”.

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.

A wide variety of air cleaners may be installed for use with this engine. Consult the OEM information for the correct procedure to replace the air cleaner.

i02335405

Engine Air Cleaner Service Indicator - Inspect

Some engines may be equipped with a different service indicator.

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

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

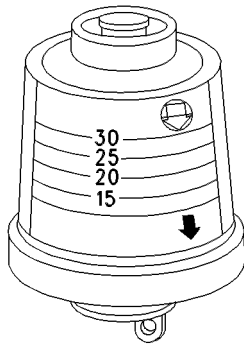


Illustration 63

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

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

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

i02343354

Engine Air Precleaner - Check/Clean

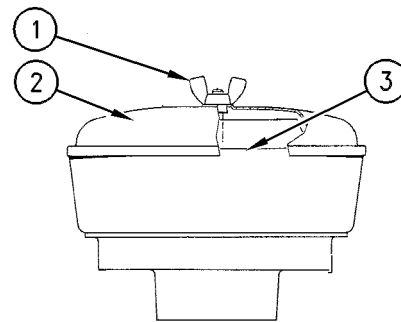


Illustration 64

g00287039

Typical example

- (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 applications, more frequent cleaning is required.

i04151729

Engine Crankcase Breather Element - Replace

WARNING

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

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

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.

The crankcase breather is a very important component in order to keep your engine emissions compliant.

- The filter element within the crankcase breather must be serviced at the prescribed service interval.
- The correct filter element must be installed before the engine is operated.
- The installation of the filter element is very important.
- The quality of the filter element that is installed is very important.
- The filter element protects the engine from excessive quantities of oil from entering the induction system. The filter element also protects the engine aftertreatment system.

Note: Excessive quantities of oil that enter the induction system of the engine can rapidly increase the engine speed without control.

For information on aftermarket products, refer to Operation and Maintenance Manual, "Engine Description". Within that section, refer to the title "Aftermarket Products and Perkins Engines".

The breather element can be serviced from the top position or the breather element can be serviced from the bottom position.

Top Service

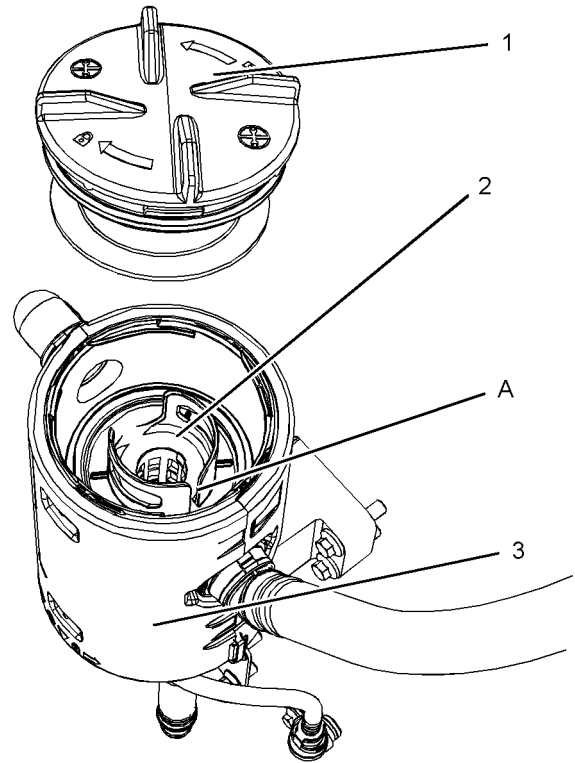


Illustration 65

g02346496

Typical example

(A) Alignment position

1. Ensure that dirt cannot enter the breather assembly. Ensure that the outside body of the breather assembly is clean and free from damage. Place a container under the breather assembly.
2. Rotate the top cap (1) counterclockwise into the unlocked position. Remove the top cap from the body of the breather (3).
3. Note the orientation of the filter element (2). Remove the filter element .

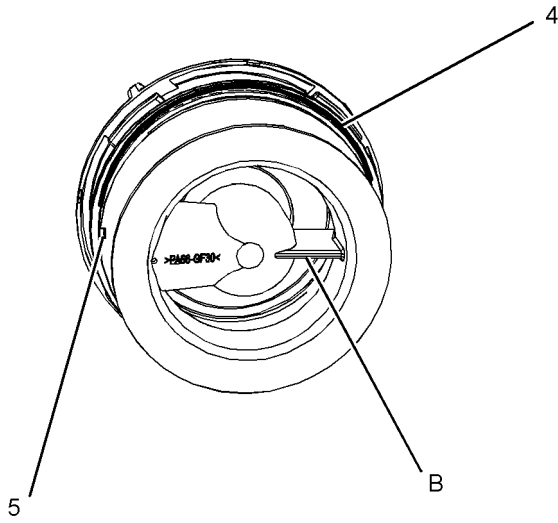


Illustration 66
Typical example
(B) Alignment position

4. Remove the old seal (4) and install a new seal.

Note: The cut away from section (5) in the top cap allows access to the seal.

5. Install a new filter element into the breather body (3). Align position (A) on the filter element to position (B) on the top cap.

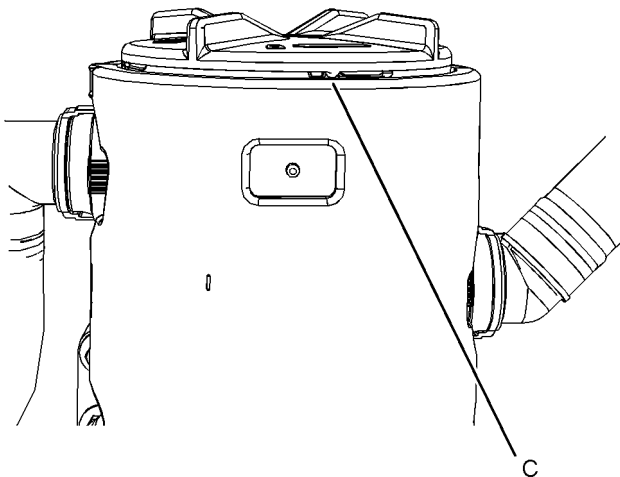


Illustration 67
Typical example

6. Install the top cap (1). Rotate the top cap by hand clockwise until the top cap locks into the locked position (C) on the breather body.

7. Remove the container.

Bottom Service

Ensure that dirt cannot enter the breather assembly.

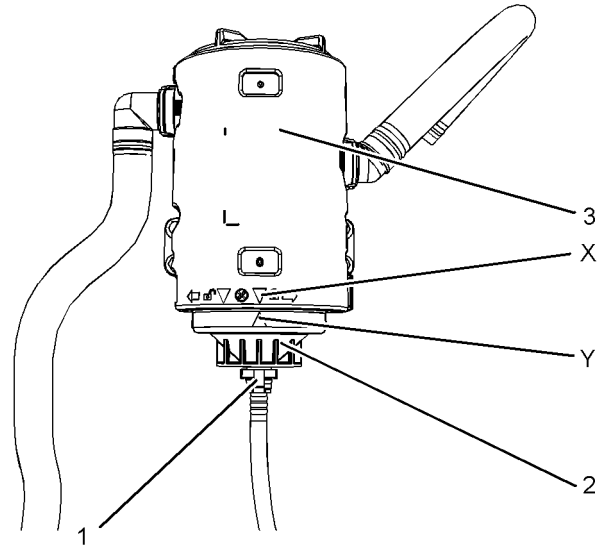


Illustration 68
(X) Alignment mark
(Y) Alignment mark

1. Ensure that the outside body of the breather assembly is clean and free from damage. Place a container under the breather.
2. Remove the tube connection (1). Ensure that dirt cannot enter the tube connection. Note the position of the alignment marks (X and Y). Rotate the bottom cap (2) counterclockwise in order to release the cap and the filter element (4) from the breather body (3).

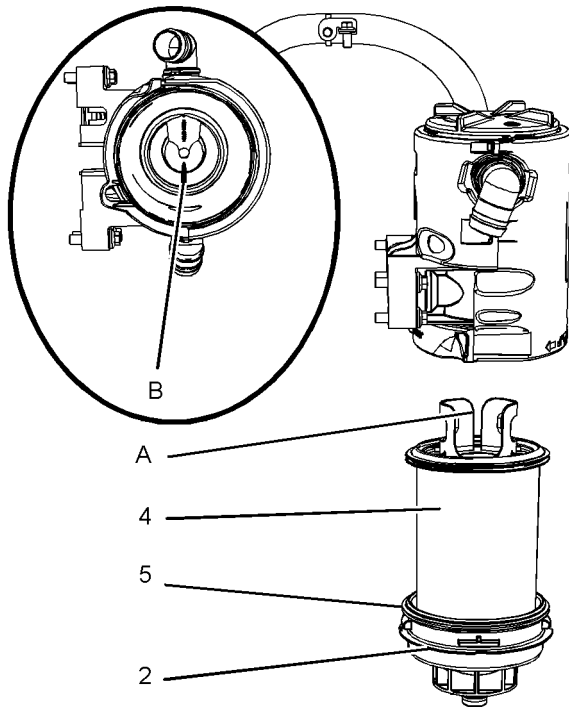


Illustration 69

g02346499

Typical example

(A) Alignment position
(B) Alignment position

- Note the orientation of the filter element. Remove the filter element (4) from the bottom cap (2). Remove the seal (5).

Note: The bottom cap has a section that allows access in order to remove the seal.

- Install a new seal (5). Install a new filter element into the bottom cap (2).
- Align position (A) on the filter element to position (B) on the top cap. Refer to illustration 69.
- Install the assembly of the filter element and the bottom cap (2). Rotate the bottom cap by hand clockwise until the bottom cap locks into the locked position on the breather body. Ensure that the alignment marks (X and Y) are correctly aligned. Refer to illustration 68.
- Install tube connection (1). Ensure that the retaining clips on the tube connection are correctly engaged. Remove the container.

Check the System

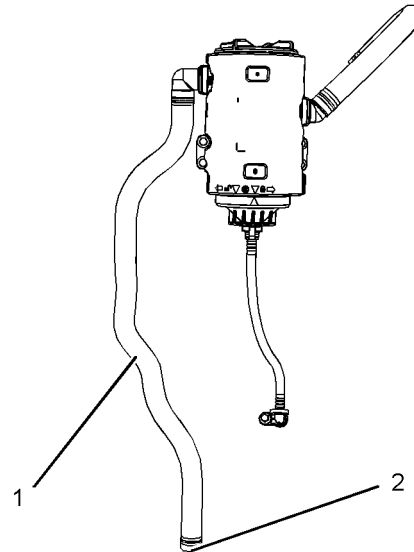


Illustration 70

g02346500

Typical example

Inspect the breather tube (1) for damage. Ensure that the outlet (2) is clean and free from any obstructions. Ice can cause obstructions in adverse weather conditions.

i02323089

Engine Mounts - Inspect

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

Inspect the engine mounts for deterioration and for correct bolt torque. 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.

i03996001

i01907674

Engine Oil Level - Check

WARNING

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



Illustration 71

g02173847

"L" Low

"H" High

NOTICE

Perform this maintenance with the engine stopped.

Note: Ensure that the engine is either level or that the engine is in the normal operating position in order to obtain a true level indication.

Note: After the engine has been switched OFF, wait for 10 minutes in order to allow the engine oil to drain to the oil pan before checking the oil level.

1. Maintain the oil level between the mark (L) and the mark (H) on the engine oil dipstick. Do not fill the crankcase above the "H".

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.

If an increase in the oil level is noticed, refer to Troubleshooting, "Oil Contains Fuel".

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.

i03996054

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

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

Drain the Engine Lubricating Oil

Note: Ensure that the vessel that will be used is large enough to collect the waste 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 oil pan:

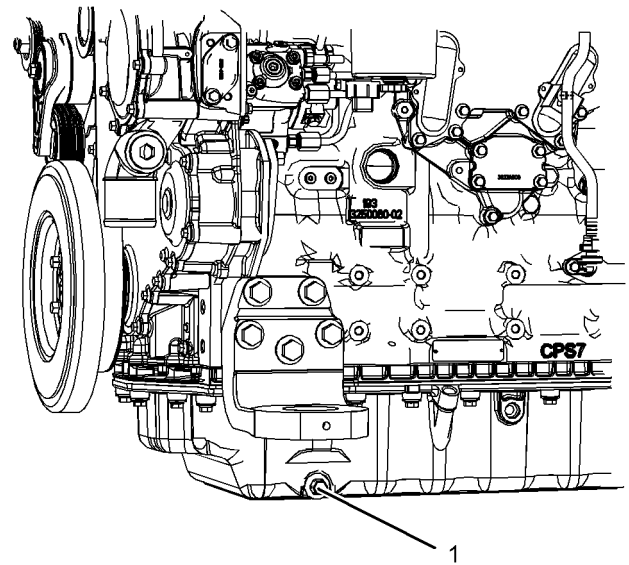


Illustration 72

g01880893

Typical example

- If the engine is equipped with a drain valve, turn the drain valve knob counterclockwise in order to drain the oil. After the oil has drained, turn the drain valve knob clockwise in order to close the drain valve.
- If the engine is not equipped with a drain valve, remove the oil drain plug (1) in order to allow the oil to drain. If the engine is equipped with a shallow oil pan, remove the bottom oil drain plugs from both ends of the oil pan.

After the oil has drained, the oil drain plugs should be cleaned and installed. If necessary, replace the O ring seal. Tighten the drain plug to 34 N·m (25 lb ft).

Replace the Oil Filter

NOTICE

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

1. Remove the oil filter with a suitable tool.

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

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

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

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

Due to normal wear and friction, it is not uncommon to find small amounts of debris in the oil filter.

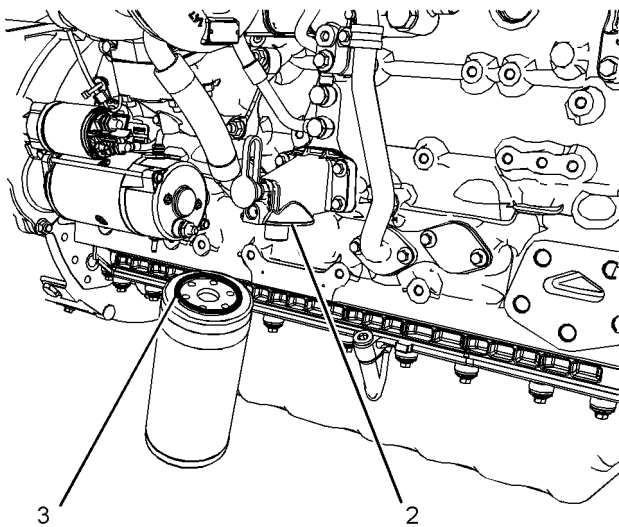


Illustration 73

g02351361

Typical example

3. Clean sealing surface (2).
4. Apply clean engine oil to O ring seal (3) for the new oil filter.

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.

5. Install the new oil filter. Spin on the oil filter until the O ring contacts the sealing surface (2). Then rotate the oil filter $\frac{3}{4}$ of a full turn.

Fill the Oil Pan

1. Remove the oil filler cap. Refer to this Operation and Maintenance Manual, "Fluid Recommendations" for more information on suitable oils. Fill the oil pan with the correct amount of new engine lubricating oil. Refer to this Operation and Maintenance Manual, "Refill Capacities" for more information on refill capacities.

NOTICE

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

2. Start the engine and run the engine at "LOW IDLE" for 2 minutes. Perform this procedure in order 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 oil pan for a minimum of 10 minutes.



Illustration 74

g02173847

"L" Low

"H" High

4. Remove the engine oil level gauge in order to check the oil level. Maintain the oil level between the "L" and "H" marks on the engine oil level gauge. Do not fill the crankcase above the "H" mark.

i03926370

Fan Clearance - Check

There are different types of cooling systems. Refer to the OEM for information on clearance for the fan.

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

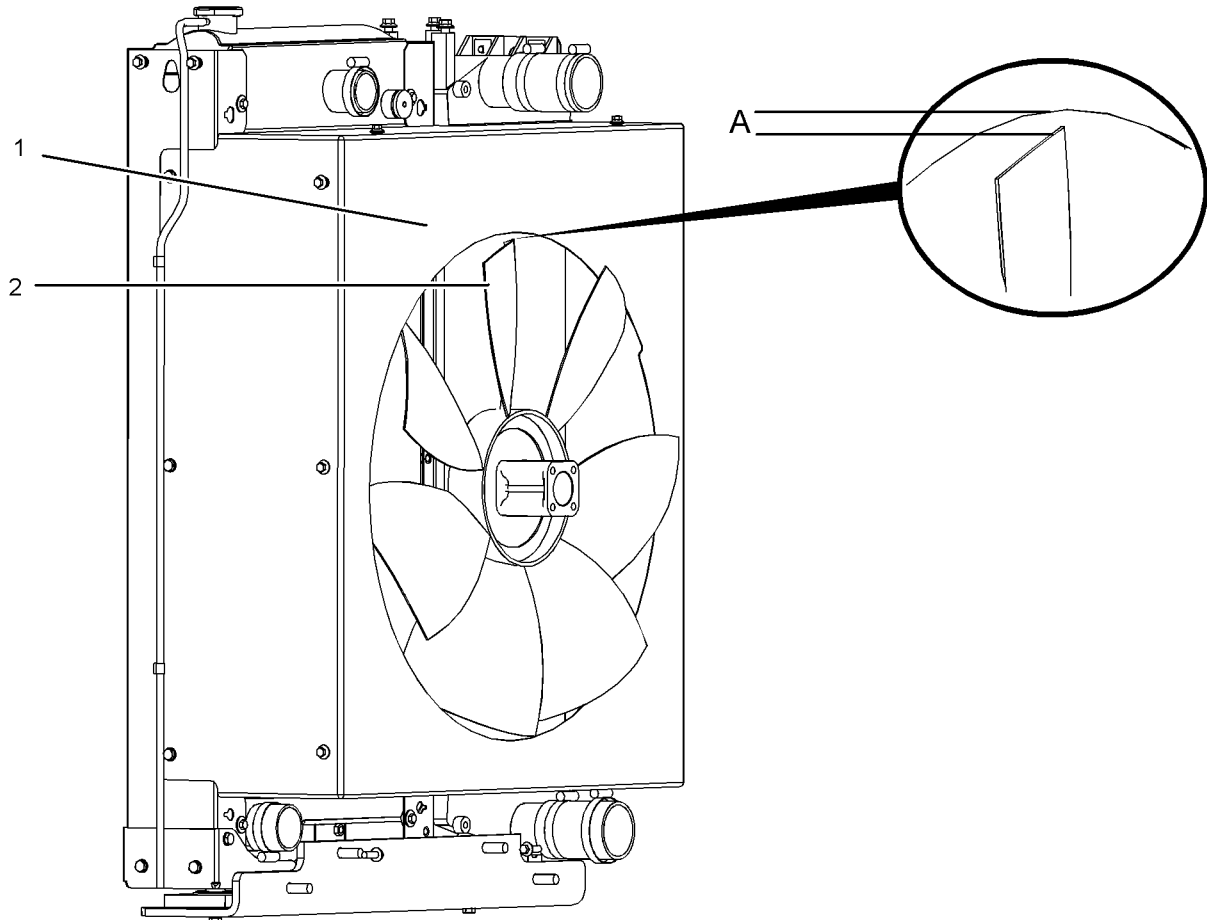


Illustration 75

g01348394

Adjustment of the cover will change the clearance (gap) between the edge of the cover and the tip of the fan blade. Ensure that the cover is centralized to the fan.

i03906114

The clearance (A) must be 11 ± 2 mm
(0.43307 ± 0.07874 inch).

Fuel System - Prime

Note: Refer to Systems Operation, Testing, and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

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

NOTICE

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

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

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

Use the following procedures in order to remove air from the fuel system:

1. Ensure that the fuel system is in working order. Check that the fuel supply valve (if equipped) is in the "ON" position.
2. Turn the keyswitch to the "RUN" position.
3. The keyswitch will allow the electric priming pump to operate. Operate the electric priming pump. The ECM will stop the pump after 2 minutes.
4. Turn the keyswitch to the "OFF" position. The fuel system should now be primed and the engine should be able to start.
5. Operate the engine starter and crank the engine. After the engine has started, operate the engine at low idle for a minimum of 5 minutes. Ensure that the fuel system is free from leaks.

Note: Operating the engine for this period will help ensure that the fuel system is free of air. **DO NOT loosen the high-pressure fuel lines in order to purge air from the fuel system. This procedure is not required.**

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low-pressure fuel system and from the cooling, lubrication, or air systems. Replace any high-pressure fuel line that has leaked. Refer to Disassembly and Assembly Manual, "Fuel Injection Lines - Install".

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

If the engine will not start, refer to Troubleshooting, "Engine Cranks but will not Start".

i03980070

Fuel System Primary Filter (Water Separator) Element - 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.

Note: Refer to Systems Operation, Testing, and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

Remove the Element

1. Turn the fuel supply valve (if equipped) to the OFF position before performing this maintenance.
2. Place a suitable container under the water separator in order to catch any fuel that might spill. Clean up any spilled fuel. Clean the outside body of the filter assembly.
3. Make a temporary Mark (A) across the filter before the assembly is removed.

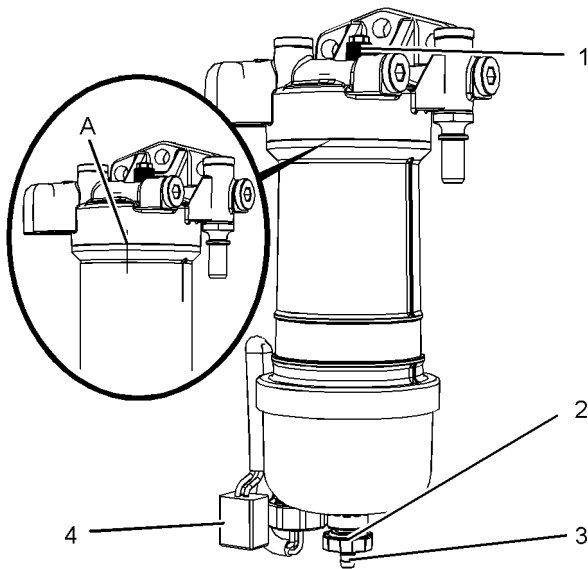


Illustration 76

g02148376

Typical example

4. Install a suitable tube onto drain (3). Open the drain valve (2). Rotate the drain valve counterclockwise. Two full turns are required. Loosen vent screw (1).

Note: Two complete rotations of the valve will release the valve from the filter element.

5. Allow the fuel to drain into the container. Remove the tube and install the valve into the filter element. Engage the threads of the valve into the filter element. Do not secure the valve.
6. Tighten the vent screw (1) securely. Remove the wiring harness from connection (4).
7. Remove the filter bowl (6). Rotate the filter assembly counterclockwise in order to remove the filter assembly. Use a suitable tool in order to remove the filter assembly.

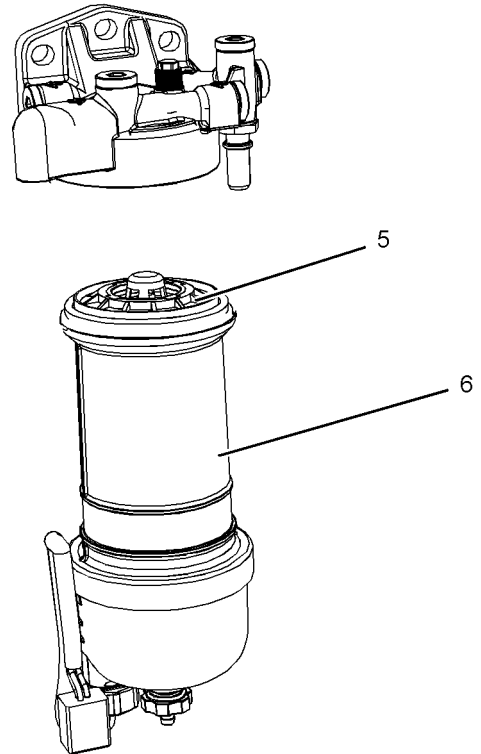


Illustration 77

g02148402

Typical example

8. Rotate the filter element counterclockwise and remove the filter element (5). Clean the filter bowl.

Install the Element

i03980098

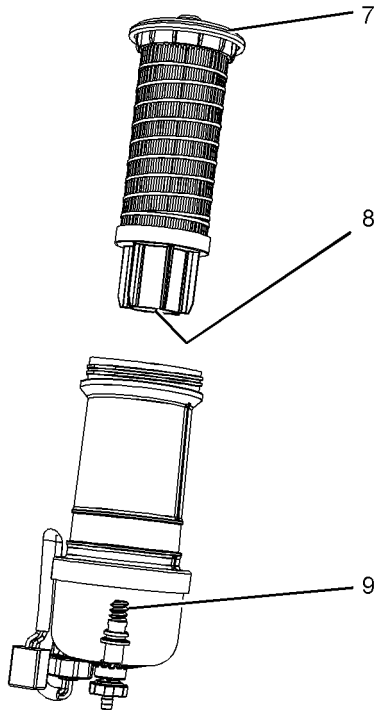


Illustration 78

g02148441

Typical example

1. Locate the thread in the filter element (8) onto the threads (9). Spin on the element. Do not tighten.
2. Lubricate the O ring seal (7) with clean engine oil. Do NOT fill the bowl with fuel before the assembly is installed.
3. Do not use a tool in order to install the filter assembly. Tighten the filter bowl (6) by hand. Install the filter bowl (6) and align with your temporary marks (A).
4. Tighten the valve (2) securely. Remove the container and dispose of the fuel in a safe place.
5. The secondary filter element must be replaced at the same time as the primary filter element. Refer to the Operation and Maintenance Manual , "Fuel System Filter - Replace".

In-line Strainer

The fuel system as an in-line strainer installed before the electric priming pump. Perkins recommended that the in-line strainer be replaced when required.

The location of the in-line strainer will depend on the application.

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

Ensure that the engine is stopped before any servicing or repair is performed.

NOTICE

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

1. Place a suitable container under the water separator in order to catch any fluid that might spill. Clean up any spilled fluid.
2. Ensure that the outer body of the filter assembly is clean and free from dirt.

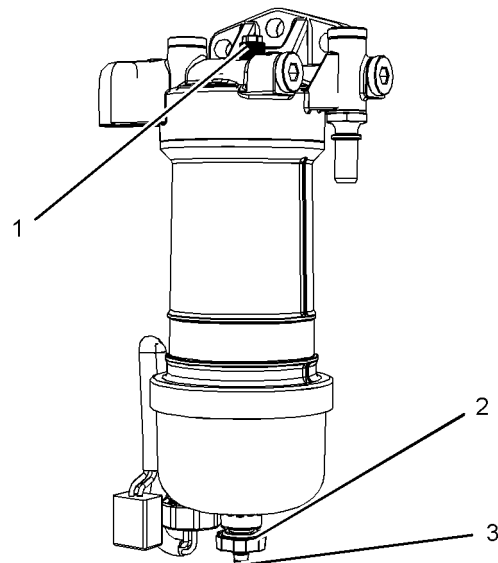


Illustration 79

g02148370

Typical example

3. Install a suitable tube onto drain (3). Open the drain valve (2). Rotate the drain valve counterclockwise. Two full turns are required. Loosen vent screw (1).

Note: Two complete rotations of the valve will release the valve from the filter element.

4. Allow the fluid to drain into the container.
5. Engage the threads of the valve into the filter element and tighten the drain valve by hand pressure only. Remove the tube and remove the container.
6. Tighten vent screw securely.

i03980099

Fuel System Secondary Filter - Replace

WARNING

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

NOTICE

Ensure that the engine is stopped before any servicing or repair is performed.

Refer to Systems Operation, Testing, and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

Remove the Element

1. Turn the fuel supply valve (if equipped) to the OFF position before performing this maintenance.
2. Place a suitable container under the fuel filter in order to catch any fuel that might spill. Clean up any spilled fuel. Clean the outside body of the filter assembly.

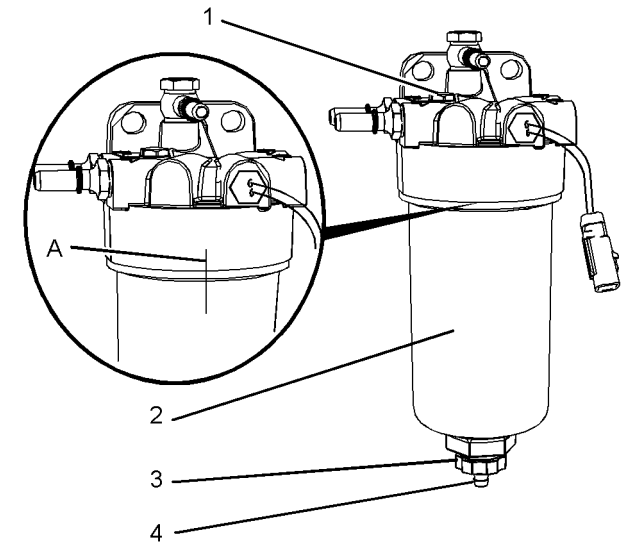


Illustration 80

g02148699

Typical example

3. Make a temporary Mark (A) across the filter before the assembly is removed. Install a suitable tube onto drain (4). Open the drain valve (3). Rotate the drain valve counterclockwise. Two full turns are required. Loosen vent screw (1).

Note: Two complete rotations of the valve will release the valve from the filter element.

4. Allow the fuel to drain into the container. Remove the tube and install the valve into the filter element. Engage the threads of the valve into the filter element. Do not secure the valve.
5. Tighten the vent screw (1) securely.
6. Remove the filter bowl (2). Rotate the filter assembly counterclockwise in order to remove the assembly. Use a suitable tool in order to remove the filter bowl.

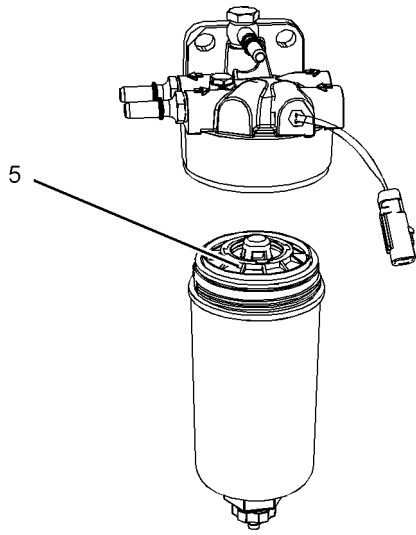


Illustration 81

g02148527

Typical example

7. Rotate the filter element counterclockwise and remove the filter element (5). Clean the filter bowl.

Install the Element

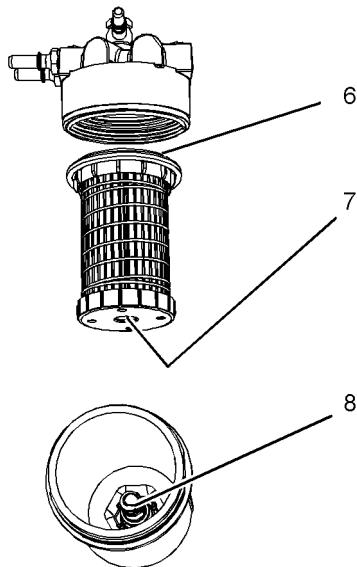


Illustration 82

g02148528

Typical example

1. Locate the thread in the filter element (7) onto the threads (8). Spin on the element. Do not tighten.
2. Lubricate the O ring seal (6) with clean engine oil. Do NOT fill the filter bowl (2) with fuel before the filter assembly is installed.

3. Do not use a tool in order to install the filter assembly. Tighten the assembly by hand. Install the filter bowl (2) and align with your temporary Marks.
4. Tighten the drain valve (3). Turn the fuel supply valve to the ON position.
5. The Primary filter element must be replaced at the same time as the secondary filter element. Refer to the Operation and Maintenance Manual , "Fuel System Primary Filter (Water Separator) Element - Replace".
6. Prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" for more information.

i02335436

Fuel Tank Water and Sediment - Drain

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Fuel Tank

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

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

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

Drain the Water and the Sediment

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

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

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

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

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

Fuel Storage Tanks

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

- Weekly
- Service intervals
- Refill of the tank

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

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

i02349879

Hoses and Clamps - Inspect/Replace

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.

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

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.

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.

i02335774

Radiator - Clean

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

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

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

 **WARNING**

Personal injury can result from air pressure.

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

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

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

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

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

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

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

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

i03639888

Radiator Pressure Cap - Clean/Replace

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. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the radiator pressure cap.
2. Check coolant level. Refer to Operation and Maintenance Manual, “Cooling System Coolant Level - Check”.
3. Install new radiator pressure cap.

i02335775

Severe Service Application - Check

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

- Performance such as power range, speed range, and fuel consumption
- Fuel quality
- Operational Altitude

- Maintenance intervals
- Oil selection and maintenance
- Coolant type and maintenance
- Environmental qualities
- Installation
- The temperature of the fluid in the engine

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

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

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

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

Environmental Factors

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

Quality of the air – The engine may be 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
- Operating at excessive loads
- Operating at excessive speeds
- Operating outside the intended application

Incorrect Maintenance Procedures

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

i02177969

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 or consult your Perkins dealer or your Perkins distributor for assistance.

i04103131

Turbocharger - Inspect (High Pressure and Low Pressure Turbochargers)

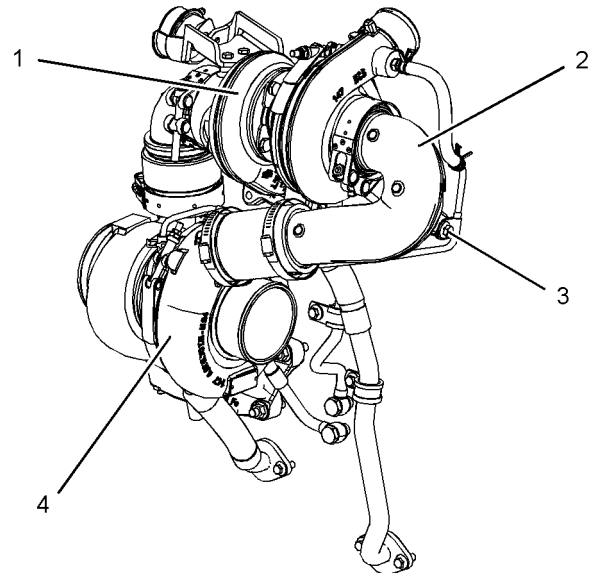


Illustration 83
Typical example

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WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

The engine is equipped with a high-pressure turbocharger (1) and a low-pressure turbocharger (4). A regular visual inspection of both turbochargers is recommended. If the turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to the turbocharger compressor wheel can cause additional damage to the pistons, the valves, and the cylinder head.

NOTICE

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

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

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

A visual inspection of the turbochargers can minimize unscheduled downtime. A visual inspection of the turbochargers can also reduce the chance for potential damage to other engine parts. Do not inspect the engine with the engine in operation.

Removal and Installation

Refer to the Disassembly and Assembly Manual, "Turbocharger - Remove and Turbocharger Install" for further information.

Inspecting

NOTICE

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

1. Ensure that the turbocharger is clean and free from dirt before removing components for inspection.
2. Remove the pipe from the high-pressure turbocharger exhaust outlet and remove the air intake pipe to the turbocharger. Visually inspect the piping for the presence of oil. Clean the interior of the pipes in order to prevent dirt from entering during reassembly.
3. Remove bolt (3).
4. Remove air duct (2) and check for the presence of engine oil.
5. Check for any loose bolts or any missing bolts. Check for damage to the oil supply line and the oil drain line. Check for cracks in the housing of the turbocharger. Ensure that the compressor wheel can rotate freely.
6. Check for the presence of oil. If oil is leaking from the back side of the compressor wheel, there is a possibility of a failed turbocharger oil seal.

The presence of oil may be the result of extended engine operation at low idle. The presence of oil may also be the result of a restriction of the line for the intake air (clogged air filters), which causes the turbocharger to slobber.
7. If engine oil is found in the system, the cause can be the engine operating condition.
 - a. Ensure that the air duct (2) is clean and free from dirt. Install air duct (2). Install bolt (3). Ensure that the air intake is not clogged.
 - b. Operate the engine for 15 minutes at a moderate high load condition.
 - c. Allow the engine to cool. Remove air duct and check for the presence of engine oil. If the deposits of wet engine oil have been removed, the air duct can be installed and the engine can operate normally. For more information, refer to Systems Operation, Testing and Adjusting, "Turbocharger - Inspect".
8. Inspect the bore of the housing of the turbine outlet for corrosion.
9. Fasten the air intake pipe and the exhaust outlet pipe to the turbocharger housing. Ensure that all clamps are installed correctly and that all clamps are tightened securely.

i04156712

Walk-Around Inspection

Inspect the Tube of the Crankcase Breather

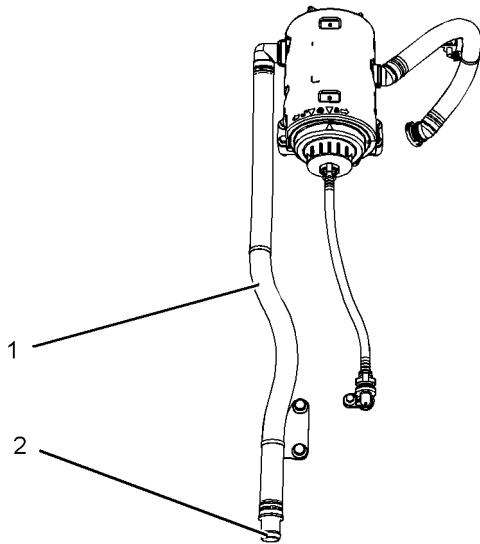


Illustration 84
Typical example

g02351425

Inspect the breather tube (1) for damage. Ensure that the outlet (2) is clean and free from any obstructions. Ice can cause obstructions in adverse weather conditions.

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. Remove the water pump. Refer to Disassembly and Assembly, "Water Pump - Remove and Install". For more information, 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 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.
- Ensure that the areas around the rotating parts are clear.
- Inspect the alternator belts and any accessory drive belts for cracks, breaks, or other damage.
- Inspect the wiring harness for 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.

i03570653

High Pressure Fuel Lines

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.

After the engine has stopped, you must wait for 10 minutes in order to allow the fuel pressure to be purged from the high-pressure fuel lines before any service or repair is performed on the engine fuel lines. If necessary, perform minor adjustments. Repair any leaks from the low-pressure fuel system and from the cooling, lubrication or air systems. Replace any high-pressure fuel line that has leaked. Refer to Disassembly and Assembly Manual, "Fuel Injection Lines - Install".

If you inspect the engine in operation, always use the proper inspection procedure in order to avoid a fluid penetration hazard. Refer to Operation and Maintenance Manual, "General hazard Information".

Visually inspect the high-pressure fuel lines for damage or signs of fuel leakage. Replace any damaged high-pressure fuel lines or high-pressure fuel lines that have leaked.

Ensure that all clips on the high-pressure fuel lines are in place and that the clips are not loose.

- Inspect the rest of the fuel system for leaks. Look for loose fuel line clamps.
- 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. Check for any loose tie-wraps or missing tie-wraps.
- 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 cannot be calibrated.

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

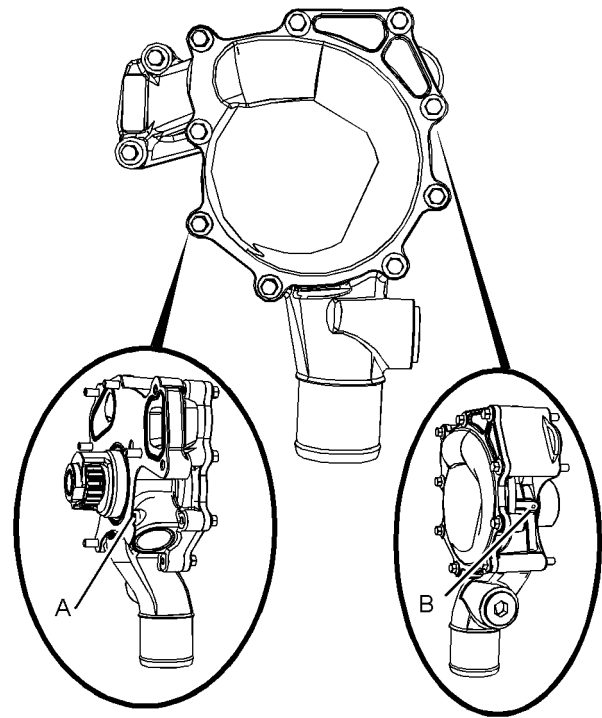


Illustration 85

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(A) Weep hole
(B) Vent hole

Note: The water pump seals are lubricated by the coolant in the cooling system. It is normal for a small amount of leakage to occur. Refer to illustration 85 for the position of the weep hole and the vent hole.

Visually inspect the water pump for leaks.

Note: If engine coolant enters the engine lubricating system the lubricating oil and the engine oil filter must be replaced. This will remove any contamination that is caused by the coolant and this will prevent any irregular oil samples.

The water pump is not a serviceable item. In order to install a new water pump, refer to the Disassembly and Assembly Manual, "Water Pump - Remove and Install".

Warranty Section

Warranty Information

i03586564

Federal Emission Control Warranty

Emissions Warranty

The 1206E-E70TTA diesel engine is a nonroad compression ignition engine. Perkins Engine Company limited warrants to the initial owner and to the subsequent owner of the 1206E-E70TTA diesel engine that such an engine is:

1. Designed, built and equipped so that the engine conform, at the time of sale, with all applicable regulations adopted by the United States Environmental Protection Agency (EPA).
2. Free from defects in materials and workmanship in specific emission related parts for the following period:
 - The warranty period is for 3000 hours or for 5 years, whichever occurs first, after the date of delivery to the owner that operates the engine.

If an emission related part fails during any of the warranty periods, the part will be repaired or replaced. Any such part repaired or replaced under warranty is warranted for the remainder of the warranty period.

During the term of this warranty, Perkins Engine Company limited will provide through a Perkins distributor or your Perkins dealer or other establishment authorized by it, repair or replacement of any warranted part at no charge to the engine owner.

In an emergency, repairs may be performed at any service establishment, or by the owner, using any replacement part. It is recommended that emission related parts be replaced with genuine Perkins Engine Company limited parts.

Perkins Engine Company limited will reimburse the owner for their expenses, including diagnostic charges for such an emergency repair. These expenses shall not exceed the Perkins Engine Company limited suggested retail price for all warranted parts replaced, and labor charges based on Perkins Engine Company limited recommended time allowance for the warranty repair and the geographically appropriate hourly labor rate.

As a condition of reimbursement, replaced parts and receipted invoices must be presented at a place of business of a Perkins distributor or your Perkins dealer or other establishment authorized by Perkins Engine Company limited

This warranty covers the following emission related parts and components:

- Turbocharger System
- Inlet Manifold
- Fuel Injection System
- Crankcase Ventilation System
- Electronic Engine Control System
- Engine Aftertreatment System
- NOx Reduction System
- Aftertreatment Regeneration Device
- Miscellaneous valves, switches, hoses, clamps, connectors, tubing and sealing devices that are used in the above systems

Limitations and Responsibilities

The warranty is subject to the following conditions:

Perkins Engine Company limited Responsibilities

During the emission warranty period, if a defect in material or workmanship of an emission related part or component is found, Perkins Engine Company limited will provide the following:

- New, Remanufactured or repaired parts and/or components, approved pursuant to EPA Regulations, required to correct the defect.
- Reasonable and customary labor, during normal working hours that is required to make the warranty repair. This includes labor in order to remove an engine and install the engine, if necessary.

Note: Items that are replaced under this warranty become the property of Perkins Engine Company limited .

Owner Responsibilities

During the emission warranty period, the owner is responsible for the following items:

- The costs in order to investigate complaints which are not caused by a defect in Perkins Engine Company limited material or Perkins Engine Company limited workmanship.
- Providing timely notice of a warrantable failure and promptly making the product available for repair

Limitations

Perkins Engine Company limited is not responsible for resultant damages to an emission related part or component resulting from the following items:

- Any application or any installation that Perkins Engine Company limited deems improper.
- Attachments, accessory items or parts not sold nor approved by Perkins Engine Company limited
- Improper engine maintenance, repair or abuse.
- Use of improper fuel, lubricants, or fluids.
- Owner's unreasonable delay in making the product available after being notified of a potential product problem.

This warranty is in addition to Perkins Engine Company limited standard warranty, applicable to the engine product involved.

Remedies under this warranty are limited to the provision of material and services as specified herein. Perkins Engine Company limited is not responsible for incidental or consequential damages, including but not limited to downtime or loss-of-use of engine.

i03586562

California Emission Control Warranty Statement

Emissions Warranty

The 1206E-E70TTA is a nonroad compression ignition engine.

The California Air Resources Board (CARB) and Perkins Engines Company Limited are pleased to explain the emission control system warranty on your 1206E-E70TTA diesel engine.

In California, new motor vehicle engines must be designed, built and equipped in order to meet the state's stringent anti-smog standards. Perkins Engines Company Limited must warrant the emission control system on your engine for the duration of time listed below provided, there has not been any abuse, neglect or improper maintenance of your engine or your engine aftertreatment system.

Perkins Engines Company Limited warrants to the initial owner and to the subsequent owner of the 1206E-E70TTA diesel engine that such an engine is:

1. Designed, built and equipped so that the engine conform, at the time of sale, with all applicable regulations adopted by the California Air Resources Board (CARB).
2. Free from defects in materials and workmanship in specific emission related parts for the following period:
 - The warranty period is for 3000 hours or for 5 years, whichever occurs first, after the date of delivery to the owner that operates the engine.

If an emission related part fails during any of the warranty periods, the part will be repaired or replaced. Any such part repaired or replaced under warranty is warranted for the remainder of the warranty period.

During the term of this warranty, Perkins Engines Company Limited will provide through a Perkins distributor or your Perkins dealer or other establishment authorized by it, repair or replacement of any warranted part at no charge to the engine owner.

In an emergency, repairs may be performed at any service establishment, or by the owner, using any replacement part. It is recommended that emission related parts be replaced with genuine Perkins Engines Company Limited parts.

Perkins Engines Company Limited will reimburse the owner for their expenses, including diagnostic charges for such an emergency repair. These expenses shall not exceed the Perkins Engines Company Limited suggested retail price for all warranted parts replaced, and labor charges based on Perkins Engines Company Limited recommended time allowance for the warranty repair and the geographically appropriate hourly labor rate.

As a condition of reimbursement, replaced parts and receipted invoices must be presented at a place of business of a Perkins distributor or your Perkins dealer or other establishment authorized by Perkins Engines Company Limited .

This warranty covers the following emission related parts and components:

- Turbocharger System
- Inlet Manifold
- Fuel Injection System
- Crankcase Ventilation System
- Electronic Engine Control System
- Engine Aftertreatment System
- NOx Reduction System
- Aftertreatment Regeneration Device
- Miscellaneous valves, switches, hoses, clamps, connectors, tubing and sealing devices that are used in the above systems

Limitations and Responsibilities

The warranty is subject to the following conditions:

Perkins Engines Company Limited Responsibilities

During the emission warranty period, if a defect in material or workmanship of an emission related part or component is found, Perkins Engines Company Limited will provide the following:

- New, Remanufactured or repaired parts and/or components, approved pursuant to (CARB) Regulations, required to correct the defect.
- Reasonable and customary labor, during normal working hours that is required to make the warranty repair. This includes labor in order to remove an engine and install the engine, if necessary.

Note: Items that are replaced under this warranty become the property of Perkins Engines Company Limited .

Owner Responsibilities

During the emission warranty period, the owner is responsible for the following items:

- The costs in order to investigate complaints which are not caused by a defect in Perkins Engines Company Limited material or Perkins Engines Company Limited workmanship.
- Providing timely notice of a warrantable failure and promptly making the product available for repair

Limitations

Perkins Engines Company Limited is not responsible for resultant damages to an emission related part or component resulting from the following items:

- Any application or any installation that Perkins Engines Company Limited deems improper.
- Attachments, accessory items or parts not sold nor approved by Perkins Engines Company Limited
- Improper engine maintenance, repair or abuse.
- Use of improper fuel, lubricants, or fluids.
- Owner's unreasonable delay in making the product available after being notified of a potential product problem.

This warranty is in addition to Perkins Engines Company Limited standard warranty, applicable to the engine product involved.

Remedies under this warranty are limited to the provision of material and services as specified herein. Perkins Engines Company Limited is not responsible for incidental or consequential damages, including but not limited to downtime or loss-of-use of engine.

104141345

Emissions Warranty Information

- EPA _____ United States Environmental Protection Agency
- CARB _____ California Air Resources Board

Note: The warranty of the engine applies to engines that are operated within the areas of the world where the following regulations apply: US EPA Tier 4 Interim, EU Stage IIIB or Japanese MLIT Step 4. If an engine is operated in regions of the world where these regulations do not apply the warranty will be void. Contact your Perkins dealer or your Perkins distributor for more information.

Maintenance Recommendations

Perkins Engines Company Limited engines are certified by the EPA and the CARB in order to comply with exhaust emission standards and gaseous emission standards that are prescribed by the law at the time of manufacture.

Efficiency of the emission control and the engine performance depends on adherence to proper operation and maintenance recommendations and use of recommended fuels and lubricating oils. According to recommendations, major adjustments and repairs should be made by your authorized Perkins distributor or your authorized Perkins dealer.

Various chemical fuel additives which claim to reduce visible smoke are available commercially. Although additives have been used to solve some isolated smoke problems in the field, additives are not recommended for general use. The engines should be certified without smoke depressants according to federal smoke regulations.

Take corrective steps immediately after worn parts which may affect the emissions level are discovered in order to ensure the proper operation of the emission control systems. The use of genuine Perkins components is recommended. If the owner uses non-Perkins components, then the non-Perkins components must not adversely affect the emissions level of the engine.

For information on the use of Aftermarket Products and Perkins Engines, refer to this Operation and Maintenance Manual, "Engine Description".

Regular maintenance intervals with a special emphasis on the following items are necessary in order to keep exhaust emissions within acceptable limits for the useful life of the engine. Refer to the Operation and Maintenance Manual, "Severe Service Application - Check" topic (Maintenance Section). If the engine is operating under severe conditions, adjust the maintenance schedule accordingly. See your authorized Perkins distributor/dealer in order to help analyze your specific application, operating environment, and maintenance schedule adjustments.

The following information is an explanation of maintenance items for emission-related components. See the Operation and Maintenance Manual, "Maintenance Interval Schedule" (Maintenance Section) for the specific interval for the following items.

ENGINE AFTERTREATMENT SYSTEM – The Engine Aftertreatment Systems are sensitive to the type of fuel and lubricants that is used. Also, the engine aftertreatment systems are sensitive to the operating schedule. Low quality fuel, lubricants, or fluids may cause increases in exhaust back pressure or clogging resulting in loss of power. An authorized Perkins distributor/dealer can determine if the engine aftertreatment systems require a service.

NOx Reduction System (NRS) – The NRS is monitored. An authorized Perkins distributor/dealer can determine if the NRS needs service.

FUEL INJECTORS – Fuel injector tips are subject to wear as a result of fuel contamination. This damage can cause the following conditions: an increase in fuel consumption, black smoke, misfire, and rough running engine. The fuel injector should be inspected, tested, and replaced, if necessary. Fuel injectors can be tested by an authorized Perkins distributor/dealer.

TURBOCHARGER – Refer to this Operation and Maintenance Manual, "Turbocharger - Inspect" for information on inspection of the turbocharger.

ELECTRONIC ENGINE CONTROL (ECM) – The ECM is the control computer of the engine. The ECM provides power to the electronics. The ECM monitors data that is input from the sensors of the engine. The ECM acts as a governor in order to control the speed and the power of the engine. The ECM adjusts injection timing and fuel pressure for the best engine performance, the best fuel economy, and the best control of exhaust emissions.

Erratic behavior of the engine may indicate a need for repair to the ECM. Your Perkins distributor/dealer is equipped with the necessary tools, personnel, and procedures in order to perform this service.

The owner is encouraged to keep adequate maintenance records. However, the absence of such records will not invalidate the warranty. Refer to the Operation and Maintenance Manual, "Maintenance Log" (Reference Materials Section).

The owner may perform routine maintenance, repairs, and other work that is outside of the warranty. The work may be done at any repair facility. Such work does not need to be performed at a designated station that is determined by the warranty in order for the warranty to remain in force.

Reference Information Section

Reference Materials

i04020001

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:

www.perkins.com

NOTICE

Dependant upon engine type and application.

Index

A

After Starting Engine	60
After Stopping Engine.....	66
Aftercooler Core - Clean/Test (Air-To-Air Aftercooler)	89
Aftercooler Core - Inspect.....	89
Alternator - Inspect	90
Alternator and Fan Belts - Replace	90
ARD Spark Plug - Clean/Inspect/Replace	89

B

Battery - Replace.....	90
Battery Electrolyte Level - Check	91
Battery or Battery Cable - Disconnect	91
Before Starting Engine	15, 58
Belt - Inspect.....	92
Belt Tensioner - Inspect.....	92
Burn Prevention.....	10
Batteries.....	11
Coolant.....	11
Induction System	11
Oils.....	11

C

California Emission Control Warranty Statement	126
Emissions Warranty	126
Cold Weather Operation.....	68
Hints for Cold Weather Operation.....	68
Idling the Engine	69
Recommendations for Coolant Warm Up	69
Recommendations for the Coolant	68
Viscosity of the Engine Lubrication Oil.....	68
Cold Weather Starting	58
Configuration Parameters.....	53
Customer Specified Parameters	54
System Configuration Parameters	53
Cooling System Coolant (Commercial Heavy-Duty) - Change	93
Drain	93
Fill	94
Flush	94
Cooling System Coolant (ELC) - Change.....	95
Drain	95
Fill	96
Flush	96
Cooling System Coolant Level - Check.....	97
Engines With a Coolant Recovery Tank.....	97
Engines Without a Coolant Recovery Tank.....	97
Cooling System Supplemental Coolant Additive (SCA) - Test/Add.....	98
Add the SCA, If Necessary	98
Test for SCA Concentration	98

Cooling System Water Temperature Regulator - Replace.....	99
Crankshaft Vibration Damper - Inspect	99
Viscous Damper.....	99
Crushing Prevention and Cutting Prevention	13

D

Diagnostic Flash Code Retrieval	46
Diagnostic Lamp.....	46
Diesel Particulate Filter - Clean	100
Diesel Particulate Filter Regeneration	61
Lamps	62
Modes of Regeneration.....	62
Regeneration	61
Regeneration Switch.....	63
Soot Level Monitoring and Indicator Lamps.....	63
Driven Equipment - Check.....	100

E

Electrical System.....	16
Grounding Practices	16
Emergency Stopping	66
Emissions Certification Film	29
Label for compliant engines	29
Emissions Warranty Information.....	127
Maintenance Recommendations	128
Engine - Clean.....	101
Aftertreatment	101
Engine Air Cleaner Element (Dual Element) - Clean/Replace	101
Cleaning the Primary Air Cleaner Elements	102
Servicing the Air Cleaner Elements	101
Engine Air Cleaner Element (Single Element) - Inspect/Replace	103
Engine Air Cleaner Service Indicator - Inspect...	104
Test the Service Indicator.....	104
Engine Air Precleaner - Check/Clean.....	104
Engine Crankcase Breather Element - Replace..	105
Bottom Service.....	106
Check the System.....	107
Top Service	105
Engine Description	25
Aftermarket Products and Perkins Engines	26
Electronic Engine Features.....	25
Engine Cooling and Lubrication.....	26
Engine Diagnostics	26
Engine Service Life.....	26
Engine Specifications.....	25
Engine Diagnostics.....	46
Engine Electronics.....	17
Engine Mounts - Inspect.....	107

Engine Oil and Filter - Change	109	Fuel System Primary Filter/Water Separator -	
Drain the Engine Lubricating Oil	109	Drain	114
Fill the Oil Pan	110	Fuel System Secondary Filter - Replace	115
Replace the Oil Filter	109	Install the Element	116
Engine Oil Level - Check	108	Remove the Element	115
Engine Oil Sample - Obtain	108	Fuel Tank Water and Sediment - Drain	116
Obtain the Sample and the Analysis	108	Drain the Water and the Sediment	116
Engine Operation	61	Fuel Storage Tanks	117
Engine Operation and Active Regeneration	61	Fuel Tank	116
Reduction of Particulate Emissions	61		
Engine Operation with Active Diagnostic Codes ...	52	G	
Engine Operation with Intermittent Diagnostic		Gauges and Indicators	34
Codes	53	Aftertreatment Lamps	35
Engine Protection Plans (Extended Service		Indicator Lamps	35
Contract)	129	General Hazard Information	7
Engine Shutoffs and Engine Alarms	44	Asbestos Information	9
Alarms	44	Containing Fluid Spillage	9
Shutoffs	44	Dispose of Waste Properly	10
Testing	45	Fluid Penetration	9
Engine Starting	15, 58	Pressurized Air and Water	9
Engine Stopping	15, 66		
		H	
F		High Pressure Fuel Lines	13
Fan Clearance - Check	110	Hoses and Clamps - Inspect/Replace	117
Fault Logging	52	Replace the Hoses and the Clamps	117
Features and Controls	36		
Federal Emission Control Warranty	125	I	
Emissions Warranty	125	Important Safety Information	2
Fire Prevention and Explosion Prevention	11		
Fire Extinguisher	13	L	
Lines, Tubes and Hoses	13	Lifting and Storage	30
Fluid Recommendations	72, 77, 79		
Diesel Fuel Characteristics	82	M	
Diesel Fuel Requirements	79	Maintenance Interval Schedule	88
ELC Cooling System Maintenance	74	Maintenance Recommendations	86
Engine Oil	77	Maintenance Section	72
General Coolant Information	72	Model View Illustrations	19
General Information	79	Engine Aftertreatment System	22
General Lubricant Information	77	Engine views	20
Foreword	4	Model Views	19
California Proposition 65 Warning	4	Monitoring System (Engine)	36
Literature Information	4	Instrument panels and Displays	37
Maintenance	4	Programmable Options and Systems	
Maintenance Intervals	4	Operation	37
Operation	4	Mounting and Dismounting	13
Overhaul	4		
Safety	4	O	
Fuel and the Effect from Cold Weather	70	Operation Section	30
Fuel Conservation Practices	65	Overspeed	45
Fuel Related Components in Cold Weather	71		
Fuel Filters	71		
Fuel Heaters	71		
Fuel Tanks	71		
Fuel System - Prime	111		
Fuel System Primary Filter (Water Separator)			
Element - Replace	112		
In-line Strainer	114		
Install the Element	114		
Remove the Element	112		

P

Plate Locations and Film Locations..... 27
 Serial Number Plate (1) 27
Plate Locations and Film Locations (Engine
 Aftertreatment System)..... 28
Product Identification Information 27
Product Information Section 19
Product Lifting..... 32
Product Lifting (Clean Emission Module) 30
Product Lifting (Engine)..... 30
Product Storage (Engine and Aftertreatment) 33
 Condition for Storage 33

R

Radiator - Clean 118
Radiator Pressure Cap - Clean/Replace 119
Reference Information Section 129
Reference Materials 129
Reference Numbers 28
 Record for Reference..... 28
Refill Capacities..... 72
 Cooling System..... 72
 Lubrication System 72

S

Safety Messages..... 5
 (1) Universal Warning 5
 (2) Ether 6
 (3) Hand (High Pressure)..... 7
Safety Section 5
Self-Diagnostics..... 46
Sensors and Electrical Components 38
 Programmable Monitoring System (PMS) 41
 Sensor Locations 38
Sensors and Electrical Components
 (Aftertreatment)..... 42
Severe Service Application - Check 119
 Environmental Factors 119
 Incorrect Maintenance Procedures 120
 Incorrect Operating Procedures..... 120
Starting Motor - Inspect 120
Starting the Engine 58
 Starting the Engine 58
Starting with Jump Start Cables 59
Stopping the Engine 66
System Pressure Release 86
 Coolant System..... 86
 Engine Oil 86
 Fuel System..... 86

T

Table of Contents..... 3

Turbocharger - Inspect (High Pressure and Low
 Pressure Turbochargers)..... 120
 Inspecting..... 121
 Removal and Installation..... 121

W

Walk-Around Inspection 122
 High Pressure Fuel Lines..... 123
 Inspect the Engine for Leaks and for Loose
 Connections 122
 Inspect the Tube of the Crankcase Breather ... 122
Warranty Information 125
Warranty Section 125
Water Pump - Inspect 123
Welding on Engines with Electronic Controls 86

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: _____

