

Operation and Maintenance Manual

4016-61 TRG Industrial Engine

S16 (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

Safety Section

Safety Messages 5

General Hazard Information 5

Burn Prevention 7

Fire Prevention and Explosion Prevention 7

Crushing Prevention and Cutting Prevention 9

Mounting and Dismounting 9

Before Starting Engine 10

Engine Starting 10

Engine Stopping 10

Electrical System 11

Engine Electronics 11

Product Information Section

General Information 12

Model Views 13

Product Identification Information 17

Operation Section

Lifting and Storage 19

Features and Controls 22

Engine Starting 26

Engine Operation 28

Engine Stopping 29

Maintenance Section

Refill Capacities 30

Maintenance Interval Schedule 42

Warranty Section

Warranty Information 76

Index Section

Index 77

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

Safety Messages

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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 of 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 dealer or your 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.

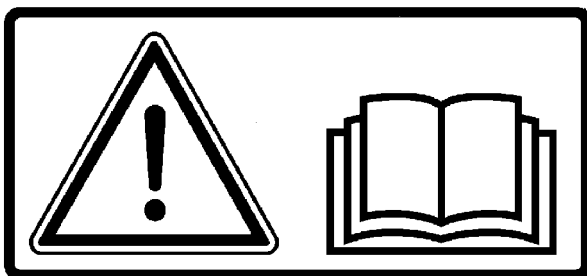


Illustration 1

g01231164

(2) Hot Coolant

WARNING

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



Illustration 2

g01231165

i02328435

General Hazard Information

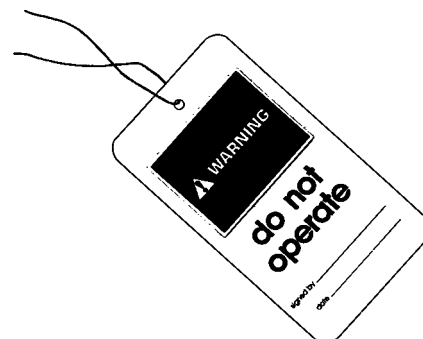


Illustration 3

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

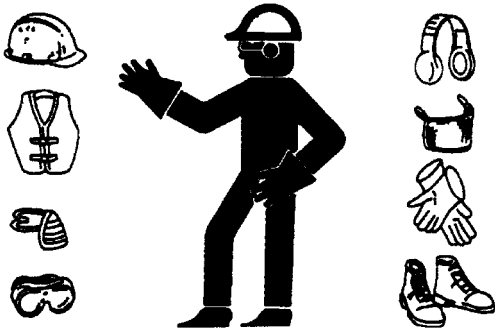


Illustration 4

g00702020

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

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

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

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

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

Obey all local regulations for the disposal of liquids.

Use all cleaning solutions with care.

Report all necessary repairs.

Do not allow unauthorized personnel on the equipment.

Ensure that the power supply is disconnected before you work on the bus bar or the glow plugs.

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

Pressure 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.

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

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

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

Fluid Penetration

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

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

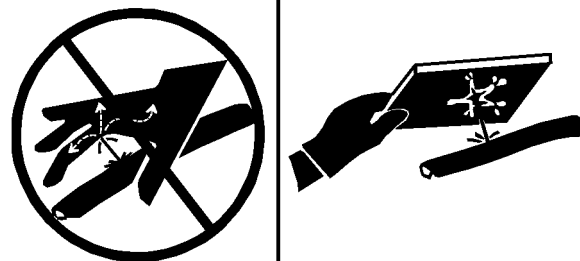


Illustration 5

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

Containing Fluid Spillage

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

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

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

Obey all local regulations for the disposal of liquids.

i02334785

Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine.

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 60 seconds 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.

Coolant

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

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

Check 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 6

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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 60 seconds 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 7

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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.

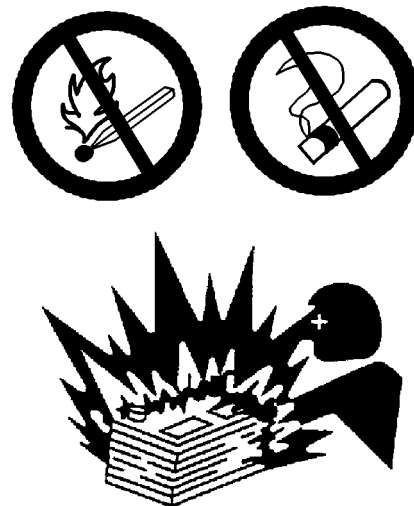


Illustration 8

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

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

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

Do not charge a frozen battery. This 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

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

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

Face the engine in order to mount the engine or dismount the engine. Maintain a three-point contact with the steps and handholds. Use two feet and one hand or use one foot and two hands. Do not use any controls as handholds.

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

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

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Before Starting Engine

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.

i02414669

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.

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

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

Note: Do not use Lube oil heaters.

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.

i02414676

Engine Stopping

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

Use the Emergency Stop Button 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. In the event of an overspeed condition, the air shutoff valves will operate. After operation, the air shutoff valves must be manually reset.

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Electrical System

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

To help prevent sparks from igniting combustible gases that are produced by some batteries, the negative “-” cable should be connected last from the external power source to the negative “-” terminal of the starting motor.

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.

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.

i02414684

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.

The engine is controlled by a digital Pandoras governor. The control system includes the following components.

- Control unit
- Actuator

- Setpoint adjusters (if equipped)
- Sensors
- Wiring Harness

System Description

The system is controlled by an Electronic control Unit (ECU). The ECU contains a microprocessor that has an Electronic Programmable Read Only Memory (EPROM). The operating parameters for the governor are stored in the EPROM. The actuator is connected to the fuel injectors via a mechanical linkage.

A laptop computer is used to set the operating parameters of the governor. The laptop computer is connected to the governor via an interface cable. The operating parameters for the governor should only be modified by a trained Perkins representative. Refer to the Special Instruction, “Pandoras Digital Governor” for more information.

Product Information Section

General Information

Welding on Engines with Electronic Controls

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NOTICE

Proper welding procedures are necessary in order to avoid damage to the engine's 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 with a unit that is equipped with an Electronic Engine. The following procedure is considered to be the safest procedure to weld 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.

1. Stop the engine. Turn the switched power to the OFF position.
2. Disconnect the negative battery cable from the battery. If a battery disconnect switch is provided, open the switch.
3. Disconnect the connectors from the ECM.

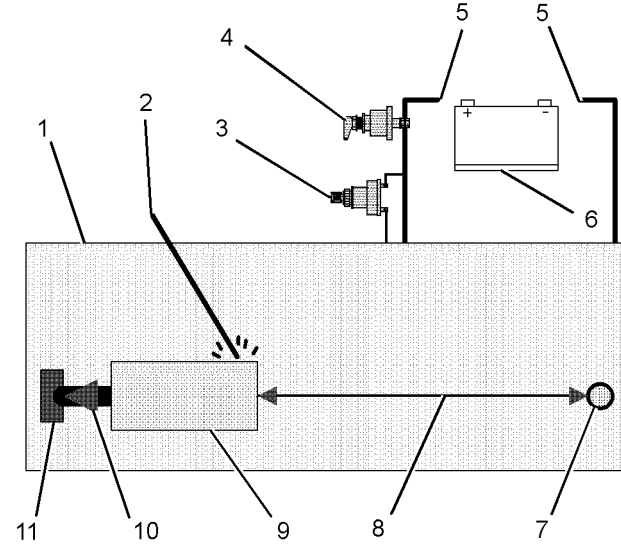


Illustration 9

g01324562

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

- (1) Engine
- (2) Welding rod
- (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) Maximum 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

4. 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 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.

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

Model Views

i03754000

Model View Illustrations

4016-61TRG

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

Note: Only serviced components are identified on the following Illustrations.

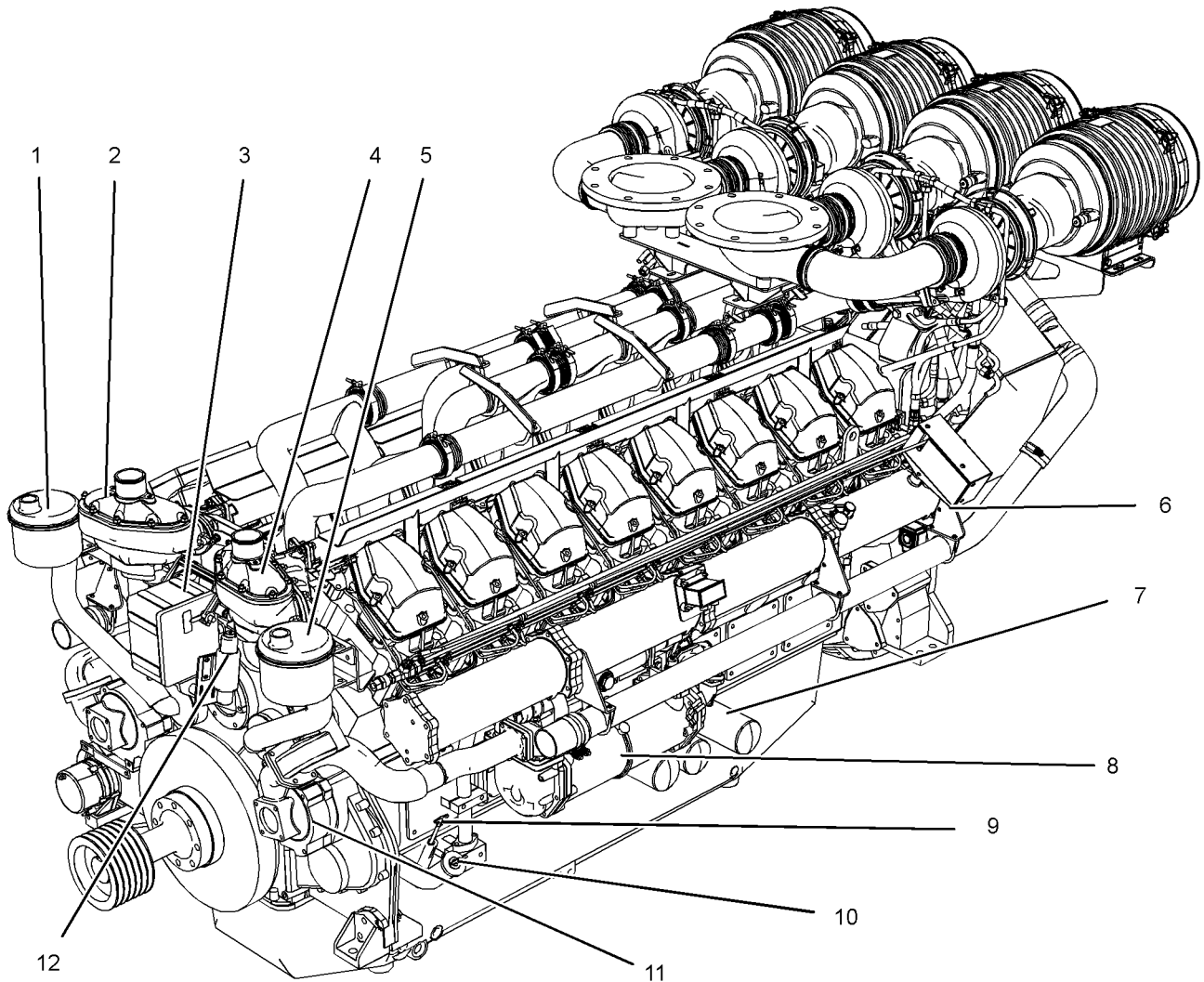


Illustration 10

g02029553

Left side view of engine

- (1) Engine crankcase breather (A Bank)
- (2) Thermostat housing (A Bank)
- (3) Electronic governor actuator
- (4) Thermostat housing (B Bank)

- (5) Engine crankcase breather (B Bank)
- (6) Air shutoff valve (B Bank)
- (7) 3x Oil filters (B Bank)
- (8) Oil cooler

- (9) Oil level gauge (Dipstick)
- (10) Oil filler
- (11) Water pump
- (12) Stop solenoid

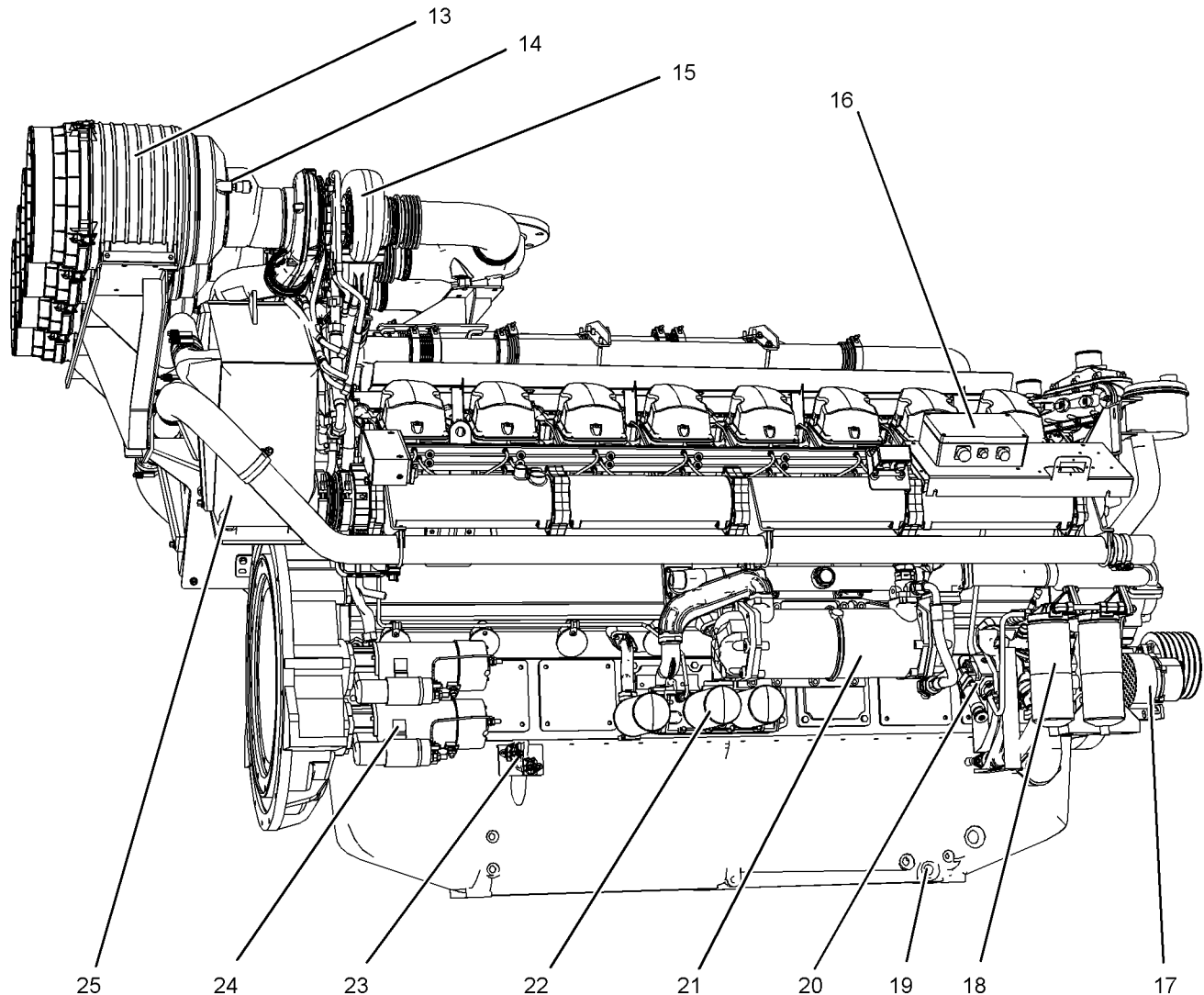


Illustration 11

g02029554

Right side view of engine

- | | | |
|--|------------------------------|---------------------|
| (13) Air cleaner | (18) Fuel filters | (23) Starter relay |
| (14) Restriction indicator for air cleaner | (19) Oil drain plug | (24) Starting motor |
| (15) Turbocharger | (20) Fuel priming pump | (25) Aftercooler |
| (16) Electronic governor control unit | (21) Oil cooler (A Bank) | |
| (17) Alternator | (22) 3x Oil filters (A Bank) | |

i03754029

Engine Description

The 4016-61 TRG engine model is designed for power generation. The engine is available with turbocharged aftercooled aspiration.

Engine Specifications

Note: The number 1 cylinders are to the front. The front of the engine is farthest from the flywheel. Bank A cylinders are on the right hand side of the engine. Bank B cylinders are on the left hand side of the engine. To determine the left and right sides of the engine, stand behind the flywheel and face the dampers.

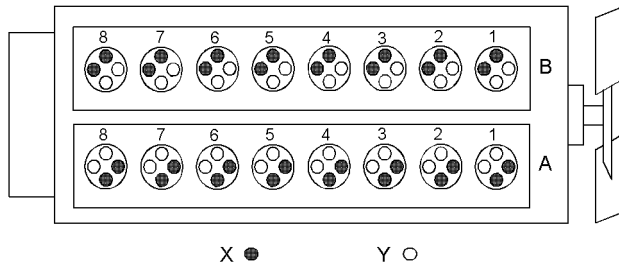


Illustration 12

g01210841

4016-61 TRG engine model

- (A) Bank
- (B) Bank
- (X) Inlet valves
- (Y) Exhaust valves

Table 1

4016-61 Engine Specifications	
Cycle	4 Stroke
Number of Cylinders	16
Configuration	Vee-form
Bore	160 mm (6.299 inch)
Stroke	190 mm (7.480 inch)
Displacement	61.123 L (3729.954 in ³)
Compression Ratio	13:1
Rotation (flywheel end)	Counterclockwise
Firing Order	1A-1B-3A-3B-7A-7B-5A-5B-8A-8B-6A-6B-2A-2B-4A-4B
Inlet Valve Lash (Cold)	0.40 mm (0.016 inch)
Exhaust Valve Lash (Cold)	0.40 mm (0.016 inch)

Engine Cooling and Lubrication

The cooling system consists of the following components:

- Gear-driven water pumps
- Water temperature regulators which regulate the engine coolant temperature
- Gear-driven oil pump (gear type)
- Oil coolers

The engine lubricating oil is supplied by a gear-driven pump. The lubrication oil is cooled and filtered. Bypass valves provide unrestricted flow of lubrication oil to the engine parts when oil viscosity is high. Bypass valves can also provide unrestricted flow of lubrication oil to the engine parts 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.

Product Identification Information

i03754088

Plate Locations and Film Locations

Engine Identification

Perkins engines are identified by an engine serial number.

A typical example of an engine serial number is DGB R**** U00001M.

D _____ Made in Stafford
 G _____ Application (Table 2)
 B _____ Type of engine (Table 3)
 R _____ Number of cylinders (Table 4)
 ****_ _____ Fixed build number
 U _____ Built in the United Kingdom
 00001 _____ Engine Number
 M _____ Year of Manufacture

Table 2

Application	
G	Genset
I	Gas

Table 3

Type of engine (Diesel)	
F	TG
L	TAG
A	TAG1
B	TAG2
D	TAG3
M	TWG
K	TWG2
N	TWG3
P	TRG1
R	TEG2
S	TEG3
W	TRG2
X	TGR3
Type of engine (Gas)	
F	TESI Gas unit
E	TESI Combined Heat and Power unit
G	4016-E61-TRS
H	TRS Combined Heat and Power Unit
J	TRS Gas Unit

Table 4

Number of Cylinders	
F	6
H	8
M	12
R	16

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

Serial Number Plate

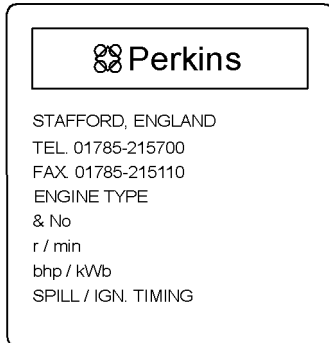


Illustration 13
Serial number plate

g01266904

The engine serial number plate contains the following information:

- Place of manufacture
- Telephone number of manufacturer
- Fax number of manufacturer
- Type of engine
- Engine serial number
- Rated speed
- Power output
- Engine timing
- Rating

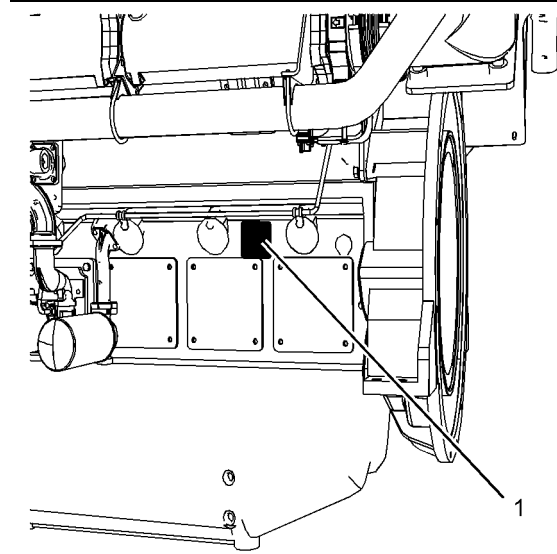


Illustration 14
Typical example

g02029586

The serial number plate (1) on a engine is located on the left side of the cylinder block (bank B).

Operation Section

Lifting and Storage

i03880885

Engine Lifting

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.

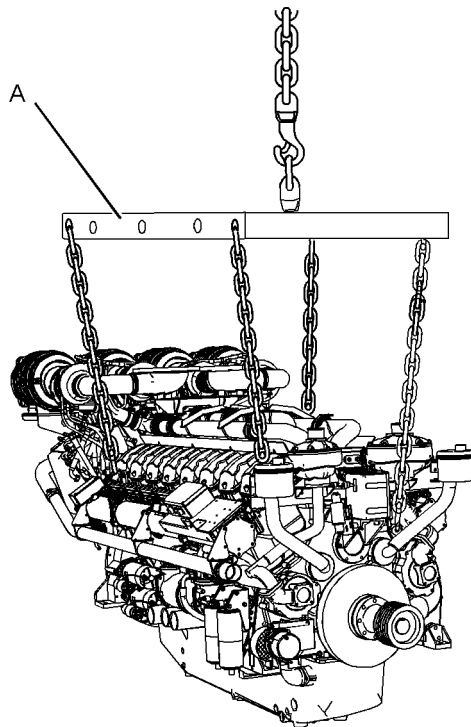


Illustration 15
Typical example

g02126835

Use a hoist to remove heavy components. Use a lifting beam (A) 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.

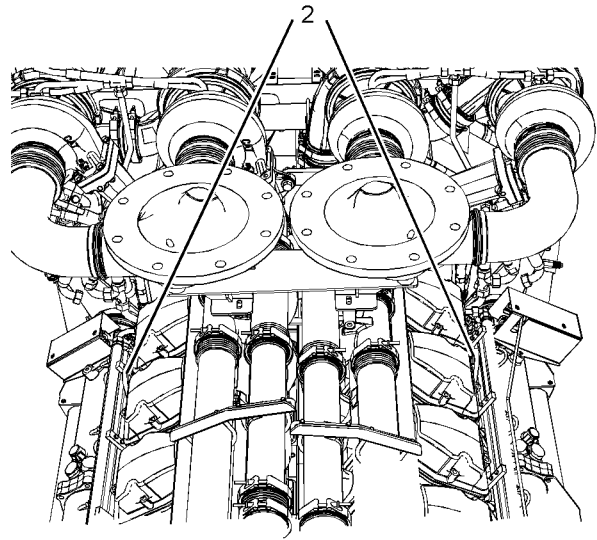
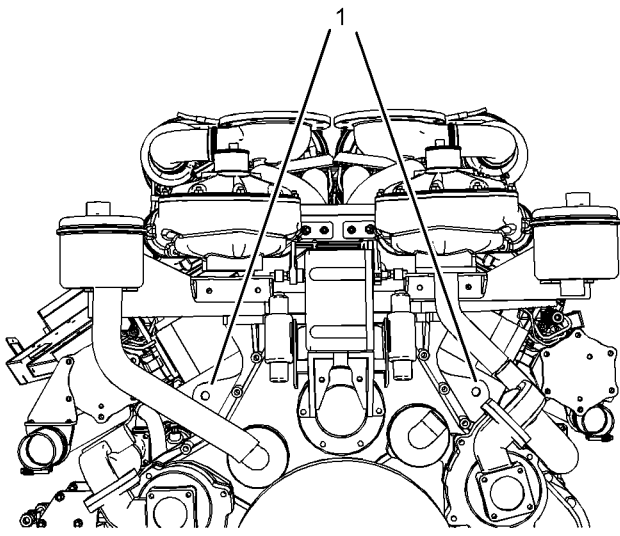


Illustration 16

g02131153

(1) Front lifting eyes

(2) Rear lifting eye

To remove the engine ONLY, use the lifting eyes that are shown in illustration 16. If necessary, remove engine components in order to avoid damage from the lifting device.

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.

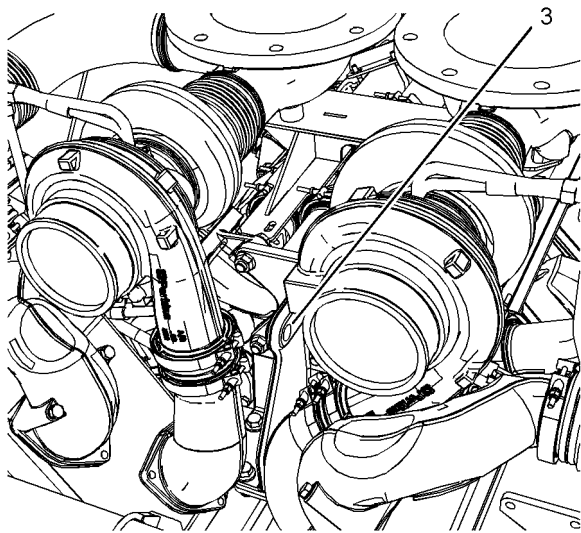


Illustration 17

g02130795

Note: The lifting eye (3) must NOT be used in order to lift the engine. The lifting eye (3) has not been designed in order to lift the engine. The lifting eye is used in factory assembly of engine components.

i03781209

Engine Storage

Refer to Perkins Engine Company Limited, Stafford, ST16 3UB for information on engine storage.

There are three different levels of engine storage. Level "A, B and C".

Level "A "

Level "A" will give protection for 12 months for diesel engines and for gas engines. This level is used for engines that are transported in a container or by a truck.

Level "B "

This level is additional to level "A". Level "B " will give protection under normal conditions of storage from -15° to +55°C (5° to 99°F) and "90%" relative humidity, for a maximum of 2 year.

Level "C "

This level is additional to level "B". Level "C" will give protection for five years in tropical or in arctic climates. Level "C" also meets MOD NES 724 Level "J" for Europe, when engines are stored in an unheated building or in the open under a waterproof cover.

Features and Controls

i03882309

Monitoring System

The engine is equipped with sensors or switches to monitor the following parameters:

- Coolant temperature (Switch)
- Oil pressure (Switch)
- Intake manifold boost pressure (Sensor)
- Exhaust temperature Sensors
- Engine speed (Sensor)
- Engine overspeed (Sensor or Switch)

i03781211

Sensors and Electrical Components

Sensor Locations

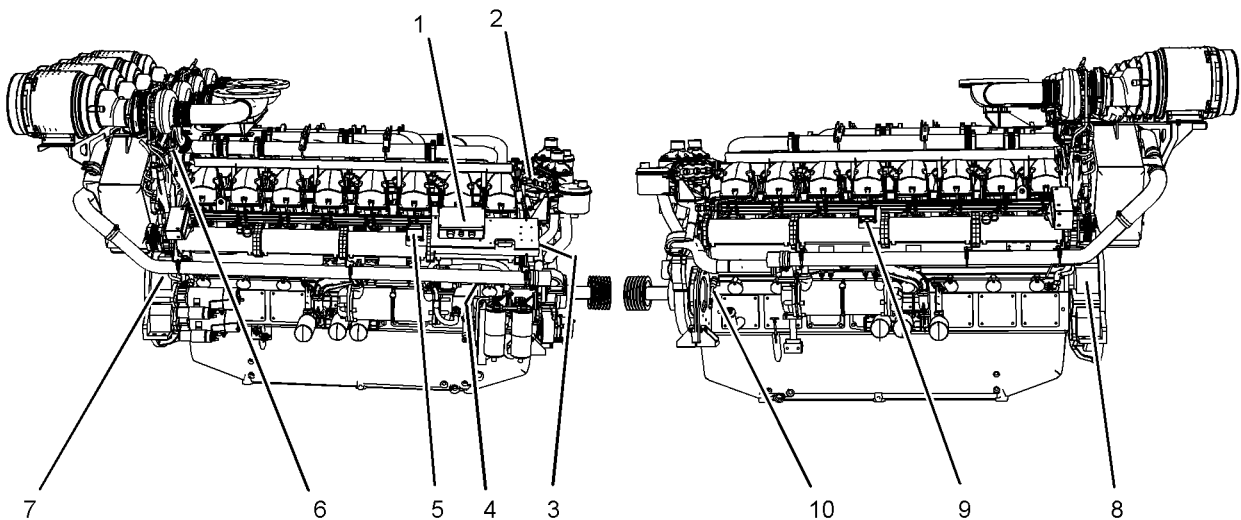


Illustration 18

g02088773

- (1) Electronic control unit (ECU)
- (2) Coolant temperature sensor
- (3) Boost pressure sensor
- (4) Oil pressure switch

- (5) High turbine inlet temperature shutdown sensor (A bank)
- (6) Thermocouple
- (7) Speed sensor

- (8) Overspeed sensor
- (9) High turbine inlet temperature shutdown sensor (B bank)
- (10) Oil pressure switch

The Illustrations show the typical locations of the sensors on the engine. Specific engines may appear different from the illustrations due to differences in applications.

The boost pressure sensor (3) measures the pressure in the inlet air manifold. A signal is sent to the ECU (1).

Coolant Temperature Sensor

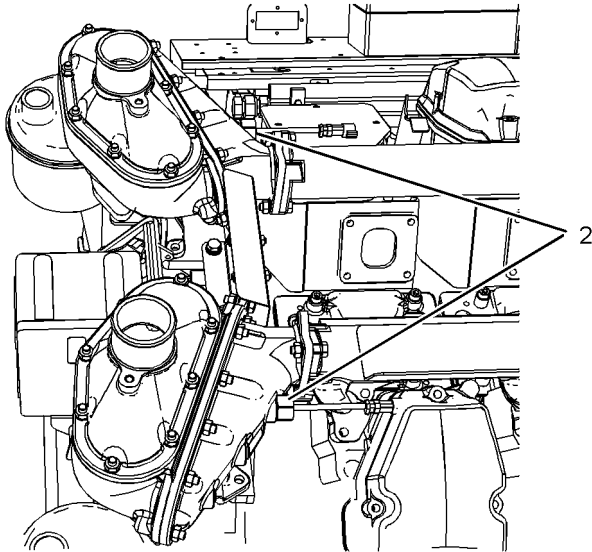


Illustration 19

g02088775

Coolant temperature switches

The coolant temperature switches (2) monitor the engine coolant temperature. The switches are supplied for connecting to an OEM supplied panel.

Boost Pressure Sensors

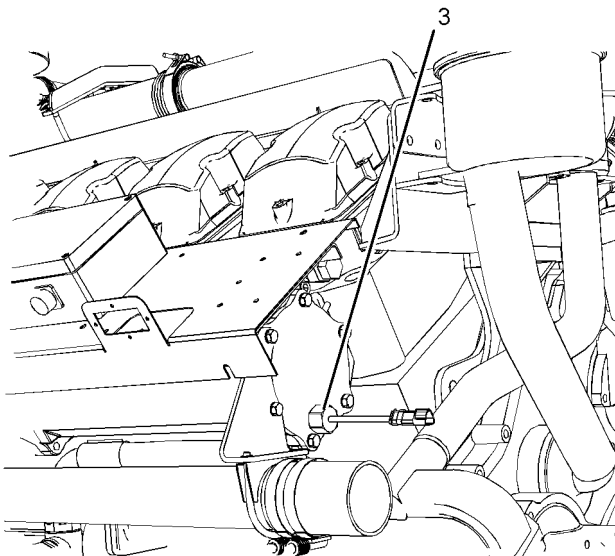


Illustration 20

g02125658

Boost pressure sensor

Engine Oil Pressure Switch

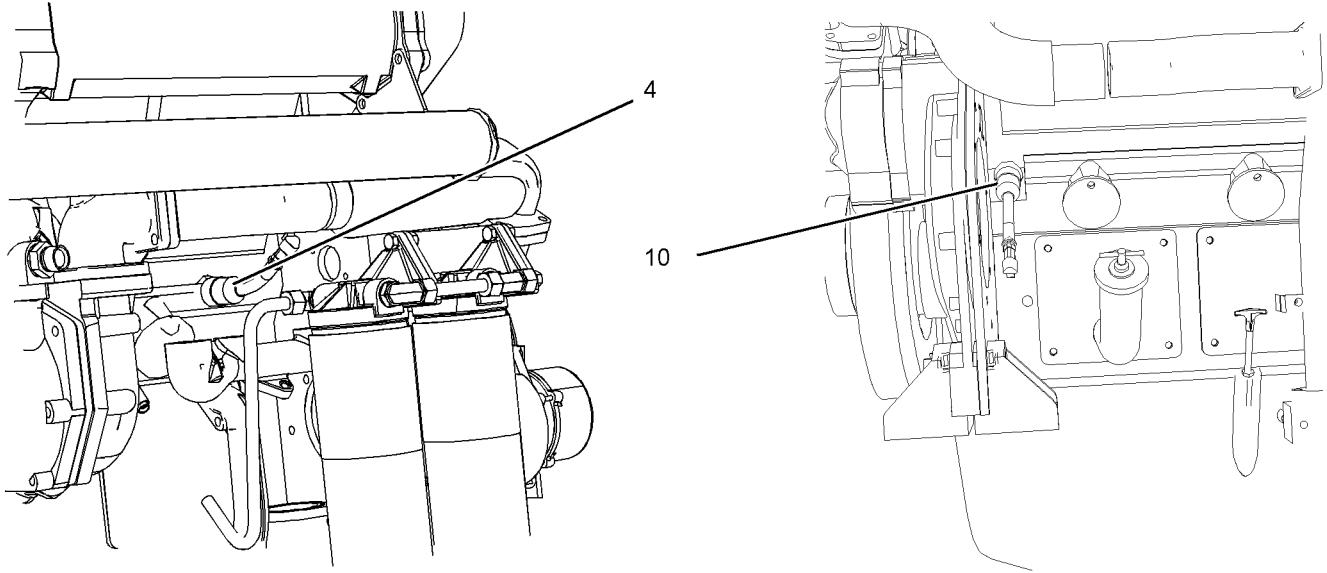


Illustration 21

g02041294

Engine oil pressure sensor

(4) Oil pressure sensor (A Bank)

(9) Oil pressure sensor (B Bank)

An oil pressure sensor is installed on both side of the engine. The engine oil pressure sensors are mounted in the main oil gallery. The engine oil pressure sensors are supplied for connecting to an OEM supplied panel.

High Turbine Inlet Temperature Shutdown Sensor

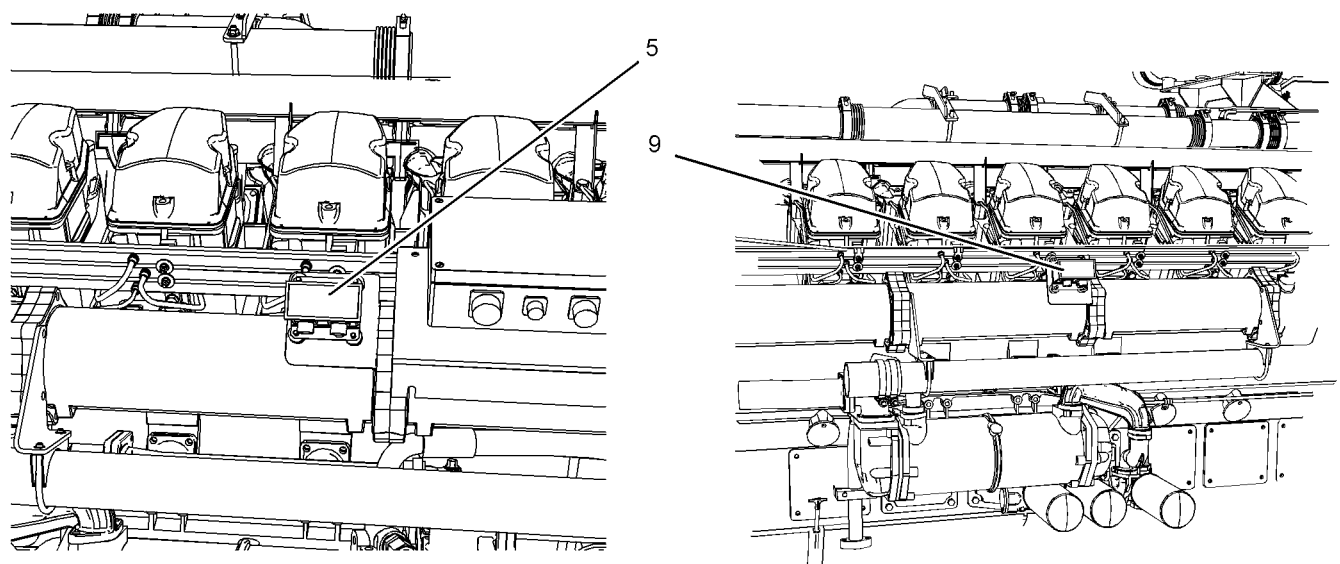


Illustration 22

g02124274

(5) High turbine inlet temperature shutdown sensor (A bank)

(8) High turbine inlet temperature shutdown sensor (B bank)

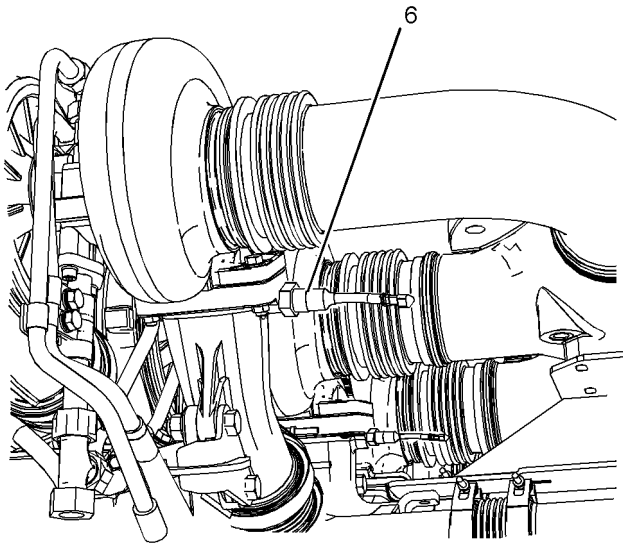


Illustration 23
Thermocouple

g02123434

Four thermocouples are installed. One thermocouple is installed in each of the exhaust manifolds. There are two high turbine inlet temperature shutdown sensors. One sensor monitors each engine bank. A sensor monitors two thermocouples. If high temperatures are indicated the engine will be shutdown.

Speed Sensor

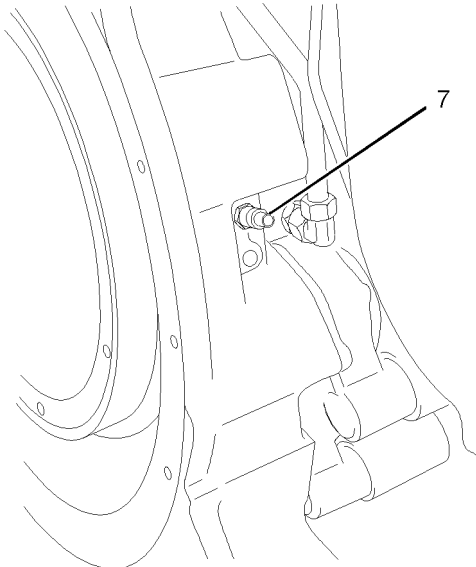


Illustration 24
Speed sensor

g02123433

The speed sensor (7) should be serviced at the required maintenance interval. Refer to the Operation and Maintenance Manual, "Speed Sensor, Clean/Inspect".

Failure of the Speed Sensor

If the ECU (1) does not receive a signal from the speed sensor (4), the engine cannot run.

If the ECU does not receive a signal from the speed sensor (7), the engine will shut down. A faulty speed sensor should be replaced.

Note: Intermittent failure of the speed sensor will cause the engine to run erratically. This may also cause overspeed.

Overspeed Sensor

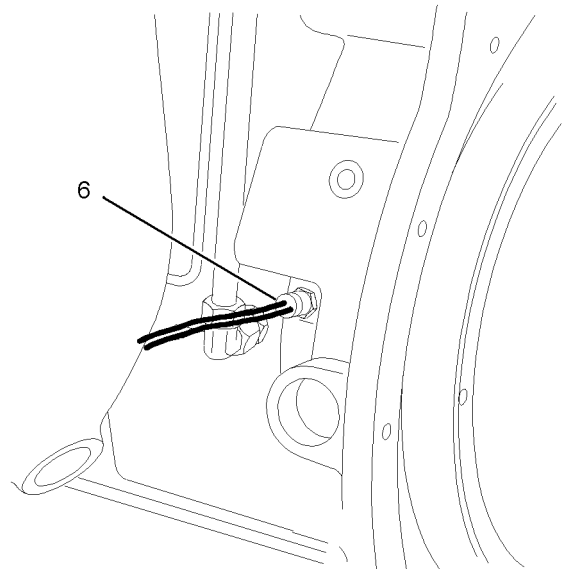


Illustration 25
Overspeed sensor

g01231518

The signal from the overspeed sensor (8) is connected to the overspeed switch or the overspeed circuit in the OEM supplied panel.

The location of the sensor can vary depending on the application.

Engine Starting

i03873029

Before Starting Engine

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

Note: 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.

1. Open the fuel supply valves and open the return lines (if equipped).
2. If the engine has not been started for several weeks, fuel may have drained from the fuel system. 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.

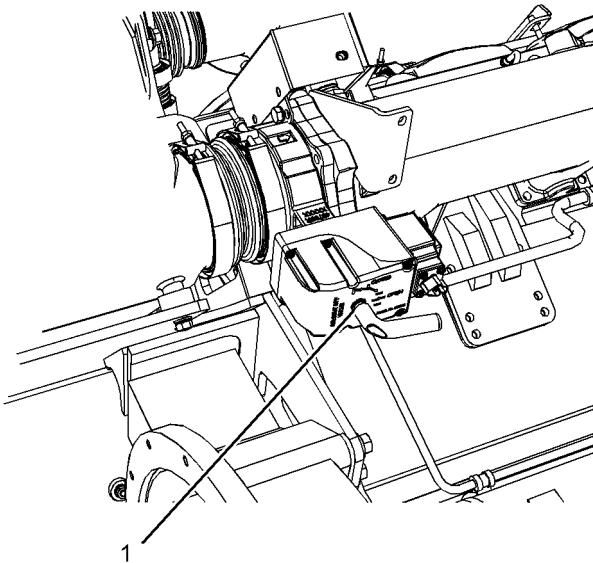


Illustration 26

i02114793

3. Ensure that the two air shutoff valves (1) are in the OPEN position.
4. If the engine has not been started for more than three months, the engine oil system must be primed. Follow Steps 4.a through 4.d in order to prime the engine oil system.

- a. Ensure that the governor stays in the STOP position by disconnecting the speed pickup connector on the governor control.
- b. Turn the keyswitch to the START position. Hold the keyswitch in this position until the oil pressure gauge indicates 100 kPa (14.5040 psi). Continue to hold the keyswitch in the START position for an additional 10 seconds.

Note: The keyswitch is part of the OEM supplied panel. The exact procedure for starting may vary. Refer to OEM supplied instructions for the correct starting procedure.

- c. Turn the keyswitch to the STOP position.
- d. Reconnect the speed pickup connector.

The engine is now ready to run.

i02415221

Starting the Engine

Normal Engine Starting Procedure

Note: When possible, ensure that the engine is not started under load.

1. Turn the keyswitch to the START position. The engine should start immediately.
2. Allow the keyswitch to return to the RUN position after the engine starts.

If the engine does not start after 10 seconds, return the keyswitch in the RUN position for 10 seconds. Then repeat Steps 1 and 2.

Note: If the engine fails to start after three attempts, investigate the cause.

3. After the engine has started follow Steps 3.a through 3.d.
 - a. Check the oil pressure.
 - b. Inspect the engine for leaks.
 - c. Ensure that the batteries for the engine are receiving a charge.
 - d. After the engine has run for five minutes, check the engine monitoring systems. Ensure that the engine is operating correctly before the load is applied.

i02415223

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 +10 °C (+50 °F) from the use of a jacket water heater or extra battery capacity.

Engine Operation

i02415226

Engine Operation

i02415225

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

Gauge readings (if equipped) 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.

Fuel Conservation Practices

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

- Avoid spilling fuel. Fuel expands when the fuel is warmed up. The fuel may overflow from the fuel tank. Inspect fuel lines for leaks. Repair the fuel lines, as needed.
- Be aware of the properties of the different fuels. Use only the recommended fuels.
- Avoid unnecessary running at a low load. If the engine is not under load, the engine should be shut down.
- Observe the air cleaner service indicator frequently. The air cleaner elements should be replaced when the air cleaner elements are dirty.
- Maintain the electrical systems. One damaged battery cell will overwork the alternator. This will consume excess power and excess fuel.
- Ensure that the drive belts are correctly adjusted. The drive belts should be in good condition.
- Ensure that all of the connections of the hoses are tight. The connections should not leak.
- Ensure that the driven equipment is in good working order.
- Cold engines consume excess fuel. Utilize heat from the jacket water system and the exhaust system, when possible. Keep cooling system components clean and keep cooling system components in good repair. Never operate the engine without water temperature regulators. All of these items will help maintain operating temperatures.

Engine Stopping

i02415231

Stopping the Engine

i02415227

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. Allow the engine to run off load 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.

i02415230

Emergency Stopping

NOTICE

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

The engine should be equipped 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.

In the event of an overspeed condition, the air shutoff valves will operate. After operation, the air shutoff valves must be manually reset.

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.

- 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".
- Check the crankcase oil level. Maintain the oil level between the "MIN" mark and the "MAX" mark on the engine oil level gauge.
- If necessary, perform minor adjustments. Repair any leaks from the low pressure fuel system and from the cooling, lubrication or air systems.
- 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 Coolant Specifications that are in the 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.

Maintenance Section

Refill Capacities

i03754119

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 5

Engine Refill Capacities	
Compartment or System	4016 TRG
Crankcase Oil Sump ⁽¹⁾	238 L (52.4 Imp gal)

⁽¹⁾ These values are the total capacities for the crankcase oil sump which includes the standard factory installed oil filters and oil coolers. Engines with auxiliary oil filters will require additional oil. Refer to the OEM specifications for the capacity of the auxiliary oil filter.

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 and antifreeze that is required for the Total Cooling System.

Table 6

Engine Refill capacities	
Compartment or System	Liters
Engine cooling system	95
Secondary cooling system ⁽¹⁾	50
External System Per OEM ⁽²⁾	-

⁽¹⁾ The volume of coolant that is given in this table is for the engine. The volume for the total cooling capacity will depend on the application.

⁽²⁾ Refer to the OEM specifications .

Fuel System

Refer to the OEM specifications for additional information on the capacity of the Fuel System.

Table 7

Engine Refill Capacities	
Compartment or System	4016
Minimum Capacity of Fuel Tank	22500 L (4949 Imp gal)

i03837413

Fluid Recommendations (Cooling System Specifications)

General Coolant Information

NOTICE

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

NOTICE

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

NOTICE

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

Clean the cooling system for the following reasons:

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

NOTICE

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

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

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

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

Water

Water is used in the cooling system 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 8.

Table 8

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 $-23\text{ }^{\circ}\text{C}$ ($-9\text{ }^{\circ}\text{F}$).

Most conventional coolants use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. Refer to Tables 9 and 10."

Table 9

Ethylene Glycol		
Concentration	Freeze Protection	Boil Protection
50 Percent	$-36\text{ }^{\circ}\text{C}$ ($-33\text{ }^{\circ}\text{F}$)	$106\text{ }^{\circ}\text{C}$ ($223\text{ }^{\circ}\text{F}$)
60 Percent	$-51\text{ }^{\circ}\text{C}$ ($-60\text{ }^{\circ}\text{F}$)	$111\text{ }^{\circ}\text{C}$ ($232\text{ }^{\circ}\text{F}$)

NOTICE

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

Table 10

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

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

Coolant Recommendations

The following two coolants are used in Perkins diesel engines:

Preferred – Perkins Extended Life Coolant (ELC)

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

NOTICE

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

Perkins recommends a 1:1 mixture of water and glycol. This mixture of water and glycol will provide optimum heavy-duty performance as a coolant.

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

Table 11

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

Extended Life Coolant (ELC)

Perkins provides Extended Life Coolant (ELC) for use in the following applications:

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

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

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

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

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

ELC Cooling System Maintenance

Correct additions to the Extended Life Coolant

NOTICE

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

Use only Perkins Extender with Extended Life Coolant.

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

In order to maintain the correct balance between the coolant and the additives, you must maintain the recommended concentration of Extended Life Coolant (ELC). Lowering the proportion of coolant lowers the proportion of additive. This will lower the ability of the coolant to protect the system from pitting, from cavitation, from erosion, and from deposits.

NOTICE

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

Do not use standard supplemental coolant additive (SCA). Only use ELC Extender in cooling systems that are filled with ELC.

NOTICE

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.

After the cooling system is drained and after the cooling system is refilled, install the filler cap. Operate the engine until the coolant level reaches the normal operating temperature. Shut the engine down using the normal shutdown procedure.

As needed, add the coolant mixture in order to fill the system to the specified level. Install the filler cap.

Changing to Perkins ELC

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant into a suitable container.
2. Dispose of the coolant according to local regulations.
3. Flush the system with clean water 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).
-

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. Shut down the engine by using the normal shutdown procedure. 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 the Steps 6 and repeat the 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. Use only Perkins ELC extender with Perkins ELC. Failure to follow these recommendations can result in shortened cooling system component life.

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

- Drain the cooling system into a suitable container. Dispose of the coolant according to local regulations. Flush the system with clean water. Fill the system with the Perkins ELC.

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

Commercial Heavy-Duty Coolant and SCA

NOTICE

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

NOTICE

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

Check the coolant (glycol concentration) in order to ensure adequate protection against boiling or freezing. Perkins recommends the use of a refractometer for checking the glycol concentration.

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

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

Refer to Table 12 for part numbers and for quantities of SCA.

Table 12

Perkins Liquid SCA	
Part Number	Quantity
21825735	10

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

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

Use the equation that is in Table 13 to determine the amount of Perkins SCA that is required when the cooling system is initially filled.

Table 13

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 14 is an example for using the equation that is in Table 13.

Table 14

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)	$\times 0.045$	0.7 L (24 oz)

Adding The SCA to The Heavy-Duty Coolant For Maintenance

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

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

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

Use the equation that is in Table 15 to determine the amount of Perkins SCA that is required, if necessary:

Table 15

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

Table 16

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 Coolant

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

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

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Fluid Recommendations (Fuel Specifications)

Fuel Recommendations

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

Class A1 Fuels

- Cetane number _____ 50
- Viscosity _____ 1.5 to 5.0 cSt at 40 °C (104 °F)
- Carbon residue _____ 0.20% Ramsbottom on 10% residue
- Sulfur content _____ 0.05% of mass, maximum
- Distillation _____ 56% at 350 °C (662 °F)
- Lubricity _____ 460 micrometers maximum wear scar on “ISO 12156 - 1”

Class A2 Fuels

- Cetane number _____ 45

- Viscosity _____ 1.5 to 5.5 cSt at 40 °C (104 °F)
- Carbon residue _____ 0.20% Ramsbottom on 10% residue
- Sulfur content _____ 0.05% of mass, maximum
- Distillation _____ 56% at 350 °C (662 °F)
- Lubricity _____ 460 micrometers maximum wear scar on “ISO 12156 - 1”

Cetane number

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

Viscosity

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

Sulfur

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

Distillation

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

Lubricity

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

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

- Group 1 (preferred fuels)
- Group 2 (permissible fuels)

Group 1 (preferred fuels): Specification

“DERV to EN590”

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

Gas oil to “BS29 Class A2”

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

Group 2 (permissible fuels): Specification

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

“ASTM D975 - 91 Class 1D”

“JP7, Mil T38219”

“NATO F63”

NOTICE

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

Low temperature fuels

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

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

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

Biofuel: Specification

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

NOTICE

Water emulsion fuels: These fuels are not permitted

Refer to the following fuel specifications for North America.

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

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

Diesel fuels that meet the specifications in Table 17 will help to provide maximum engine service life and performance. In North America, diesel fuel that is identified as No. 2-D in “ASTM D975” generally meets the specifications. Table 17 is for diesel fuels that are distilled from crude oil. Diesel fuels from other sources could exhibit detrimental properties that are not defined or controlled by this specification.

Table 17

Perkins Specifications for Distillate Diesel Fuel		
Specifications	Requirements	ASTM Test
Aromatics	35% maximum	“D1319”
Ash	0.02% maximum (weight)	“D482”
Carbon Residue on 10% Bottoms	0.35% maximum (weight)	“D524”
Cetane Number	40 minimum (DI engines)	“D613”
Cloud Point	The cloud point must not exceed the lowest expected ambient temperature.	-

(continued)

(Table 17, contd)

Copper Strip Corrosion	No. 3 maximum	"D130"
Distillation	10% at 282 °C (540 °F) maximum	"D86"
	90% at 360 °C (680 °F) maximum	
Flash Point	legal limit	"D93"
API Gravity	30 minimum	"D287"
	45 maximum	
Pour Point	6 °C (10 °F) minimum below ambient temperature	"D97"
Sulfur ⁽¹⁾	0.2% maximum	"D3605" or "D1552"
Kinematic Viscosity ⁽²⁾	2.0 cSt minimum and 4.5 cSt maximum at 40 °C (104 °F)	"D445"
Water and Sediment	0.1% maximum	"D1796"
Water	0.1% maximum	"D1744"
Sediment	0.05% maximum (weight)	"D473"
Gum and Resins ⁽³⁾	10 mg per 100 mL maximum	"D381"
Lubricity ⁽⁴⁾	0.38 mm (0.015 inch) maximum at 25 °C (77 °F)	"D6079"

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

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

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

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

NOTICE

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

NOTICE

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

In extreme cold ambient conditions, you may use the distillate fuels that are specified in Table 18. However, the fuel that is selected must meet the requirements that are specified in Table 17. These fuels are intended to be used in operating temperatures that are down to -54 °C (-65 °F).

Table 18

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

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

These fuels are lighter than the No. 2 grades of fuel. The cetane number of the fuels in Table 18 must be at least 40. If the viscosity is below 1.4 cSt at 38 °C (100 °F), use the fuel only in temperatures below 0 °C (32 °F). Do not use any fuels with a viscosity of less than 1.2 cSt at 38 °C (100 °F). Fuel cooling may be required in order to maintain the minimum viscosity of 1.4 cSt at the fuel injection pump.

There are many other diesel fuel specifications that are published by governments and by technological societies. Usually, those specifications do not review all the requirements that are addressed in this specification. To ensure optimum engine performance, a complete fuel analysis should be obtained before engine operation. The fuel analysis should include all of the properties that are listed in Table 17.

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Fluid Recommendations (General Lubricant Information)

Engine Oil

Commercial Oils

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

Only use commercial oils that meet the following classifications:

- API CG-4
- API CH-4

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

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

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

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

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

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

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

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

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

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

NOTICE

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

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

The Total Base Number (TBN) for an oil depends on the fuel sulfur level. For direct injection engines that use distillate fuel, the minimum TBN of the new oil must be 10 times the fuel sulfur level. The TBN is defined by "ASTM D2896". The minimum TBN of the oil is 5 regardless of fuel sulfur level. Illustration 27 demonstrates the TBN.

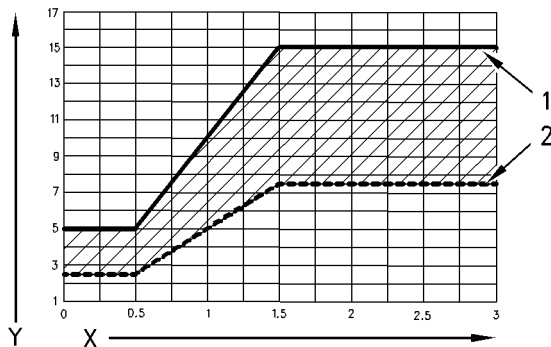


Illustration 27

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- (Y) TBN by "ASTM D2896"
- (X) Percentage of fuel sulfur by weight
- (1) TBN of new oil
- (2) Change the oil when the TBN deteriorates to 50 percent of the original TBN.

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

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

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

NOTICE

Operating Direct Injection (DI) diesel engines with fuel sulphur levels over 0.5 percent will require shortened oil change intervals in order to help maintain adequate wear protection.

Table 19

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

Lubricant Viscosity Recommendations 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 Table 20 (minimum temperature) in order to determine the required oil viscosity for starting a cold engine.

Refer to Table 20 (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.

Table 20

Engine Oil Viscosity	
EMA LRG-1 API CH-4 Viscosity Grade	Ambient Starting Temperature
SAE 10W30	Temperatures below -15 °C (5 °F)
SAE 15W40	-15 °C (5 °F) to 0 °C (32. °F)
SAE 15W40	0 °C (32. °F) to 32 °C (89.5 °F)
SAE 15W40	Temperatures above 32 °C (89.5 °F)

Synthetic Base Stock Oils

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

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

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

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

Re-refined Base Stock Oils

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

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

Lubricants for Cold Weather

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

These oils have lubricant viscosity grades of SAE 10W or SAE 15W.

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

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

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

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

NOTICE

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

Aftermarket Oil Additives

Perkins does not recommend the use of aftermarket additives in oil. It is not necessary to use aftermarket additives in order to achieve the engine's maximum service life or rated performance. Fully formulated, finished oils consist of base oils and of commercial additive packages. These additive packages are blended into the base oils at precise percentages 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 oil's additive package, which could lower the performance of the finished oil. The aftermarket additive could fail to mix with the finished oil. This could produce sludge in the crankcase. Perkins discourages the use of aftermarket additives in finished oils.

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

- Select the correct oil, or a commercial oil that meets the “EMA Recommended Guideline on Diesel Engine Oil” or the recommended API classification.
- See the appropriate “Lubricant Viscosities” table 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

Oil samples should be taken on a regular basis for the purpose of oil analysis. 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 through the use of the oil analysis. The oil analysis includes the following tests:

- The Wear Rate Analysis monitors the wear of the engine's metals. The amount of wear metal and type of wear metal that is in the oil is analyzed. The increase in the rate of engine wear metal in the oil is as important as the quantity of engine wear metal in the oil.
- Tests are conducted in order to detect contamination of the oil by water, glycol or fuel.
- The Oil Condition Analysis determines the loss of the oil's lubricating properties. An infrared analysis is used to compare the properties of new oil to the properties of the used oil sample. This analysis allows technicians to determine the amount of deterioration of the oil during use. This analysis also allows technicians to verify the performance of the oil according to the specification during the entire oil change interval.

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Maintenance Interval Schedule

When Required

Battery - Replace	45
Battery or Battery Cable - Disconnect	46
Engine - Clean	54
Engine Air Cleaner Element - Replace	55
Engine Oil Filter (Auxiliary) - Change	57
Engine Oil Sample - Obtain	58
Fuel System - Prime	64
Overhaul (Major)	69
Overhaul (Top End)	69
Severe Service Application - Check	71

Daily

Cooling System Coolant Level - Check	53
Driven Equipment - Check	54
Engine Air Cleaner Service Indicator - Inspect	55
Engine Oil Level - Check	57
Fuel System Primary Filter/Water Separator - Drain	66
Walk-Around Inspection	74

Every 50 Service Hours or Weekly

Fuel Tank Water and Sediment - Drain	66
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Initial 100 Service Hours

Alternator Pulley - Check	44
Engine Valve Lash - Inspect/Adjust	61
Fan Drive Pulley - Check	63

Every 500 Service Hours

Engine Oil Filter (Auxiliary) - Change	57
Engine Oil and Filter - Change	59

Every 500 Service Hours or 1 Year

Actuator Control Linkage - Lubricate	43
Aftercooler Core - Clean/Test	43
Aftercooler Core - Inspect	44
Battery Electrolyte Level - Check	45
Belts - Inspect/Adjust/Replace	46
Belts - Inspect/Adjust/Replace	47
Engine Crankcase Breather - Clean	56
Engine Valve Lash - Inspect/Adjust	61
Fuel Injector - Inspect/Adjust	64
Fuel System Filter - Replace	65
Hoses and Clamps - Inspect/Replace	68
Radiator - Clean	70

Every Year

Cooling System Coolant - Change	51
Engine Mounts - Inspect	56

Engine Protective Devices - Check	60
Governor Actuator - Check	68
Speed Sensor - Clean/Inspect	72

Every 7500 Service Hours

Alternator - Inspect	44
Engine Oil Pump - Inspect	58
Fuel Transfer Pump (Lift Pump) - Inspect	67
Starting Motor - Inspect	73
Turbocharger - Inspect	74
Water Pump - Inspect	75

Every 12 000 Service Hours or 6 Years

Cooling System Coolant (ELC) - Change	49
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Actuator Control Linkage - Lubricate

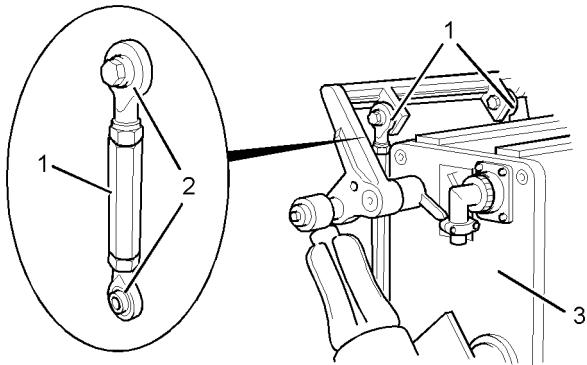


Illustration 28
Typical example

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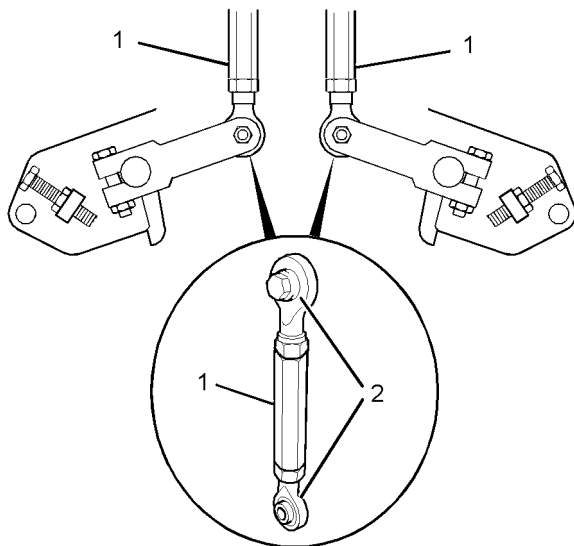


Illustration 29
Typical example

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The governor actuator (3) is connected to the fuel injectors by external linkages (1) and by internal control rods.

The linkages (1) require periodic lubrication of the ball joints (2). Use clean engine oil in order to lubricate the ball joints.

Aftercooler Core - Clean/Test

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.

Note: The core of the aftercooler can not be removed. The core may be cleaned with a suitable cleaner. The core must be dry before the engine is operated.

1. Pressurized air is the preferred method for removing loose debris. Direct the air in the opposite direction of the fan's air flow. Hold the nozzle approximately 6 mm (.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This will remove debris that is between the tubes.
2. 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.

NOTICE

Do not use a high concentration of caustic cleaner to clean the core. A high concentration of caustic cleaner can attack the internal metals of the core and cause leakage. Only use the recommended concentration of cleaner.

3. Back flush the aftercooler with a suitable cleaner.
4. Steam clean the aftercooler in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris.
5. Wash the aftercooler with hot, soapy water. Rinse the aftercooler thoroughly with clean water.

⚠ 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.

6. Dry the aftercooler with compressed air. Direct the air in the reverse direction of the normal flow. Remove all fluid from the aftercooler. Ensure that the aftercooler is dry.
7. Inspect the aftercooler in order to ensure cleanliness. Pressure test the aftercooler. If necessary, replace 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.

⚠ 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 run the engine. This will help in drying of the core. Stop the engine.

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.

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Alternator Pulley - Check

1. Isolate the electrical supply to the engine.

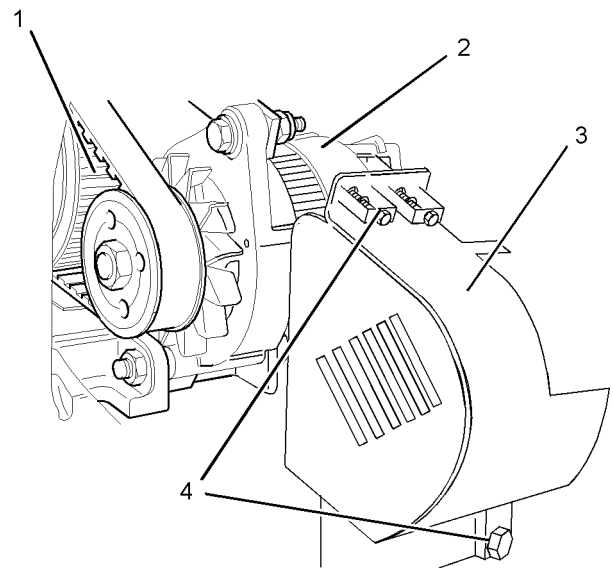


Illustration 30
Typical example

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2. Remove the guard (3) in order to gain access to the drive pulley (1) for the alternator (2).

Note: The bolts (4) are captive.

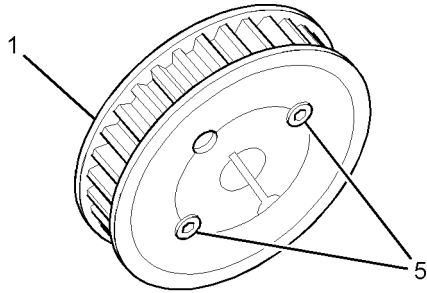


Illustration 31

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Typical example

3. Tighten the grub screws (5) to a torque of 20 N·m (15 lb ft).
4. Install the guard (3).
5. Restore the electrical supply to the engine.

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Battery - Replace

WARNING

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

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

WARNING

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

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

1. Switch the engine to the OFF position. Remove all electrical loads.

2. Turn off any battery chargers. Disconnect any battery chargers.
3. The NEGATIVE “-” cable connects the NEGATIVE “-” battery terminal to the NEGATIVE “-” terminal on the starting motor. Disconnect the cable from the NEGATIVE “-” battery terminal.
4. The POSITIVE “+” cable connects the POSITIVE “+” battery terminal to the POSITIVE “+” terminal on the starting motor. Disconnect the cable from the POSITIVE “+” battery terminal.

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

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

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

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

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 connections must be disconnected.
3. Remove the positive connection.
4. Clean all disconnected connection and battery terminals.
5. Use a fine grade of sandpaper to clean the terminals and the cable clamps. Clean the items until the surfaces are bright or shiny. DO NOT remove material excessively. Excessive removal of material can cause the clamps to not fit correctly. Coat the clamps and the terminals with a suitable silicone lubricant or petroleum jelly.
6. Tape the cable connections 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.

i03896240

Belts - Inspect/Adjust/Replace (Alternator Belt)

Inspection

1. Isolate the electrical supply to the engine.

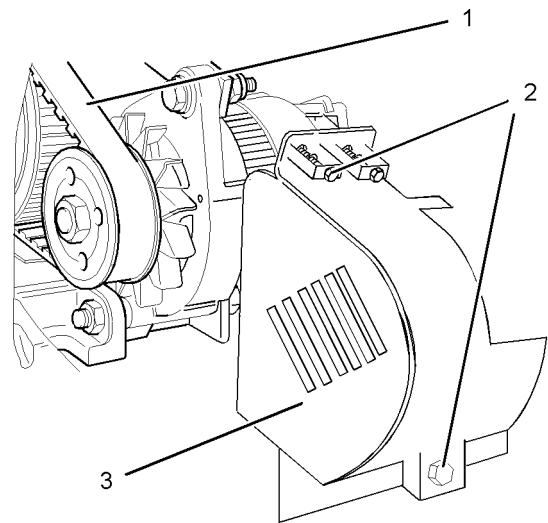


Illustration 32

g02139788

Typical example

2. Remove the guard (3).

Note: The bolts (2) are captive.

3. Inspect the belt (1) for cracks. Inspect the belt for contamination. If necessary, replace the belt. Refer to "Replacement" for more information.

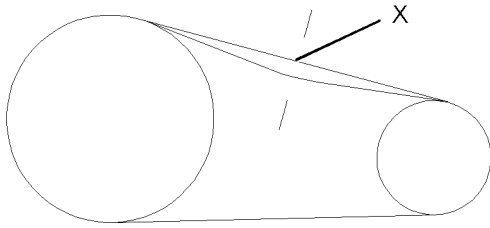


Illustration 33

g01239310

4. Apply 15.6 N (3.5 lb) of pressure at point (X).

The total deflection should not exceed 1.5 mm (0.06 inch).

Replace the belt if the total deflection exceeds 1.5 mm (0.06 inch). Refer to "Replacement" for more information.

5. Install the guard (3) and tighten the bolts (2) securely.
6. Restore the electrical supply to the engine.

Adjustment

The alternator belt is a toothed belt. The belt tension is not adjustable. The belt does not require a preload. Light tension will ensure that the belt is a snug fit on the pulleys.

Replacement

Removal of the Alternator Belt

1. If necessary, isolate the electrical supply to the engine and remove the guards.

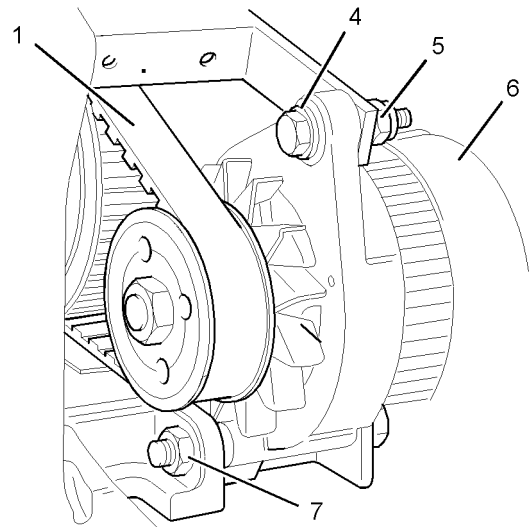


Illustration 34

g01239580

Typical example

2. Remove nut (5) and bolt (4).
3. Loosen nut (7) and push the alternator (6) toward the engine.
4. Remove the belt (1).

Installation of the Alternator Belt

1. Install the belt (1) over the pulleys.

Note: Ensure that the teeth on the belt are engaged with the teeth on the pulleys.

2. Pull the alternator (6) away from the engine. Install bolt (4) and nut (5).
3. Tighten nuts (5) and (7).
4. Check the tension of the belt. Refer to "Inspection" for the correct procedure.
5. If necessary, restore the electrical supply to the engine and install the guards.

i03754170

Belts - Inspect/Adjust/Replace (Fan Drive Belts)

Inspection

1. Isolate the electrical supply to the engine.

2. Loosen the fasteners for the air pipes (not shown).
3. Remove the guards (not shown).

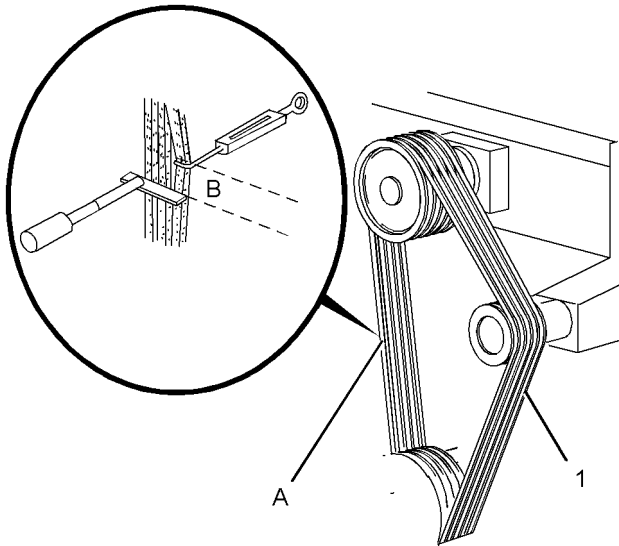


Illustration 35

g02025020

4. Inspect the belts (1) for cracks. Inspect the belts for contamination. If necessary, replace the belts. Refer to "Replacement" for more information.
5. The belt tension must be checked at position A. Use a suitable spring balance and a suitable straight edge in order to check the belt tension.
6. The belt tension should be 24 to 36 N (5.39544 to 8.09316 lb) with a maximum deflection at position B of 8 mm (0.314 inch).
7. Adjust the belts if the belt tension exceeds 36 N (8.09316 lb). Refer to "Adjustment" for more information.
8. Tighten the fasteners for the air pipes (not shown) to a torque of 120 N·m (88.5 lb ft).
9. Install the guards (not shown).
10. Restore the electrical supply to the engine.

Adjustment

1. If necessary, isolate the electrical supply to the engine. Loosen the fasteners for the air pipes and remove the guards.

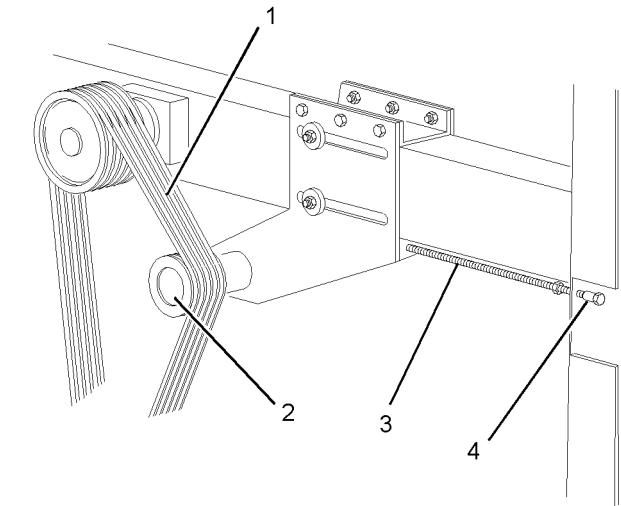


Illustration 36

g01239588

2. Loosen the locknut (4).
3. Rotate the rod (3) in order to achieve the correct tension of belts (1). Refer to "Inspection" for the correct specification.
4. Tighten the locknut (4) to a torque of 120 N·m (88.5 lb ft).
5. If necessary, restore the electrical supply to the engine. Tighten the fasteners for the air pipes and install the guards.

Replacement

Note: Fan drive belts must be replaced as a set. Do not replace individual belts.

Removal of the Fan Drive Belts

1. If necessary, isolate the electrical supply to the engine. Loosen the fasteners for the air pipes and remove the guards.
2. Loosen the locknut (4).
3. Rotate the rod (3) until the pulley (2) is toward the center of the engine.
4. Remove the belts (1).

Installation of the Fan Drive Belts

1. Install the belts (1) over the pulleys.

2. Rotate the rod (3) in order to achieve the correct tension of belts (1). The total deflection should not exceed 12.5 mm (0.5 inch).
3. Tighten the locknut (4) to a torque of 120 N·m (88.5 lb ft).
4. If necessary, restore the electrical supply to the engine. Tighten the fasteners for the air pipes and install the guards.

i03837530

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 pumps and the water temperature regulators after the cooling system has been drained. This is a good opportunity to replace the water pumps, the water temperature regulators and the hoses, if necessary.

Drain

WARNING

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

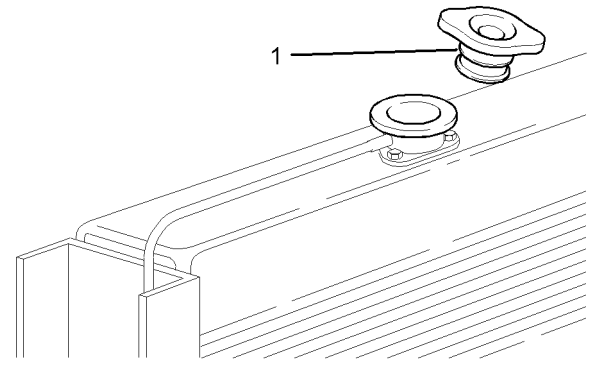


Illustration 37

g01211179

Typical example

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

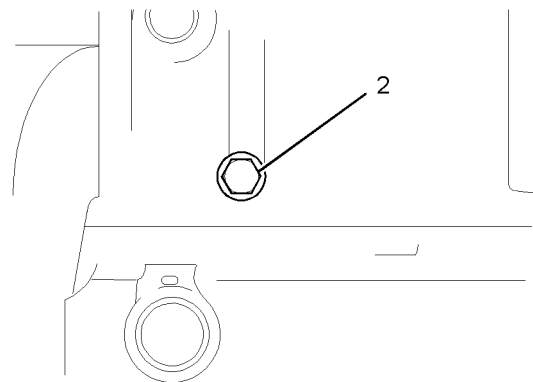


Illustration 38

g01211160

Typical example

2. Open the drain cock or remove the drain plug (2) in the cylinder block.
3. Open the drain cock or remove the drain plug on the radiator.

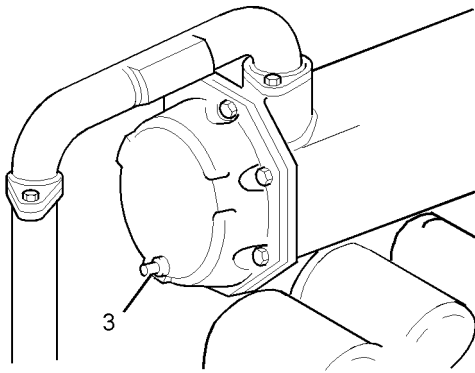


Illustration 39

g01211161

Typical example

4. Open the drain cocks or remove the drain plugs (3) in the oil coolers.

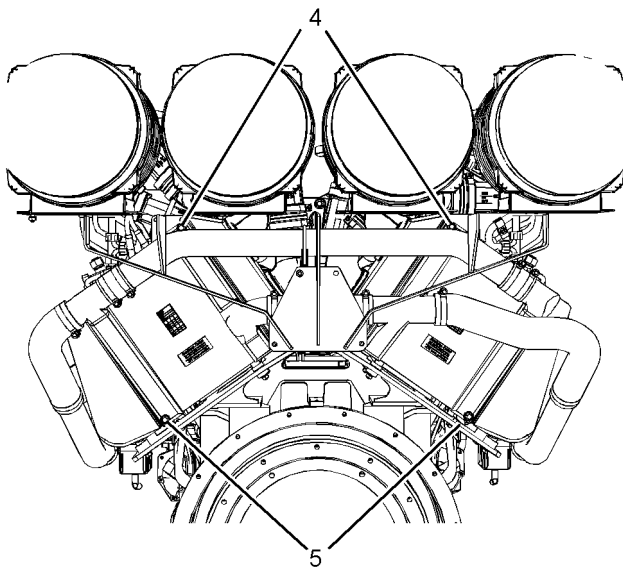


Illustration 40

g02126488

Typical example

Note: In some application, opening the air vent (4) will assist the draining of the coolant.

5. Remove the drain plugs (5) in the aftercoolers.
6. 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 (2) in the cylinder block. Close the drain cock or install the drain plug on the radiator. Close the drain cocks or install the drain plugs (3) in the oil coolers. Install the drain plugs (5) in the aftercoolers. Tighten the plugs securely.

NOTICE

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

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water.

Loosen the air vent (4) in the aftercoolers. Fill the cooling system until coolant free of air flows from the vent. Tighten the air vent securely.

Install the cooling system filler cap (1).

4. Start the engine. Operate the engine 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 (1) slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain cock or remove the drain plug (2) in the cylinder block. Open the drain cock or remove the drain plug on the radiator. Open the drain cocks or remove the drain plugs (3) in the oil coolers. Remove both the drain plugs (5) in the aftercoolers. Allow the water to drain. Flush the cooling system with clean water.

Fill

1. Close the drain cock or install the drain plug (2) in the cylinder block. Close the drain cock or install the drain plug on the radiator. Close the drain cocks or install the drain plugs (3) in the oil coolers. Install the drain plugs (5) in the aftercoolers.

NOTICE

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

Cooling system air locks may result in engine damage.

i03837649

- 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.

Note: Open the air vent (4) in order to allow air to be removed from the system. Fill the cooling system until coolant free of air flows from the vent. Tighten the air vent securely. Ensure that the filler cap is installed before operating the engine.

- Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Use the normal shutdown procedure in order to stop the engine.

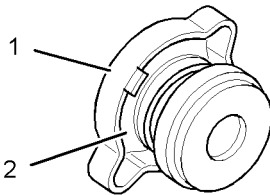


Illustration 41

g01239656

Typical example

- Remove the filler cap. Check that the coolant level is within 25 mm (1.0 inch) of the bottom of the filler pipe. Clean the cooling system filler cap (1) and inspect the seal (2). If the seal is damaged, discard the old filler cap and install a new filler cap. If the seal 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, replace the filler cap.
- Install the cooling system filler cap.
- Start the engine and operate the engine. Inspect the cooling system for leaks. Ensure that the cooling system operates at the correct temperature.

Cooling System Coolant - Change (Inhibitor)

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 inhibitor is drained and replaced.

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

Drain

WARNING

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

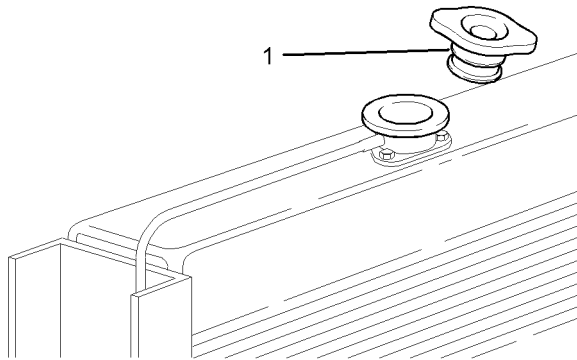


Illustration 42

g01211179

Typical example

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

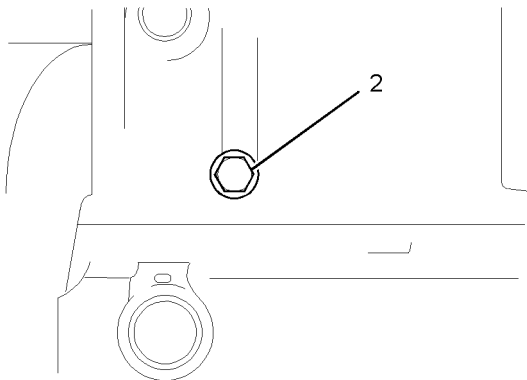


Illustration 43

g01211160

Typical example

2. Open the drain cock or remove the drain plug (2) in the cylinder block.
3. Open the drain cock or remove the drain plug on the radiator.

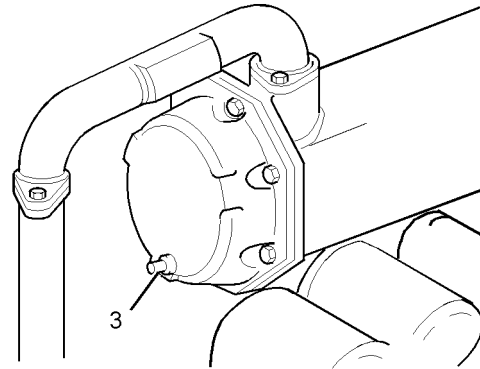


Illustration 44

g01211161

Typical example

4. Open the drain cocks or remove the drain plugs (3) in the oil coolers.

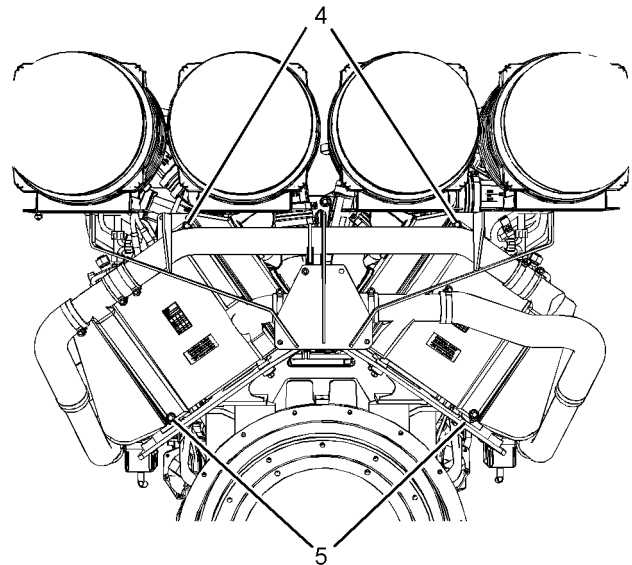


Illustration 45

g02126488

Typical example

Note: In some application, opening the air vent (4) will assist the draining of the coolant.

5. Remove both the drain plugs (5) in the aftercoolers.
6. Allow the coolant to drain.

NOTICE

Dispose of all fluids according to local regulations and mandates. When you recycle used engine coolant for reuse in engine cooling systems, the full distillation procedure is the only method acceptable by Perkins Engines Company LTD to reclaim the coolant.

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 (2) in the cylinder block. Close the drain cock or install the drain plug on the radiator. Close the drain cocks or install the drain plugs (3) in the oil coolers. Close the drain cocks or install the drain plugs (5) in the aftercoolers. Tighten the plugs securely.

NOTICE

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

Cooling system air locks may result in engine damage.

3. Fill the cooling system with clean water.

Loosen the air vent (4) in the aftercoolers. Fill the cooling system until coolant free of air flows from the vent . Tighten the air vent securely.

Install the cooling system filler cap (1).

4. Start the engine. Operate the engine 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 (1) slowly in order to relieve any pressure. Remove the cooling system filler cap. Open the drain cock or remove the drain plug (2) in the cylinder block. Open the drain cock or remove the drain plug on the radiator. Open the drain cocks or remove the drain plugs (3) in the oil coolers. Remove the drain plugs (5) in the aftercoolers. Allow the water to drain. Flush the cooling system with clean water.

Fill

1. Close the drain cock or install the drain plug (2) in the cylinder block. Close the drain cock or install the drain plug on the radiator. Close the drain cocks or install the drain plugs (3) in the oil coolers. Install the drain plugs (5) in the aftercoolers.

NOTICE

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

Cooling system air locks may result in engine damage.

2. Fill the cooling system with water and inhibitor. Refer to the Operation and Maintenance Manual, "Fluid Recommendations" topic (Maintenance Section) for more information on cooling system specifications.

Note: Open the air vent (4) in order to allow air to be removed from the system. Fill the cooling system until coolant free of air flows from the vent . Tighten the air vent securely. Ensure that the filler cap is installed before operating the engine.

3. Start the engine. Operate the engine in order to purge the air from the cavities of the engine block. Use the normal shutdown procedure in order to stop the engine.
4. Check that the coolant level is within 25 mm (1.0 inch) of the bottom of the filler pipe.

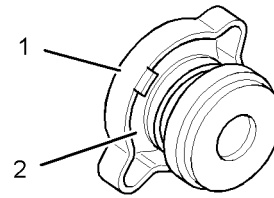


Illustration 46

g01239656

5. Clean the cooling system filler cap (1) and inspect the seal (2). If the seal is damaged, discard the old filler cap and install a new filler cap. If the seal 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, replace the filler cap.

Install the cooling system filler cap.

6. Start the engine and operate the engine. Inspect the cooling system for leaks. Ensure that the cooling system operates at the correct temperature.

i02415245

Cooling System Coolant Level - Check

WARNING

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

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

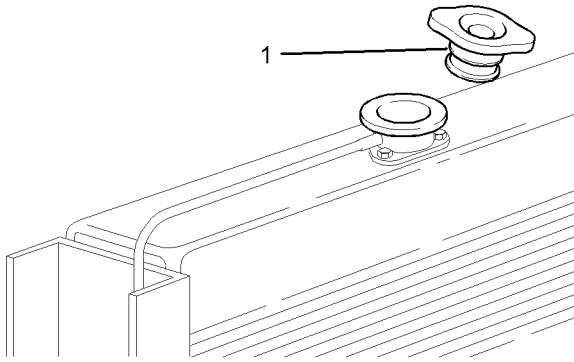


Illustration 47

g01211179

1. Remove the cooling system filler cap (1) slowly in order to relieve pressure.
2. Maintain the coolant level within 25 mm (1.0 inch) of the bottom of the filler pipe.

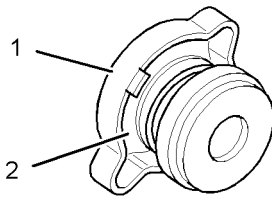


Illustration 48

g01239656

3. Clean the cooling system filler cap (1) and inspect the seal (2). If the seal is damaged, discard the old filler cap and install a new filler cap. If the seal 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, replace the filler cap.

Install the cooling system filler cap.

4. Inspect the cooling system for leaks.

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.

i02415247

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.

NOTICE

Water or condensation can cause damage to generator components. Protect all electrical components from exposure to water.

NOTICE

Failure to protect some engine components from washing may make your engine warranty invalid. Allow the engine to cool for one hour before washing the engine.

Periodic cleaning of the engine is recommended. 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 starting motors, and the ECU.

i03781216

Engine Air Cleaner Element - Replace

NOTICE

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

Renew the air filter elements if the service indicators are triggered. Refer to Operation and Maintenance Manual, "Engine Air cleaner Service Indicator - Inspect" for more information.

Some engines are equipped with air intake precleaners. Clean the precleaners before maintenance is performed on the air filters. Ensure that dirt does not enter the housing of the air cleaner.

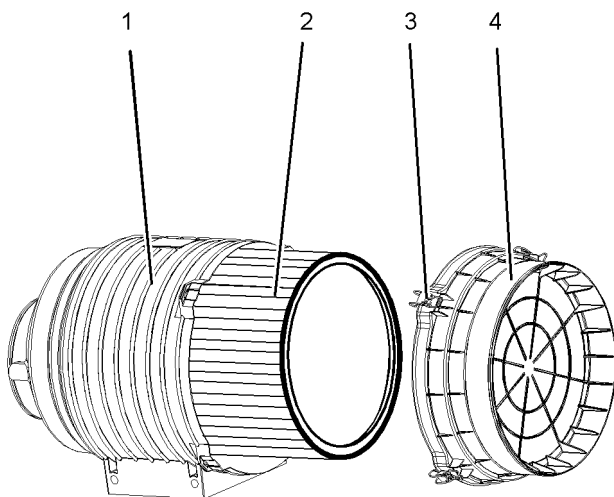


Illustration 49

g02041313

1. Release the clips (3) and remove cover (4).
2. Remove the old element (2) from the housing (1). Discard the old element.

Note: Ensure that dirt does not enter the housing.

3. Install a new element (2) into the housing (1). Align the cover (3) to the housing (1). Secure the clips (3).

i02415251

Engine Air Cleaner Service Indicator - Inspect

Service Indicator Check

Check the service indicators. Replace the air filter elements if one of service indicators has been triggered.

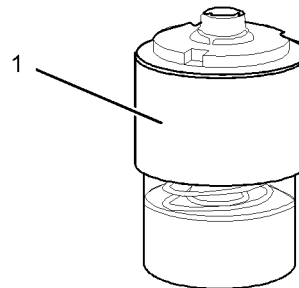


Illustration 50

g01242320

When the air filter element is in a serviceable condition, the center section of the service indicator (1) is clear.

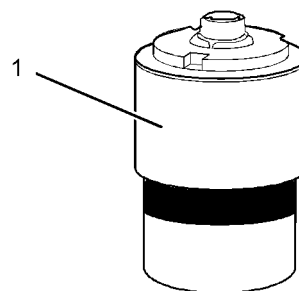


Illustration 51

g01242332

When the air filter element requires replacement, the center section of the service indicator (1) is red.

Service Indicator Reset

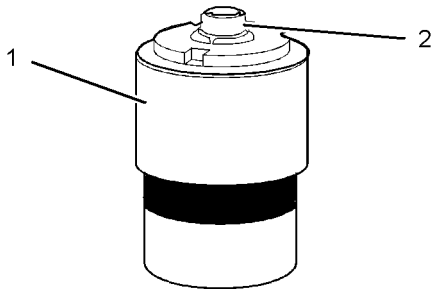


Illustration 52

g01242328

Once the service indicator has been triggered and when the air filter element has been replaced, the service indicator must be reset. In order to reset the service indicator (1), press the button (2).

If the service indicator does not reset easily, the service indicator should be replaced.

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

i03874496

Engine Crankcase Breather - Clean

The engine crankcase breathers are mounted on the side of the water regulators.

1. Isolate the electrical supply to the starting motor.

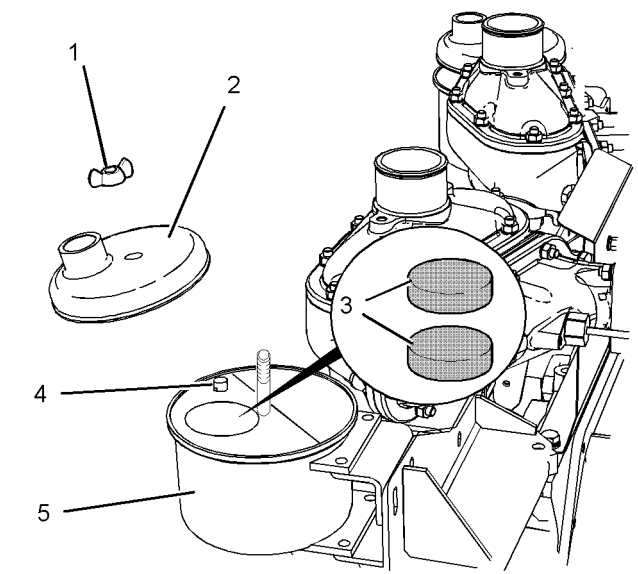


Illustration 53

g02117753

Typical example

2. Remove the wing nut (1) and the cover (2).
3. Remove the filter elements (3) from the breather body (5).
4. Clean the filter elements (3) and dry the filter elements. Inspect the filter elements for damage or deterioration. If necessary, replace the filter elements.
5. Install the filter elements (3) to the breather body (5).
6. Ensure that the seal in the cover (2) is free from damage. If necessary, replace the seal.
7. Align the cover (2) with the dowel (4). Install the cover to the breather body (5).
8. Install the wing nut (1). Tighten the wing nut securely.
9. Restore the electrical supply to the starting motor.

i02415257

Engine Mounts - Inspect

Misalignment of the engine and the driven equipment will cause extensive damage. Excessive vibration can lead to misalignment. Excessive vibration of the engine and the driven equipment can be caused by the following conditions:

- Improper mounting

- Loose bolts
- Deterioration of the isolators

Ensure that the mounting bolts are tightened to the correct torque.

Ensure that the isolators are free of oil and contamination. Inspect the isolators for deterioration. Ensure that the bolts for the isolators are tightened to the correct torque.

Replace any isolator that shows deterioration. For more information, see the literature that is provided by the OEM of the isolators.

i02472513

Engine Oil Filter (Auxiliary) - Change

Note: Refer to the Operation and Maintenance Manual, "Engine Oil Sample - Obtain" before performing maintenance.

Change the Filter with the Engine in Operation

WARNING

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

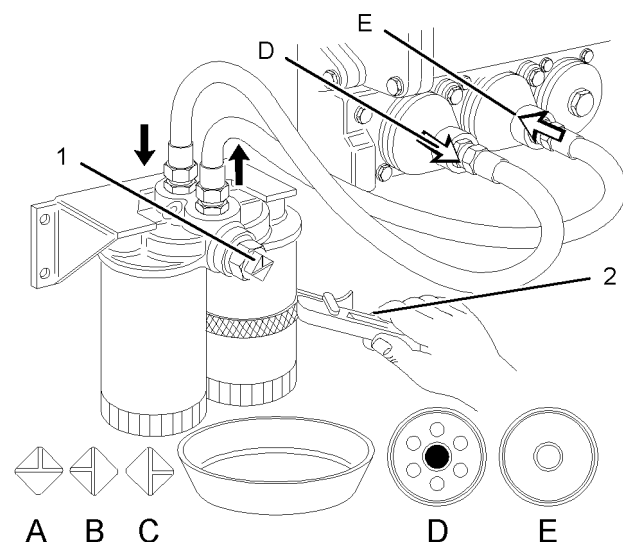


Illustration 54

g01233078

Typical example

The changeover valve (1) has three positions.

- (A) The oil flow is to both oil filters.
 - (B) The oil flow is to the left hand oil filter.
 - (C) The oil flow is to the right hand oil filter.
1. Rotate the changeover valve to position B. By using a suitable tool (2), remove the right hand oil filter.

Note: Oil flow direction (D and E).

2. Ensure that the sealing face on the housing is clean. Fill the new oil filter with clean engine oil. Install the new oil filter. Rotate the changeover valve to position A. Check for oil leaks.
3. Rotate the changeover valve to position C. By using a suitable tool, remove the left hand oil filter.
4. Ensure that the sealing face on the housing is clean. Fill the new oil filter with clean engine oil. Install the new oil filter. Apply hand pressure only in order to install the oil filter. Rotate the changeover valve to position A. Check for oil leaks.
5. Clean any spillage of engine oil.

i02415261

Engine Oil Level - Check

WARNING

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

NOTICE

Perform this maintenance with the engine stopped.

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

NOTICE

Operating your engine when the oil level is above the "Max" 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.

i02415262

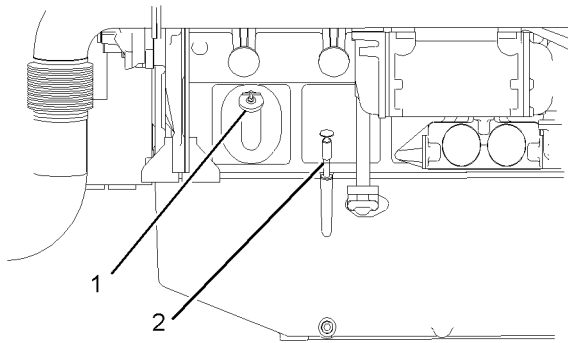


Illustration 55

g01236968

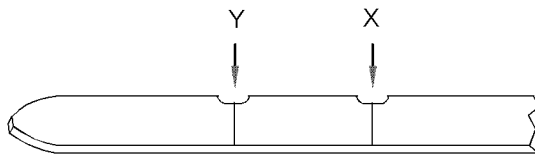


Illustration 56

g01165836

(Y) "Min" mark. (X) "Max" mark.

1. Maintain the oil level between the "Min" mark (Y) and the "Max" mark (X) on the engine oil level gauge (2). Do not fill the oil pan above the "Max" mark (X).
2. If necessary, remove the oil filler cap (1) and add oil. Clean the oil filler cap. Install the oil filler cap.

i03883009

Engine Oil Pump - Inspect

A failed engine oil pump may result in a seizure of the crankshaft.

Remove the engine oil pump and disassemble the engine oil pump. Replace any components that are worn or damaged. Alternatively, replace the engine oil pump.

Engine Oil Sample - Obtain

The condition of the engine lubricating oil should be checked at regular intervals as part of the preventive maintenance program.

Initiating an Oil analysis Program

The First 500 Hours

Oil analysis in the first 500 hours will show higher levels of iron and copper than acceptable parameters. As the engine continues to operate the levels will drop within the specified parameters.

Every 250 Hours

An oil sample should be obtained at 250 hour intervals.

A trend can be established by analyzing the results of the oil sampling. Each individual operator can develop a service program for the engine.

Note: Perkins Engines Stafford must agree to the maintenance schedule.

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.

The oil sample must be taken from the mean level in the engine oil pan. Do not take an oil sample from the drain plug.

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.

i03895137

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

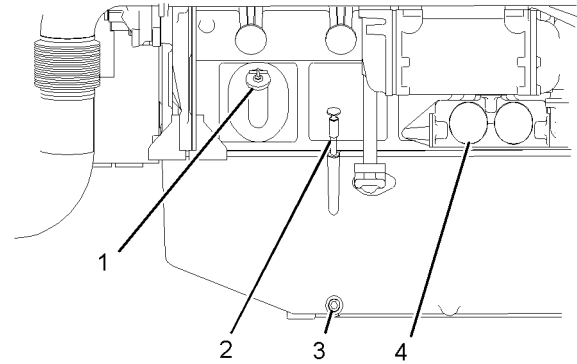


Illustration 57

g01237431

Typical example

1. Place a suitable container below the engine oil pan. Remove the drain plug (3). Allow the engine oil to drain.

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

2. Remove the sealing washer from the drain plug (3). Discard the sealing washer.
3. Install a new sealing washer to the drain plug (3). Install the drain plug to the engine oil pan. Tighten the plug to a torque of 68 N·m (50 lb ft).

Replace the Oil Filter

Table 21

Required Tools			
Tool	Part Number	Part Name	Qty
A	-	Strap Wrench	1

NOTICE

Perkins oil filters are manufactured to Perkins Engine Company LTD specifications. Use of an oil filter that is not recommended by Perkins Engine Company LTD could result in severe damage to the engine. Large particles from unfiltered engine oil will cause damage to the engine. Do not use oil filters that are not recommended by Perkins Engine Company LTD.

Note: All six oil filters must be changed as a set.

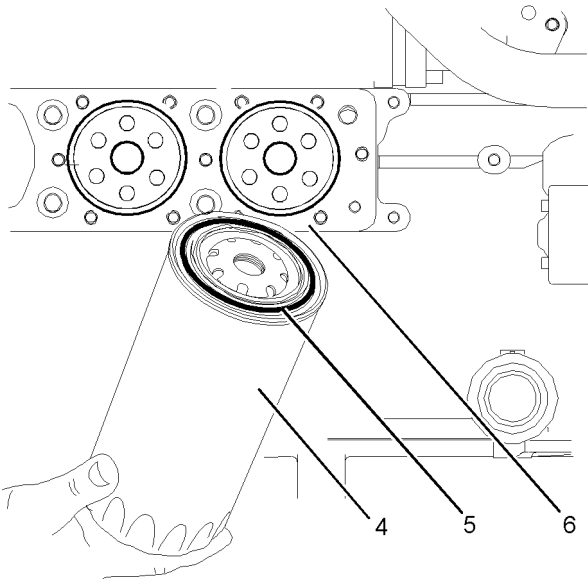


Illustration 58

g01237432

Typical example

1. Use Tooling (A) in order to remove the oil filters (4).
2. Ensure that the sealing face of the filter base (6) is clean.
3. Lubricate the sealing rings (5) with clean engine oil. Fill the oil filters with clean engine oil. Ensure that the engine oil that is added to the oil filters has not been contaminated. Install the new oil filters (4).

Note: Apply hand pressure only in order to tighten the oil filters.

Fill the Oil Pan

Refer to Operation and Maintenance Manual, "Fluid Recommendations" for information on suitable oils.

1. Remove the oil filler cap.
2. Fill the oil pan with the correct amount of new engine lubricating oil. Refer to Operation and Maintenance Manual, "Refill Capacities" for more information.

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.

Note: Before starting the engine, crank the engine on the starter in order to obtain oil pressure.

3. Start the engine and run the engine for two minutes. Perform this procedure in order to ensure that the lubrication system has oil and that the oil filters are filled. Inspect the oil filters for oil leaks.

4. Stop the engine and allow the oil to drain back to the oil pan for a minimum of ten minutes.

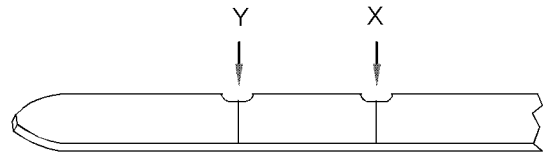


Illustration 59

g01165836

(Y) "Min" mark. (X) "Max" mark.

5. Remove the engine oil level gauge (2) in order to check the oil level. Maintain the oil level between the "MIN" and "MAX" marks on the engine oil level gauge.

i02461963

Engine Protective Devices - Check

Alarms and shutoffs must function properly. Alarms provide timely warning to the operator. Shutoffs help to prevent damage to the engine. It is impossible to determine if the engine protective devices are in good working order during normal operation. Malfunctions must be simulated in order to test the engine protective devices.

A calibration check of the engine protective devices will ensure that the alarms and shutoffs activate at the setpoints. Ensure that the engine protective devices are functioning properly.

NOTICE

During testing, abnormal operating conditions must be simulated.

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

To prevent damage to the engine, only authorized service personnel or your Perkins dealer should perform the tests.

Visual Inspection

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

i03783810

Engine Valve Lash - Inspect/Adjust (Valves and Valve Bridges)

Table 22

Required Tools			
Tool	Part Number	Part Name	Qty
A	SE253	Crankshaft Turning Tool	1
B	-	Feeler Gauges	1

NOTICE

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

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

WARNING

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

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

Note: The valve bridges must be equalized before the valve lash is adjusted.

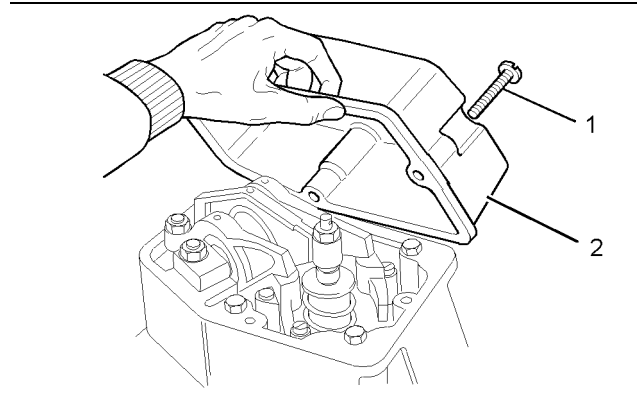


Illustration 60

g01241573

1. Remove the setscrews (1).
2. Remove the rocker cover (2).
3. Remove the joint (not shown).
4. Repeat Steps 1 through 3 for the remaining rocker covers.

For 4016 engines, set the valve lash in the sequence that is shown in the Table 23.

Table 23

4016 Engines		
Piston at T.D.C.	Valves on the Rock	Check and Adjust Valves.
A1 & A8	A8	A1
B1 & B8	B8	B1
A3 & A6	A6	A3
B3 & B6	B6	B3
A7 & A2	A2	A7
B7 & B2	B2	B7
A5 & A4	A4	A5
B5 & B4	B4	B5
A1 & A8	A1	A8
B1 & B8	B1	B8
A3 & A6	A3	A6
B3 & B6	B3	B6
A7 & A2	A7	A2
B7 & B2	B7	B2
A5 & A4	A5	A4
B5 & B4	B5	B4

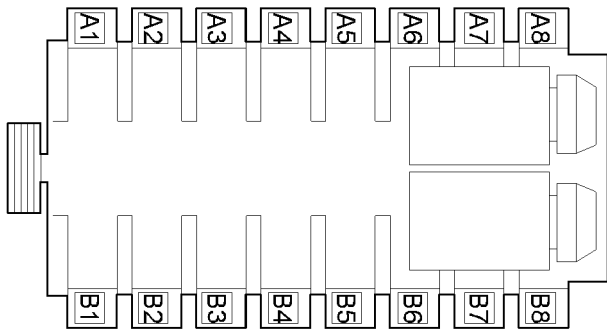


Illustration 61
4016 Engine

g01241941

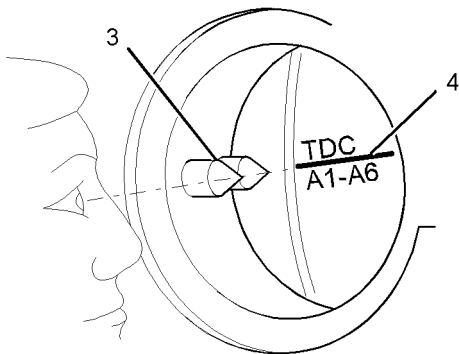


Illustration 62
Typical example

g01241570

5. Use Tooling (A) in order to rotate the crankshaft until the appropriate mark (4) on the flywheel is in alignment with the pointers (3). Ensure that there is clearance between the rocker arm and the valve.

Note: The timing window is located in the flywheel housing of B bank.

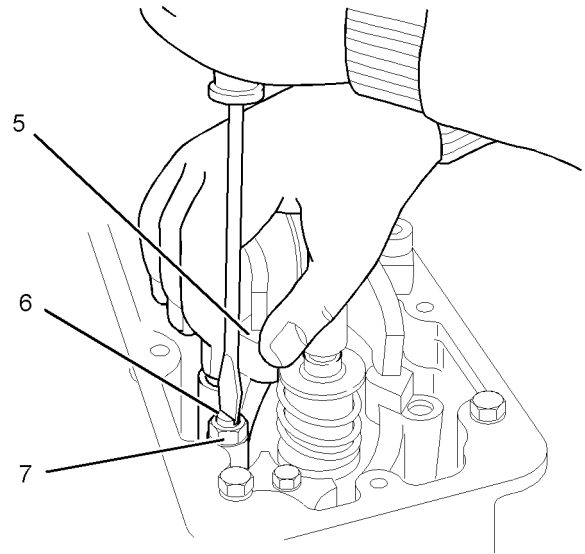


Illustration 63

g01241584

6. Loosen the locknut (7) on the inlet valve bridge.
7. In order to equalize the bridge, turn the adjuster (6) until the fixed pad on the valve bridge (5) and the adjuster is in contact with the valve.
8. Tighten the locknut (7) to a torque of 50 N·m (37 lb ft).
9. Repeat Steps 6 through 8 for the exhaust valve bridge.

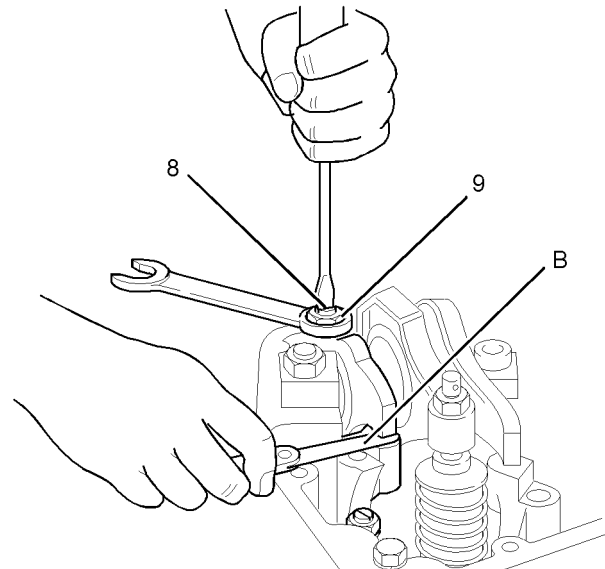


Illustration 64

g01241598

10. Use Tooling (B) in order to check the valve lash. If necessary, follow Steps 10.a through 10.f in order to adjust the valve lash. Set the valve lash to 0.4 mm (0.016 inch).

- a. Loosen the locknut (9) on the rocker arm of the inlet valve.
- b. Use Tooling (B) in order to set the valve lash.
- c. Turn the adjuster (8) until the pad on the rocker arm is in contact with Tooling (B).
- d. Tighten the locknut (7) to a torque of 50 N·m (37 lb ft).
- e. Ensure that the valve lash is correct.
- f. Repeat Step 10 for the rocker arm of the exhaust valve.

11. Repeat Steps 5 through 10 for the remaining rockers.

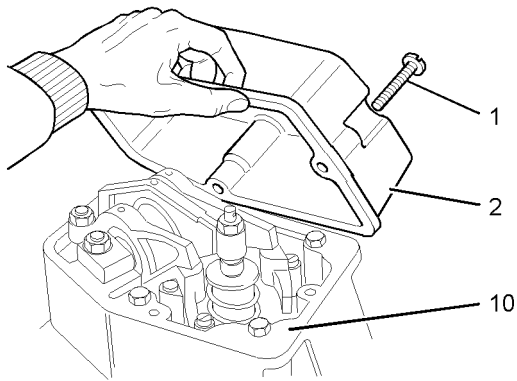


Illustration 65

g01241917

12. Ensure that the rocker cover (2) is clean and free from damage. Ensure that the joint face of the rocker base (10) is clean and free from damage.
13. Install a new joint (not shown).
14. Install the rocker cover (2).
15. Install the setscrews (1). Tighten the setscrews to a torque of 4 N·m (35 lb in).
16. Repeat Steps 12 through 15 for the remaining rocker covers.

i02463729

Fan Drive Pulley - Check

1. Isolate the electrical supply to the engine.

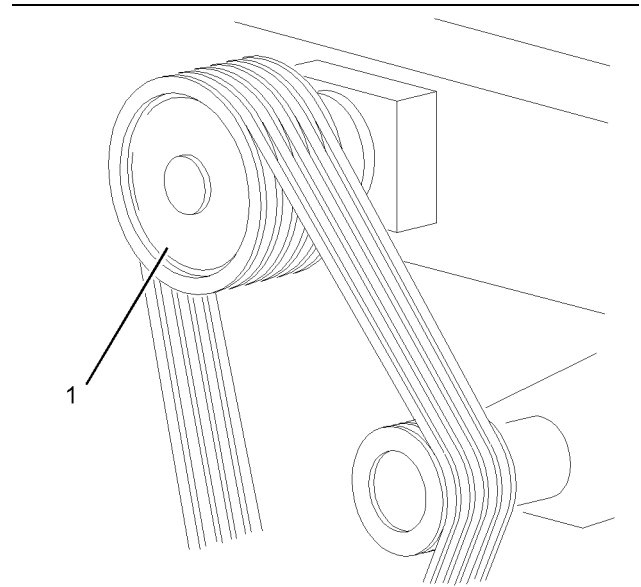


Illustration 66

g01238304

Typical example

2. Remove the guards (not shown) in order to gain access to the fan drive pulley (1).

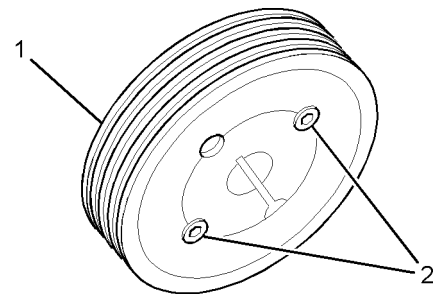


Illustration 67

g01238305

3. Tighten the grub screws (2) to a torque of 90 N·m (66 lb ft).
4. Install the guards (not shown).
5. Restore the electrical supply to the engine.

i03784609

Fuel Injector - Inspect/Adjust

Inspect the Fuel Injectors

Refer to System Operation, Testing and Adjusting , KENR9224, "Fuel Injector Adjustment" for information on inspection of the fuel injectors.

i02415266

Fuel System - Prime

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

- The fuel day tank is empty or 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.

Note: Do not bleed the fuel system from the water separator (if equipped).

1. Ensure that the fuel system is in working order. Check that the fuel supply from the fuel day tank is in the "ON" position.

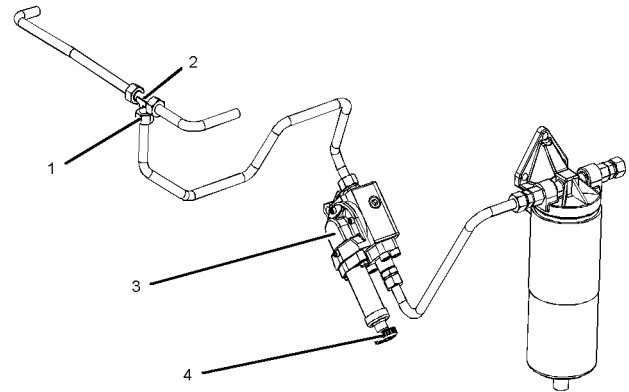


Illustration 68

g01280510

Typical example

2. Place a suitable container below the tee piece (2) in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

3. Loosen the connection (1) at the tee piece (2).
4. Unscrew the handle (4) in order to operate the fuel priming pump (3). Pump the handle until fuel that is free of air flows from the tee piece (2).
5. Tighten the connection (1) on the tee piece (2).

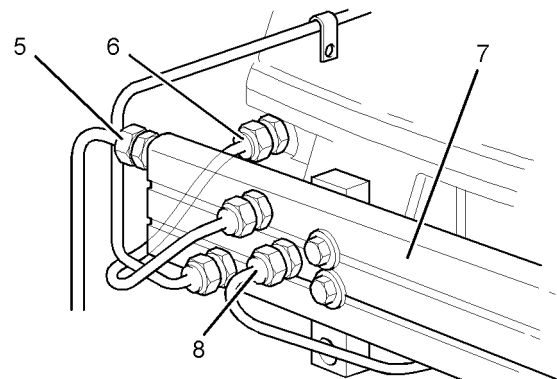


Illustration 69

g01237503

Typical example

6. Place a suitable container below the rear of the fuel rail (7) on A bank, in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

7. Loosen the connection (5).

8. Operate the handle (4) until fuel that is free of air flows from the connection (5).
9. Tighten the connection (5).
10. Loosen connections (6) and (8).
11. Operate the handle (4) until fuel that is free of air flows from the connection (6) and (8).
12. Tighten connections (6) and (8).

One cylinder is now primed. An amount of fuel will have reached the remaining cylinders.

13. Push the handle and twist the handle in order to return the priming pump to the locked position.
14. Operate the starting motor and crank the engine. After the engine has started, run the engine for a minimum of five minutes.

Note: Operating the engine for this period of time will purge the remaining air from the fuel system.

i03837989

Fuel System Filter - Replace

WARNING

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

NOTICE

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

Fuel Filter with Water Separator

Table 24

Required Tools			
Tool	Part Number	Part Name	Qty
A	-	Strap Wrench	1

Note: Two fuel filters are installed. Both fuel filters must be replaced at the same time.

1. Isolate the fuel supply to the engine.

2. Place a suitable container under the fuel filter in order to catch any fuel that might spill.

Note: Clean up any spilled fuel immediately.

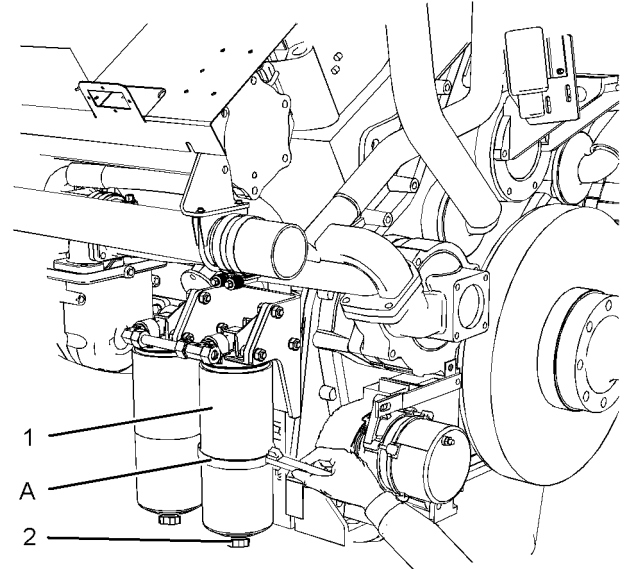


Illustration 70

g02126034

3. Loosen the drain plug (2). Allow the fluid to drain into the container.
4. Clean the outside of the fuel filter. Use Tooling (A) in order to remove the canister (1). Dispose of the canister in accordance with local regulations.
5. Lubricate the O ring seal on the new canister with clean fuel oil. Install the new canister. Tighten the canister by hand.
6. Tighten the drain plug (2). Use hand pressure only.
7. Remove the container and dispose of the fuel in accordance with local regulations.
8. Restore the fuel supply to the engine.
9. Prime the fuel system. Refer to the Operation and Maintenance Manual, "Fuel System - Prime" for more information.
10. Start the engine and run the engine. Check the fuel system for leaks.

i03880440

i02335436

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 fuel that might spill.

Note: Clean up any spilled fuel immediately.

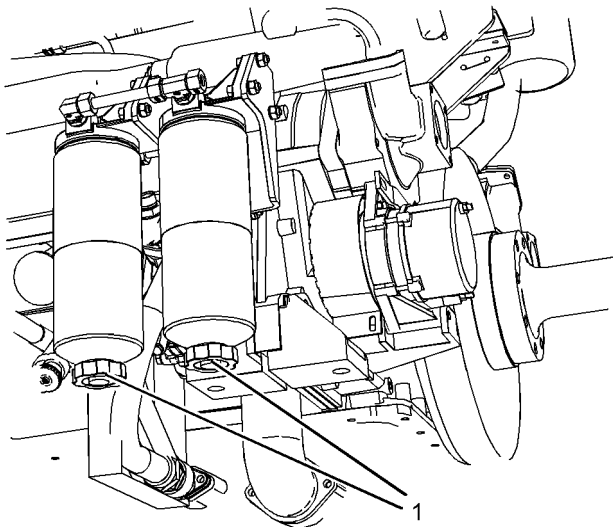


Illustration 71

g02126453

2. Loosen the drain plugs (1). Allow the fluid to drain into the container until clean fuel can be seen.
3. Tighten the drain plugs (1). Use hand pressure only. Dispose of the drained fluid in accordance with local regulations.

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.

i02471681

Fuel Transfer Pump (Lift Pump) - Inspect

Visually inspect the lift pump for leaks. The lift pump is not a serviceable item. Replace a lift pump that is faulty. Replace a lift pump that leaks.

Replacement of the Lift Pump

Removal of the Lift Pump

1. Isolate the fuel supply to the lift pump.
2. Place a suitable container below the lift pump in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

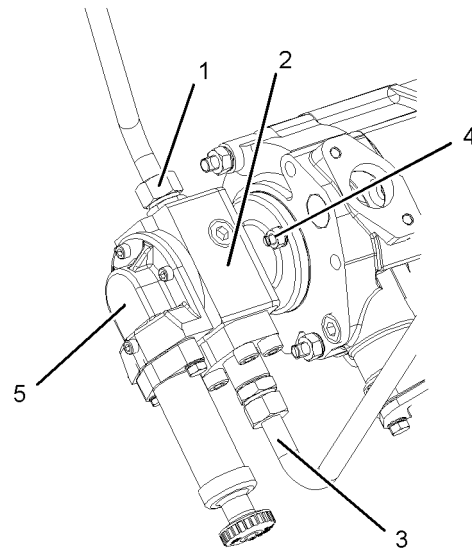


Illustration 72

g01280509

3. Remove the fuel priming pump (5).
4. Disconnect fuel line (3) and the connection (1). Cap the fuel line with a suitable cap.
5. Remove the two nuts (4).
6. Remove the fuel lift pump (2).
7. Remove the joint from the lift pump (2). Discard the joint.

Installation of the Lift Pump

1. Install a new joint to the lift pump (2).
2. Align the drive for the lift pump (2). Install the lift pump.

Note: Ensure that the oil seal is not damaged as the lift pump is installed.

3. Install the nuts (4). Tighten the nuts to a torque of 25 N·m (18 lb ft).
4. Remove the cap from the fuel line (3). Connect the fuel line and the connection (1). Tighten the fuel line and the connection to a torque of 50 N·m (37 lb ft).
5. Fit the fuel priming pump (5) to the lift pump (2).
6. Restore the fuel supply to the lift pump.
7. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime".

i02471680

Governor Actuator - Check

In order for the governor to operate correctly, the control box must be calibrated to the actuator. The feedback parameters from the control box must correspond to the 0% and the 100% positions on the actuator. Carry out a periodic calibration check of the governor system. Refer to Special Instruction, "Pandoras Digital Governor" for more information.

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.

i02461950

Overhaul (Major)

Scheduling a Major Overhaul

The need for a major overhaul is determined by several factors:

- An increase of oil consumption
- An increase of crankcase blowby
- A decrease and variation of cylinder compression

Other factors must also be considered for determining a major overhaul:

- The service hours of the engine
- The wear metal analysis of the lube oil
- An increase in the levels of noise and vibration

An increase of wear metals in the lube oil indicates that the bearings and the surfaces that wear may need to be serviced. An increase in the levels of noise and vibration indicates that rotating parts require service.

Note: It is possible for oil analysis to indicate a decrease of wear metals in the lube oil. The cylinder liners may be worn so that polishing of the bore occurs. Also, the increased use of lube oil will dilute the wear metals.

Monitor the engine as the engine accumulates service hours. Consult Perkins Engines Stafford about scheduling a major overhaul.

Note: The driven equipment may also require service when the engine is overhauled. Refer to the literature that is provided by the OEM of the driven equipment.

Major Overhaul Information

During a major overhaul, all of the bearings, seals, joints, and components that wear should be disassembled. The parts should be cleaned. The parts should then be inspected. If necessary, the parts should be replaced. The crankshaft should be inspected and measured for wear. The crankshaft may require regrinding. Alternatively, the crankshaft may be replaced.

Inspecting Components

Inspect the following components during a major overhaul.

- Engine mounted aftercoolers
- Camshafts
- Camshaft followers
- Connecting rods and bearings
- Crankshaft and bearings
- Gear train
- Inlet air piping
- Oil cooler
- Pistons and rings
- Cylinder liners

Replace the crankshaft vibration damper.

i03880466

Overhaul (Top End)

Scheduling a Top End Overhaul

Top end overhauls should be scheduled according to the recession of the valve stems. This measurement provides an accurate indication of the rate of valve wear. This measurement can be used to predict when a cylinder head requires replacement.

Note: Generally, cylinder heads wear out at different rates. In some cases, servicing the cylinder heads at different times may be the most economic decision. This depends on the valve stem projection of the individual cylinders. However, this decision must include the costs of additional downtime that is caused by this procedure. Perform an economic analysis in order to determine if cylinder heads should be serviced as a group or divided into smaller groups.

Top End Overhaul Information

A top end overhaul involves servicing the cylinder heads. During a top end overhaul, one piston should be removed. Inspect the piston, piston rings and the cylinder liner. The condition of these components will determine the period of the major overhaul.

Monitoring Valve Seat Wear

Every 500 service hours record the valve lash. The monitoring of the valve seat wear should be carried out before any adjustment of the valve lash.

1. Remove the rocker covers.
2. Refer to Operation and Maintenance Manual, "Valve Lash - Inspect Adjust".
3. On all engine cylinders, record the clearance before any adjustments are made.
4. Set the valve bridges.
5. Adjust the valve lash to 0.4 mm (0.016 inch).

The recorded values can be used to identify any excessive valve seat wear on individual valves. The recorded values can be used to schedule a top end overhaul.

An example of recorded valve lash

Table 25

Hours	Recorded clearances on A1 cylinder		Total valve wear	
	Inlet	Exhaust	Inlet	Exhaust
500	0.4mm	0.4mm	0	0
1000	0.4	0.4	0	0
1500	0.35	0.35	0.05	0.05
2000	0.35	0.35	0.1	0.1
2500	0.3	0.3	0.2	0.2
3000	0.25	0.3	0.35	0.3
3500	0.25	0.35	0.5	0.35
4000	0.25	0.3	0.65	0.45

After 4000 hours running, the valve seat wear on the inlet is 0.65 mm (0.026 inch) and the exhaust is 0.45 mm (0.018 inch).

Note: Maximum permitted valve seat wear is 1.00 mm (0.040 inch).

In this example, the valves are still serviceable after 4000 hours running.

When the valves approach the maximum wear limit, the rockers can be removed and a measurement from the cylinder head face to the top of the valve stems can be taken. When a new valve is installed the protrusion of the valve stem would be 29.75 mm (1.171 inch). therefore, a maximum wear limit would be 30.75 mm (1.211 inch).

i02415302

Radiator - Clean

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

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

WARNING

Personal injury can result from air pressure.

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

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.

After cleaning the radiator, start the engine. Run the engine. This will help in the removal of debris and the 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”. Inspect these items for good condition: Welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

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

i03896257

Speed Sensor - Clean/Inspect (Engine Speed Sensor and Overspeed Sensor)

When the engine is cranked, small metal particles are produced. These particles will contaminate the magnetic end of the crankshaft position sensor and the overspeed sensor. Contamination will distort the signals that are produced by the sensors. The sensors should be regularly cleaned and adjusted in order to ensure a good signal.

Table 26

Required Tools			
Tool	Part Number	Part Name	Qty
A	SE253	Crankshaft Turning Tool	1

Engine Speed Sensor

The crankshaft position sensor is located in the right hand side of the flywheel housing.

1. Isolate the electrical supply to the engine.

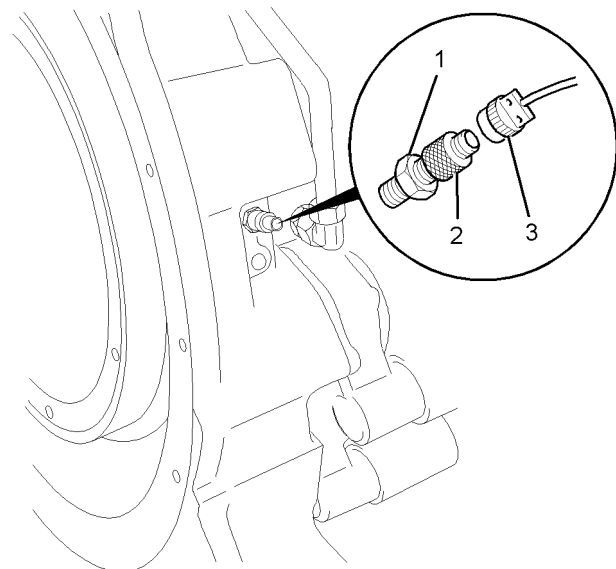


Illustration 73

g01237852

Typical example

2. Remove the connection (3). Loosen the locknut (1).
3. Remove the sensor (2).

4. Use a soft, dry cloth in order to clean any debris from the sensor (2).

Note: Do not use a wire brush in order to clean the sensor. Do not use abrasive material in order to clean the sensor.

5. Install Tooling (A). Use Tooling (A) in order to rotate the engine. Rotate the engine in order to align a tooth on the ring gear with the center of the tapped hole.

6. By hand, carefully install the sensor (2) until light contact is made with the ring gear.

Note: Do not tighten the sensor.

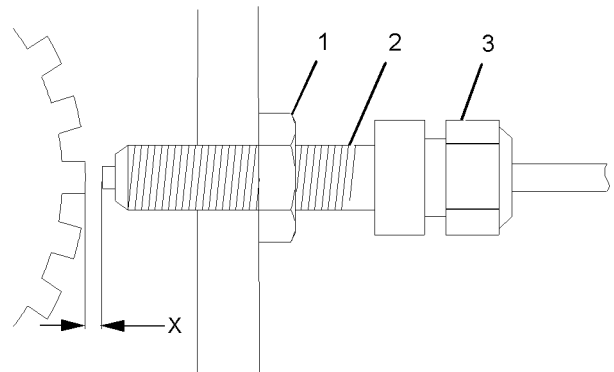


Illustration 74

g01237854

7. Unscrew the sensor (2) by half of one full turn in order to obtain a clearance (X) of 0.5 to 0.8 mm (0.02 to 0.03 inch).
8. Tighten the locknut (1). Do not allow the sensor (2) to rotate. Connect the connection (3).
9. Remove Tooling (A).
10. Restore the electrical supply to the engine.

Overspeed Sensor

The overspeed sensor is located in the left hand side of the flywheel housing.

1. Isolate the electrical supply to the engine.

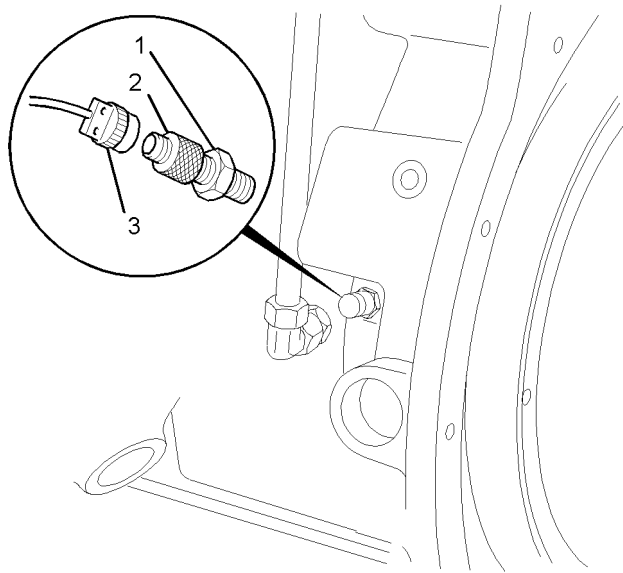


Illustration 75

g01237853

Typical example

2. Remove the connection (3). Loosen the locknut (1).
 3. Remove the sensor (2).
 4. Use a soft, dry cloth in order to clean any debris from the sensor (2).
- Note:** Do not use a wire brush in order to clean the sensor. Do not use abrasive material in order to clean the sensor.
5. Install Tooling (A). Use Tooling (A) in order to rotate the engine. Rotate the engine in order to align a tooth on the ring gear with the center of the tapped hole.
 6. By hand, carefully install the sensor (2) until light contact is made with the ring gear.

Note: Do not tighten the sensor.

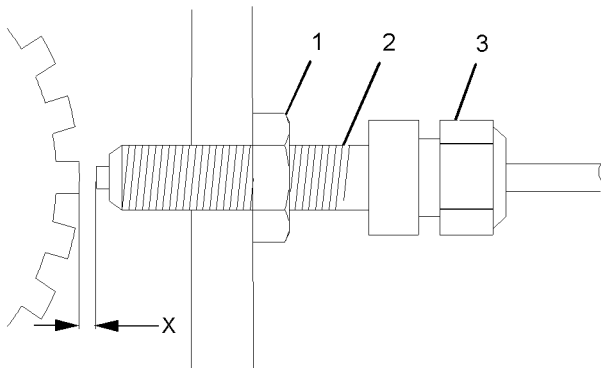


Illustration 76

g01237854

7. Unscrew the sensor (2) by half of one full turn in order to obtain a clearance (X) of 0.5 to 0.8 mm (0.02 to 0.03 inch).
8. Tighten the locknut (1). Do not allow the sensor (2) to rotate. Connect the connection (3).
9. Remove Tooling (A).
10. Restore the electrical supply to the engine.

i03882553

Starting Motor - Inspect

If a starting motor fails, the engine may not start in an emergency situation. A scheduled inspection of the starting motors is recommended.

Note: Problems with the electric starting motor can be caused by the following conditions: malfunction of the solenoid and malfunction of the electric starting system.

Inspect the electrical system for the following conditions:

- Loose connections
- Corrosion
- Wires that are worn or frayed
- Cleanliness

Make repairs, if necessary.

The starting motor pinion and the flywheel ring gear must be in good condition in order for the engine to start properly. The engine will not start if the starting motor pinion does not engage the flywheel ring gear. The teeth of the starting motor pinion and the flywheel ring gear can be damaged because of irregular engagement.

Inspect the starting motors for proper operation. Listen for grinding when the engine is started. Inspect the teeth of the starting motor pinions and the flywheel ring gear. Look for patterns of wear on the teeth. Look for teeth that are broken or chipped. If damaged teeth are found, the starting motor pinions and the flywheel ring gear must be replaced.

i03837996

Turbocharger - Inspect

Periodic inspection and cleaning is recommended for the turbochargers. Fouling of the turbine wheels can contribute to loss of engine power and overall loss of engine efficiency.

If a turbocharger fails during engine operation, damage to the turbocharger compressor wheel and/or to the engine may occur. Damage to a turbocharger compressor wheel could allow parts from the compressor wheel to enter an engine cylinder. This 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 inlet and exhaust systems. Loss of engine lubricant can result in serious engine damage.

Minor leakage of a turbocharger housing 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 repaired or replaced.

An inspection of the turbochargers can minimize unscheduled downtime. Also, the chance for potential damage to other engine parts is reduced.

Note: Turbocharger components require clearances that are precise. The turbocharger cartridge must be balanced due to high rpm.

The following conditions can cause a turbocharger to be out-of-balance:

- The buildup of deposits
- Chipping and/or flaking of deposits

If the turbocharger must be removed for inspection, use caution. Do not break deposits from the turbine wheel. Do not attempt to clean the turbine wheel. For options regarding removal, installation, repair and replacement, consult a Perkins dealer or a Perkins distributor.

1. Remove the exhaust outlet piping and remove the air inlet piping from the turbocharger. Visually inspect the piping for the presence of oil.

2. Turn the compressor wheel and the turbine wheel by hand. The assembly should turn freely. Inspect the compressor wheel and the turbine wheel for contact with the turbocharger housing. There should not be any visible signs of contact between the turbine wheel or compressor wheel and the turbocharger housing. If there is any indication of contact between the rotating turbine wheel or the compressor wheel and the turbocharger housing, the turbocharger should be reconditioned.

3. Check the compressor wheel for cleanliness. If only the inlet side of the wheel is dirty, dirt and/or moisture is passing through the air filtering system. If oil is found only on the back side of the wheel, there is a possibility of a failed turbocharger oil seal.

The presence of oil may be the result of extended engine operation at no load. The presence of oil may also result from restriction of the inlet air (plugged air filters). This causes oil to leak past the seal for the turbocharger compressor.

Note: Deposits of ash and silicone can accumulate on the turbine wheel. Turbine wheel will become unbalanced when the deposits flake off. The turbocharger cartridge must be replaced when this occurs. However, remove deposits from the housing. This will prevent wear on the blades of the new turbine wheel.

4. Inspect the turbine wheel and the housing for deposits of ash and silicone. If deposits of 1.6 mm (0.06 inch) thickness are found or if the turbine is in contact with the housing, the turbocharger must be disassembled and cleaned. Removal of the deposits can be difficult.
5. Inspect the bore of the turbine housing for corrosion and deposits.
6. Clean the turbocharger compressor housing with standard shop solvents and a soft bristle brush.
7. Fasten the air inlet piping and the exhaust outlet piping to the turbocharger housing.

i02415322

Walk-Around Inspection

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

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 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 pumps 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 a water pump. Refer to Operation and Maintenance Manual, "Water Pump - Inspect" for more information. If necessary, 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 belt and fan 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.

i03882689

Water Pump - Inspect

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

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

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

Visually inspect the water pumps for leaks. The water pumps are not serviceable items. Replace a leaking water pump.

Warranty Section

Warranty Information

i01903596

Emissions Warranty Information

This engine may be certified to comply with exhaust emission standards and gaseous emission standards that are prescribed by the law at the time of manufacture, and this engine may be covered by an Emissions Warranty. Consult your authorized Perkins dealer or your authorized Perkins distributor in order to determine if your engine is emissions certified and if your engine is subject to an Emissions Warranty.

Index

A

Actuator Control Linkage - Lubricate	43
After Stopping Engine.....	29
Aftercooler Core - Clean/Test	43
Aftercooler Core - Inspect.....	44
Alternator - Inspect	44
Alternator Pulley - Check.....	44

B

Battery - Replace.....	45
Battery Electrolyte Level - Check	45
Battery or Battery Cable - Disconnect	46
Before Starting Engine	10, 26
Belts - Inspect/Adjust/Replace (Alternator Belt)	46
Adjustment.....	47
Inspection.....	46
Replacement.....	47
Belts - Inspect/Adjust/Replace (Fan Drive Belts)...	47
Adjustment.....	48
Inspection.....	47
Replacement.....	48
Burn Prevention.....	7
Batteries.....	7
Coolant.....	7
Oils.....	7

C

Cold Weather Starting	27
Cooling System Coolant - Change (Inhibitor).....	51
Drain	52
Fill	53
Flush	53
Cooling System Coolant (ELC) - Change.....	49
Drain	49
Fill	50
Flush	50
Cooling System Coolant Level - Check.....	53
Crushing Prevention and Cutting Prevention	9

D

Driven Equipment - Check.....	54
-------------------------------	----

E

Electrical System	11
Emergency Stopping	29
Emissions Warranty Information.....	76
Engine - Clean.....	54
Engine Air Cleaner Element - Replace.....	55

Engine Air Cleaner Service Indicator - Inspect.....	55
Service Indicator Check.....	55
Service Indicator Reset.....	56
Engine Crankcase Breather - Clean.....	56
Engine Description	15
Engine Cooling and Lubrication.....	16
Engine Specifications.....	15
Engine Electronics.....	11
System Description	11
Engine Lifting.....	19
Engine Mounts - Inspect.....	56
Engine Oil and Filter - Change	59
Drain the Engine Lubricating Oil	59
Fill the Oil Pan.....	60
Replace the Oil Filter	59
Engine Oil Filter (Auxiliary) - Change	57
Change the Filter with the Engine in Operation..	57
Engine Oil Level - Check.....	57
Engine Oil Pump - Inspect.....	58
Engine Oil Sample - Obtain	58
Initiating an Oil analysis Program	58
Obtain the Sample and the Analysis.....	58
Engine Operation.....	28
Engine Protective Devices - Check	60
Visual Inspection.....	61
Engine Starting	10, 26
Engine Stopping	10, 29
Engine Storage.....	21
Level "A"	21
Level "B"	21
Level "C"	21
Engine Valve Lash - Inspect/Adjust (Valves and Valve Bridges)	61

F

Fan Drive Pulley - Check.....	63
Features and Controls	22
Fire Prevention and Explosion Prevention	7
Fire Extinguisher	9
Lines, Tubes and Hoses	9
Fluid Recommendations (Cooling System Specifications)	30
ELC Cooling System Maintenance	32
General Coolant Information.....	30
Fluid Recommendations (Fuel Specifications)	35
Fuel Recommendations.....	35
Fluid Recommendations (General Lubricant Information).....	38
Engine Oil	38

Foreword	4
California Proposition 65 Warning	4
Literature Information	4
Maintenance	4
Maintenance Intervals	4
Operation	4
Overhaul	4
Safety	4
Fuel Conservation Practices	28
Fuel Injector - Inspect/Adjust	64
Inspect the Fuel Injectors	64
Fuel System - Prime	64
Fuel System Filter - Replace	65
Fuel Filter with Water Separator	65
Fuel System Primary Filter/Water Separator - Drain	66
Fuel Tank Water and Sediment - Drain	66
Drain the Water and the Sediment	66
Fuel Storage Tanks	67
Fuel Tank	66
Fuel Transfer Pump (Lift Pump) - Inspect	67
Replacement of the Lift Pump	67
G	
General Hazard Information	5
Containing Fluid Spillage	6
Fluid Penetration	6
Pressure Air and Water	6
General Information	12
Governor Actuator - Check	68
H	
Hoses and Clamps - Inspect/Replace	68
Replace the Hoses and the Clamps	68
I	
Important Safety Information	2
L	
Lifting and Storage	19
M	
Maintenance Interval Schedule	42
Maintenance Section	30
Model View Illustrations	13
4016-61TRG	13
Model Views	13
Monitoring System	22
Mounting and Dismounting	9

O	
Operation Section	19
Overhaul (Major)	69
Major Overhaul Information	69
Scheduling a Major Overhaul	69
Overhaul (Top End)	69
Scheduling a Top End Overhaul	69
Top End Overhaul Information	70
P	
Plate Locations and Film Locations	17
Engine Identification	17
Serial Number Plate	18
Product Identification Information	17
Product Information Section	12
R	
Radiator - Clean	70
Refill Capacities	30
Cooling System	30
Fuel System	30
Lubrication System	30
S	
Safety Messages	5
(1) Universal Warning	5
(2) Hot Coolant	5
Safety Section	5
Sensors and Electrical Components	22
Boost Pressure Sensors	23
Coolant Temperature Sensor	23
Engine Oil Pressure Switch	24
High Turbine Inlet Temperature Shutdown Sensor	24
Overspeed Sensor	25
Sensor Locations	22
Speed Sensor	25
Severe Service Application - Check	71
Environmental Factors	71
Incorrect Maintenance Procedures	71
Incorrect Operating Procedures	71
Speed Sensor - Clean/Inspect (Engine Speed Sensor and Overspeed Sensor)	72
Engine Speed Sensor	72
Overspeed Sensor	72
Starting Motor - Inspect	73
Starting the Engine	26
Normal Engine Starting Procedure	26
Stopping the Engine	29
T	
Table of Contents	3

Turbocharger - Inspect 74

W

Walk-Around Inspection 74

Warranty Information 76

Warranty Section 76

Water Pump - Inspect..... 75

Welding on Engines with Electronic Controls 12

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: _____

