

Operation and Maintenance Manual

4016-61TRS1 and 4016-61TRS2 Gas Engines

G16 (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.

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Foreword

Literature Information

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

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

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

Safety

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

Operation

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

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

Maintenance

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

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

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

Maintenance Intervals

Perform maintenance on items at multiples of the original requirement. We recommend that the maintenance schedules be reproduced and displayed near the engine as a convenient reminder. We also recommend that a maintenance record be maintained as part of the engine's permanent record.

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

Overhaul

Major engine overhaul details are not covered in the Operation and Maintenance Manual except for the interval and the maintenance items in that interval. Major repairs should only be carried out by Perkins authorized personnel. Your Perkins dealer or your Perkins distributor offers a variety of options regarding overhaul programs. If you experience a major engine failure, there are also numerous after failure overhaul options available. Consult with your Perkins dealer or your Perkins distributor for information regarding these options.

California Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm. Battery posts, terminals and related accessories contain lead and lead compounds. **Wash hands after handling.**

Safety Section

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Safety Messages

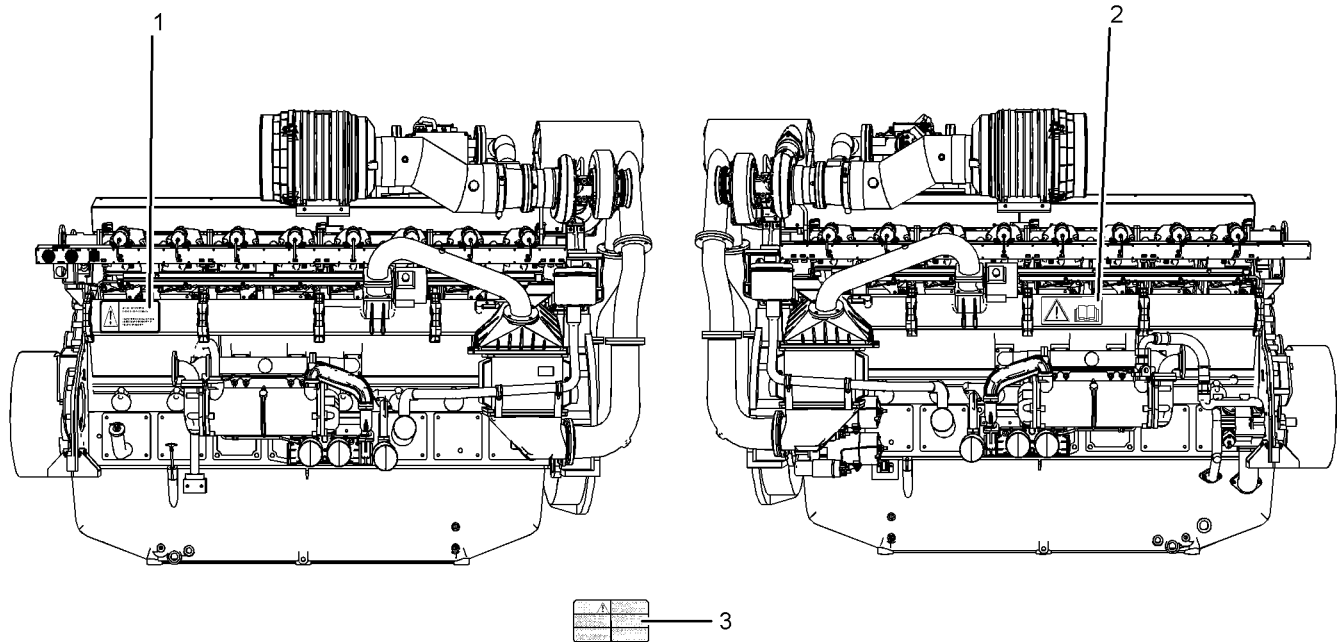


Illustration 1

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Typical example

(1) Engine Oil Level

(2) Universal warning

(3) Engine Derate

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.

The safety messages that may be attached on the engine are illustrated .

(1) Engine Oil Level

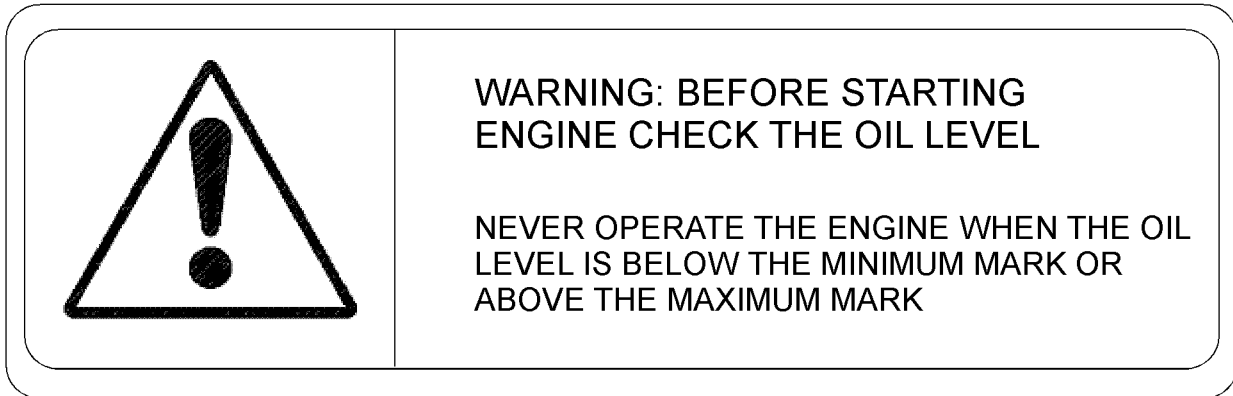


Illustration 2
Typical example

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The warning label for checking the engine oil Level (1) is located on the inlet manifold on the left side of the engine. Refer to illustration 1.

The Universal Warning label (2) is located on the inlet manifold on the right side of the engine. Refer to illustration 1.

(2) Universal Warning



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

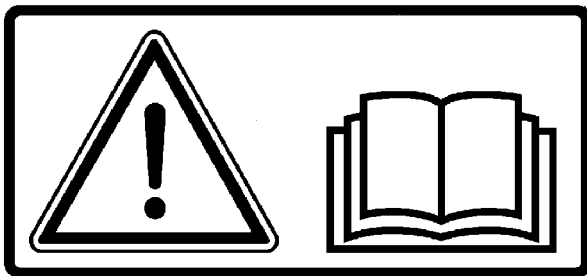


Illustration 3
Typical example

g01234595

(3) Engine Derate


<p>WARNING ATTENTION WARNUNG ADVERTENCIA ATTENZIONE</p> 	<p>THIS ENGINE HAS BEEN SET TO GIVE THE POWER UNDER I.S.O. 3046 STANDARD CONDITIONS WITHOUT DERATING—I.E. AMBIENT TEMPERATURE (AT AIR INLET)—25°C BAROMETER PRESSURE—100kPa HUMIDITY (NON TURBO CHARGED ENGINE)—30% FOR SITE CONDITIONS EXCEEDING THE ABOVE THE ENGINE MUST BE DERATED IN ACCORDANCE WITH THE RESPECTIVE ENGINE DERATING CHART AND PROCEDURE, AGAINST THE FULL RATED LOAD AND MAXIMUM SITE CONDITIONS.</p>
<p>CE MOTEUR EST REGLE POUR DONNER SA PUISSANCE SOUS LES CONDITIONS DE LA NORME I.S.O. 3046 SANS REDUCTION DU RENDEMENT NOMINAL SOIT: TEMPERATURE AMBIANTE (A L'ADMISSION D'AIR)—25°C PRESSION BAROMETRIQUE—100kPa HUMIDITE DE L'AIR (MOTEUR SANS TURBO)—30% SOUS CONDITIONS DE TRAVAIL EXCEDANT CELLES PRECITEES REDUIRE IMPERATIVEMENT LA PUISSANCE SUANT LE TABLEAU ET LA METHODE DE DETARAGE RESPECTIFS AU MOTEUR D'APRES LA CHARGE NOMINALE TOTALE ET LES CONDITIONS DE TRAVAIL MAXIMAS</p>	<p>DIESER MOTOR WURDE AUF LEISTUNGSABGABE UNTER DEN NORMAL BEDINGUNGEN VON I.S.O. 3046 OHNE LEISTUNGS-HERABSETZUNG EINGESTELLT D.H. UMGEBUNGSTEMPERATUR (AM LUFT-EINLASS)—25°C BAROMETERDRUCK—100kPa FEUCHTIGKEIT (SAUGMOTOR)—30% BEI DIE ORIGIN WERTE UBERSCHREITENDEN EINSATZBEDINGUNGEN UNTERLIEGT DER MOTOR EINER LEISTUNGSHERABSETZUNG NACH DEM BETREFFENDEN LEISTUNGSHERABSETZUNGS-DIAGRAMM UND - VERFAHREN GEGENUBER DER VOLLEN NENNBELASTUNG UND DEN MAXIMAL WERTEN DER EINSATZBEDINGUNGEN</p>
<p>ESTE MOTOR HA SIDO AJUSTADO PARA DAR LA POTENCIA PREVISTA DE ACUERDO CON LAS CONDICIONES ESTANDAR I.S.O. 3046 SIN CORRECCION DE REDUCCION A SABER: TEMPERATURA AMBIENTE EN LA ENTRADA DEL AIRE—25°C PRESION BAROMETRICA—100kPa HUMEDAD MOTOR SIN TURBOALIMENTACION—30% PARA UNAS CONDICIONES DEL EMPLAZAMIENTO QUE EXCEDAN DE LAS INDICADAS, EL MOTOR DEBE SER REAJUSTADO DE CLASIFICACION DE CONFORMIDAD CON LOS CORRESPONDIENTES GRAFICO Y PROCEDIMIENTO DE DESCLASIFICACION DEL MOTOR, CON RESPECTO A LA CARGA NOMINAL Y A LAS CONDICIONES MAXIMAS DEL EMPLAZAMIENTO</p>	<p>QUESTO MOTORE E ALLESTITO PER DARE UNA POTENZA CHE VIENE MISURATA SECONDO LE NORME I.S.O.3046, IN CONDIZIONI TIPICHE E SENZA DIMINUSIONI: TEMPERATURA DI AMBIENTE (AL MANICOTTO DI ASPIRAZIONE)—25°C PRESSIONE BAROMETRICA—100kPa UMIDITA' (NON PER MOTORI TURBOCOMPRESSII)—30% NEI CANTIERI DOVE LE CONDIZIONI CLIMATICHE ECCEDEONO I VALORI DATI SOPRA, SI DEVE RIDURRE LA POTENZA EROGATA SECONDO LA TAVOLA E LE RISPETTIVE NORME DI RIDUZIONE CONTRO LA CAPACITA MASSIMA DELLA MACCHINA E LE CONDIZIONI ESTREME DI LAVORO</p>

Illustration 4

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Typical example

The warning label for derating engine information (3) is located on the control box. Refer to OEM information for the location of the control box.

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General Hazard Information

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

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

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

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

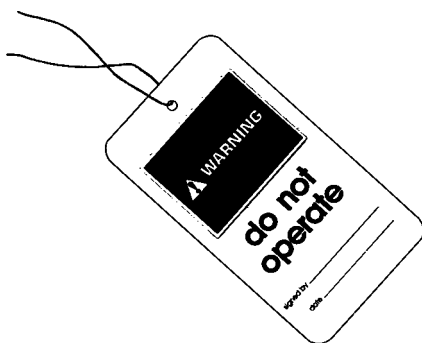


Illustration 5

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Attach a “Do Not Operate” warning tag or a similar warning tag to the start switch or to the controls before the engine is serviced or before the engine is repaired.

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

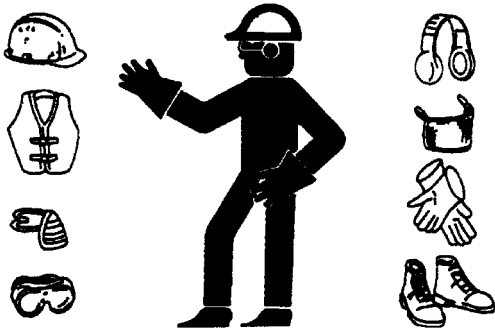


Illustration 6

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- Wear a hard hat, protective glasses, and other protective equipment, as required.
- When work is performed around an engine that is operating, wear protective devices for ears in order to help prevent damage to hearing.
- Do not wear loose clothing or jewelry that can snag on controls or on other parts of the engine.
- Ensure that all protective guards and all covers are secured in place on the engine.
- Never put maintenance fluids into glass containers. Glass containers can break.
- Use all cleaning solutions with care.
- Report all necessary repairs.

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

- The engine is stopped. Ensure that the engine cannot be started.
- Disconnect the batteries when maintenance is performed or when the electrical system is serviced. Disconnect the battery ground leads. Tape the leads in order to help prevent sparks.
- Do not attempt any repairs that are not understood. Use the proper tools. Replace any equipment that is damaged or repair the equipment.
- If work is carried out on the fuel system obey the local regulations for isolation of the gas supply.

California Proposition 65 Warning

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

Pressurized Air and Water

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

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

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

Fluid Penetration

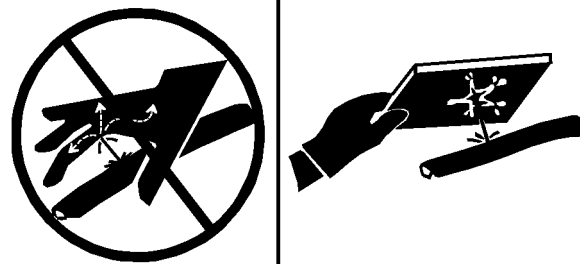


Illustration 7

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

Containing Fluid Spillage

Care must be taken in order to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the engine. Prepare to collect the fluid with suitable containers before opening any compartment or disassembling any component that contains fluids.

- Tools that are suitable for collecting fluids and equipment that is suitable for collecting fluids
- Tools that are suitable for containing fluids and equipment that is suitable for containing fluids

Obey all local regulations for the disposal of liquids.

Dispose of Waste Properly

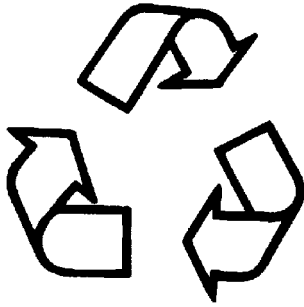


Illustration 8

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Improperly disposing of waste can threaten the environment. Potentially harmful fluids should be disposed of according to local regulations.

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

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Burn Prevention

Do not touch any part of an operating engine. Allow the engine to cool before any maintenance is performed on the engine. Relieve all pressure in the appropriate 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, the heat exchanger, the heater and lines 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 is an 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 or hot components to contact the skin.

If the application has a makeup tank, remove the cap for the makeup tank after the engine has stopped. The filler cap must be cool to the touch.

Batteries

The liquid in a battery is an electrolyte. Electrolyte is an acid that can cause personal injury. Do not allow electrolyte to contact the skin or the eyes.

Do not smoke while checking the battery electrolyte levels. Batteries give off flammable fumes which can explode.

Always wear protective glasses when you work with batteries. Wash hands after touching batteries. The use of gloves is recommended.

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Fire Prevention and Explosion Prevention



Illustration 9

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

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

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

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

If the application involves the presence of combustible gases, consult your Perkins dealer for additional information about suitable protection devices. All local regulations must be observed.

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

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

Do not expose the engine to any flame.

Exhaust shields (if equipped) protect hot exhaust components from oil or fuel spray in case of a line, a hose, 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 that contain flammable fluid. Clean any such lines thoroughly with a nonflammable solvent prior to welding or flame cutting.

Wiring must be kept in good condition. All electrical wires must be properly 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 properly maintained battery cables will help to prevent arcing or sparking.

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

Oil filters and fuel filters must be properly installed. The filter housings must be tightened to the proper torque.

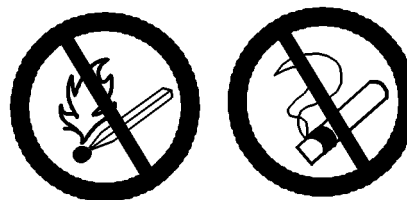


Illustration 10

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

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

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

Do not charge a frozen battery. 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 bent or damaged.

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

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

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

- End fittings are damaged or leaking.
- Outer coverings are chafed or cut.
- Wires are exposed.
- Outer coverings are ballooning.
- Flexible 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

The steps or handholds may not be installed on the engine. Refer to the OEM for information before any maintenance or repair is performed.

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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Ignition Systems

Ignition systems can cause electrical shocks. Avoid contacting the ignition system components and wiring.

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Before Starting 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.

Ensure that the engine is equipped with a lighting system that is suitable for the conditions. Ensure that all lights work properly.

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.

The initial start-up of a new engine or a engine that has been serviced make provision to shut the engine off, in order to stop an overspeed. This may be accomplished by shutting off the fuel supply to the engine, or shutting off the ignition system.

i03101447

Engine Starting

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.

If there is a possibility that unburned gas remains in the exhaust system, refer to the purge procedure in this Operation and Maintenance Manual, "Engine Starting" topic in the Operation Section.

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 properly, check the water temperature and the oil temperature during heater operation.

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

i00659907

Engine Stopping

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

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

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

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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. If the starting motor is not equipped with a negative "-" terminal, connect the cable to the engine block.

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

Grounding Practices

Note: All ground lines must return to the battery ground.

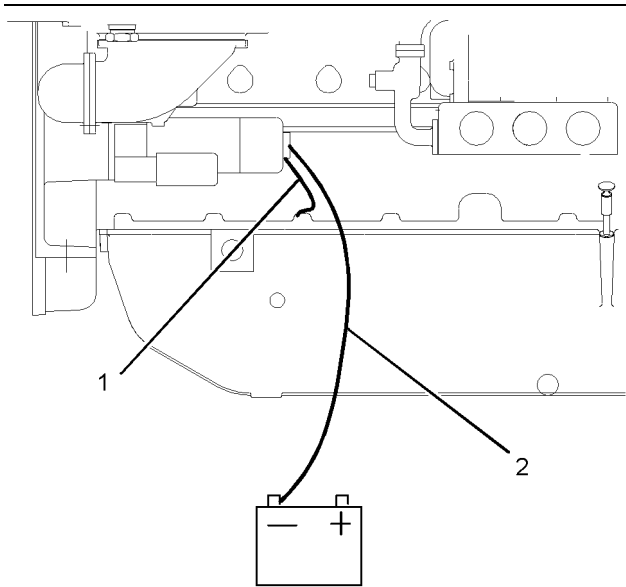


Illustration 11

g01217202

Typical example

- (1) Starting motor to ground
- (2) Battery negative to engine

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

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

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

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

Product Information Section

Model Views and Specifications

i02885828

Model View Illustrations

The illustrations show various typical features of 4016 Series TRS Engine. The illustrations do not show all of the options that are available.

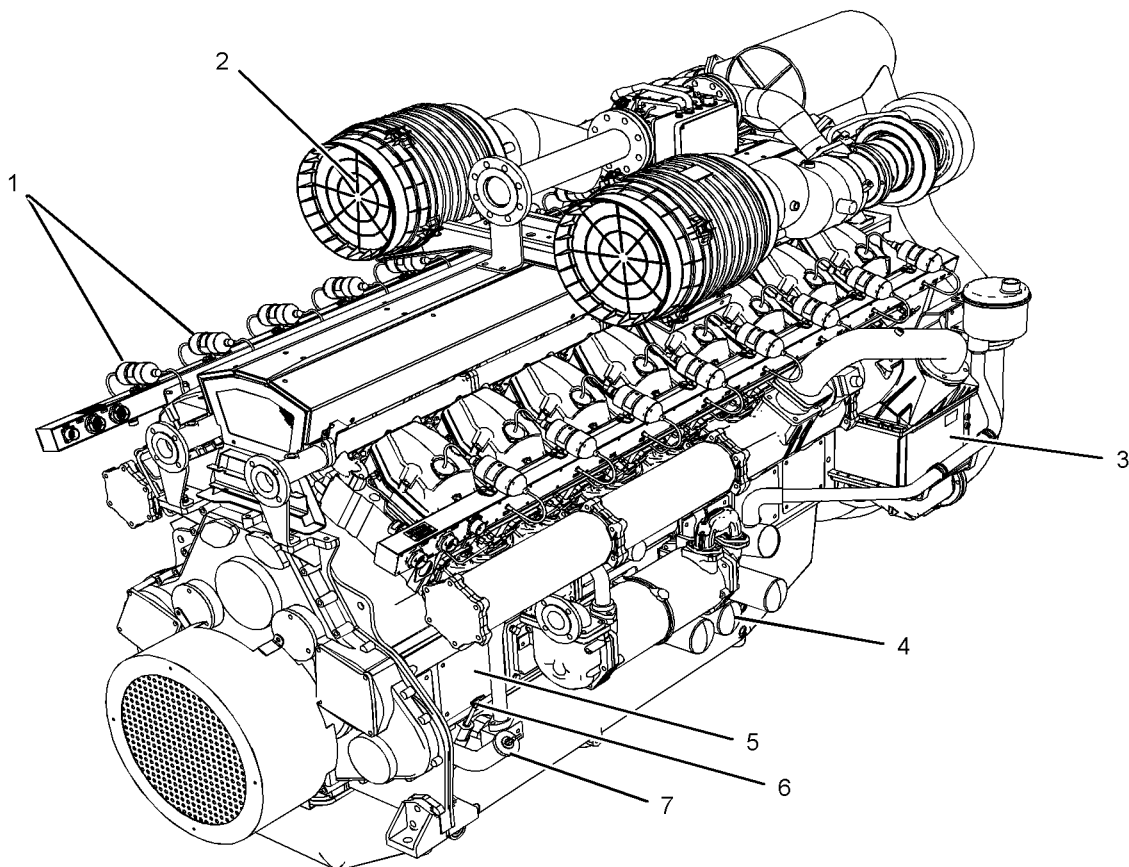


Illustration 12

g01525185

Typical example

- (1) Ignition coils
- (2) Air filter
- (3) Charge air cooler

- (4) Engine oil filters
- (5) The inspection cover for the Crankcase
- (6) Oil level gauge (dipstick)

- (7) Oil filler cap

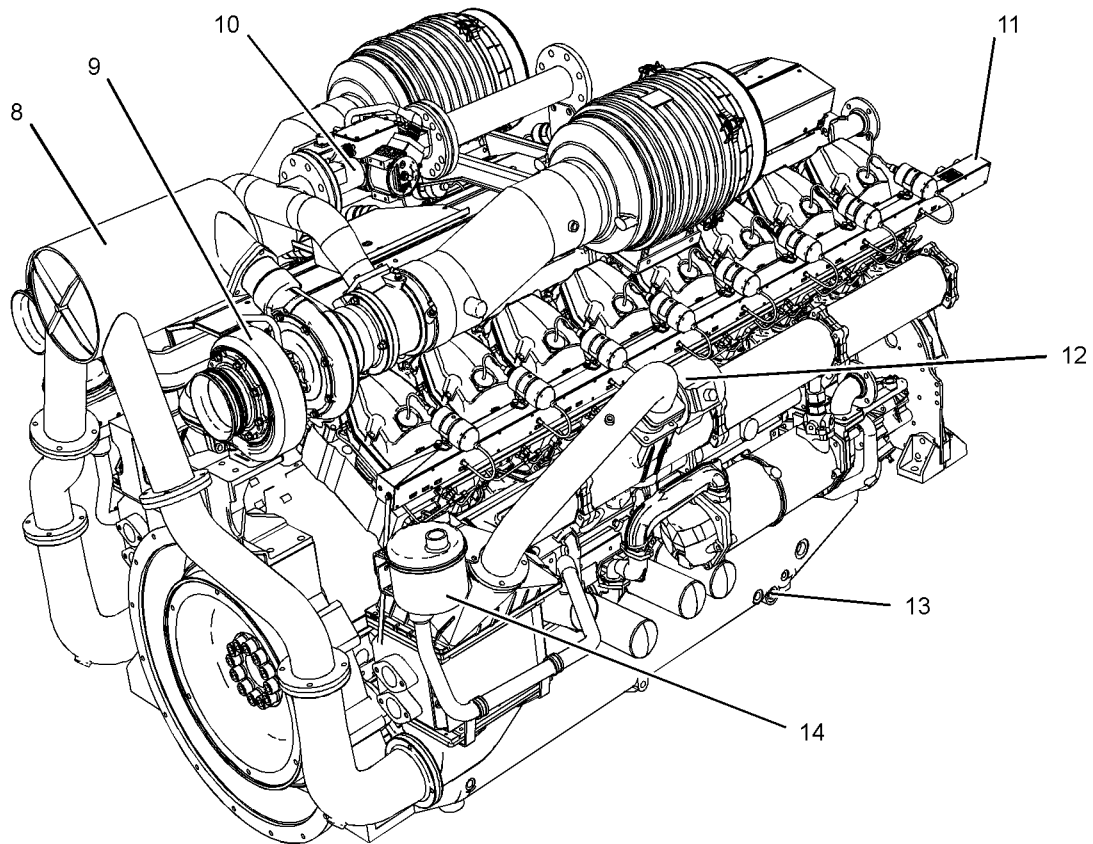


Illustration 13

g01525189

Typical example

(8) Tumbulator
(9) Turbocharger
(10) Gas control valve

(11) Rail for the engine wiring
(12) Throttle
(13) Oil drain plug

(14) Open breather system

i02885810

Product Description

The Perkins Engines were developed in order to provide gas engines for generator set applications. The engines have the ability to burn a wide variety of gaseous fuels.

Fuel System

The fuel is delivered to the gas control valve. The gas must be at a constant pressure and the gas pressure must be stable. The pressure must be within a range of 5 to 25 kPa (0.72 to 3.6 psi). Higher pressure will need to be reduced with an additional gas regulator.

The venturi is located in the gas mixer body immediately before the turbocharger. As air is accelerated through the venturi gas is mixed with the air. This mixture is compressed by the turbocharger. The mixture passes through the tumbulator, and the charge coolers, and into the inlet manifolds. The speed and the load is governed by electronically controlled throttle valves.

A digitally controlled gas valve maintains the air/fuel ratio. This system is adjustable. Refer to Systems Operation, Testing and Adjusting for details. This is the only means of adjusting the exhaust emissions.

Ignition System

The engine is equipped with an Electronic Ignition System (EIS). The EIS provides dependable firing and low maintenance. The EIS provides precise control of the following factors:

- Voltage
- Duration of the spark
- Ignition timing
- Level of energy of the ignition

All 4016TRS gas engines are equipped with a device to detect detonation which is connected directly into the ignition system. This device automatically retards the ignition timing.

The ignition timing is retarded when excessive detonation is sensed. If detonation continues after full retardation, then the engine must be shut down.

Lubrication System

The engine lubrication oil is supplied by a pump that is driven by a gear. The oil is cooled and the oil is filtered. A bypass valve provides unrestricted flow of lubrication oil to the engine parts if the oil filter elements become plugged. The bypass valve will open if the oil filter differential pressure reaches 34.4 to 48.2 kPa (5 to 7 psi). The engine oil pressure operates in a range of 415 to 450 kPa (60 to 65 psi).

Note: The engine lubrication oil is not filtered when the bypass valve is open. Do not allow the engine to operate when the bypass valve is open. This can damage the engine components.

Cooling System

The water enters the engine from the oil cooler and the water is passed through the cylinder block. The water exits the cylinder head into the rail. The water exits the engine from the water outlet.

Electrounit

This type of engine is supplied with the following components:

- Jacket water coolant pump
- Water temperature regulator (thermostat)
- Coolant pipe for the charge cooler
- A water pump for the charge cooler
- A water temperature regulator (thermostat) that controls the water inlet temperature for the charge cooler
- Battery charging alternator

The system is used when recovery of heat is not an important factor.

Cogeneration engine

Cogeneration uses energy from heat which would otherwise be wasted.

The following items are not supplied:

- Water pumps
- Water temperature regulator (thermostat)
- All water tube assemblies

This system is the responsibility of the OEM.

Engine Service Life

Engine efficiency and maximum utilization of engine performance depend on adherence to proper operation and maintenance recommendations. This includes the use of recommended lubricants, fuels, and coolants.

For the engine maintenance that is required, refer to the Operation and Maintenance Manual, "Maintenance Interval Schedule" in the Maintenance Section.

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Specifications

General Engine Specifications

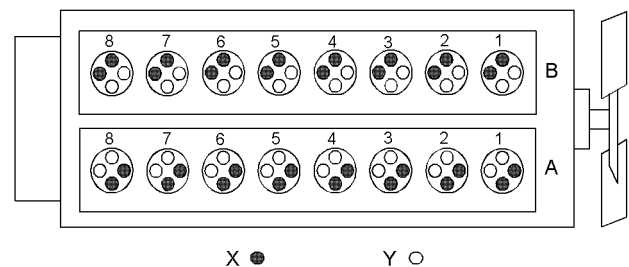


Illustration 14
Sixteen cylinder
(X) Inlet valves
(Y) Exhaust valves

g01210841

Table 1

4016 Engine Specifications	
Rated rpm	1500
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
Aspiration	Turbocharged
Rotation (flywheel end)	Counterclockwise
Inlet valve lash (cold)	0.40 mm (0.016 inch)
Exhaust valve lash (cold)	0.40 mm (0.016 inch)
Firing order	1A-1B-3A-3B-7A-7B- 5A-5B-8A-8B-6A-6B- 2A-2B-4A-4B

Product Identification Information

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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 DIH R**** U10001S.

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

Table 2

Application	
G	Genset
I	Gas

Table 3

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

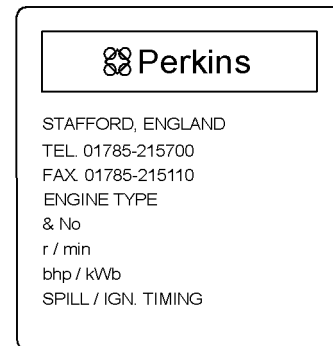


Illustration 15

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Serial number plate

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

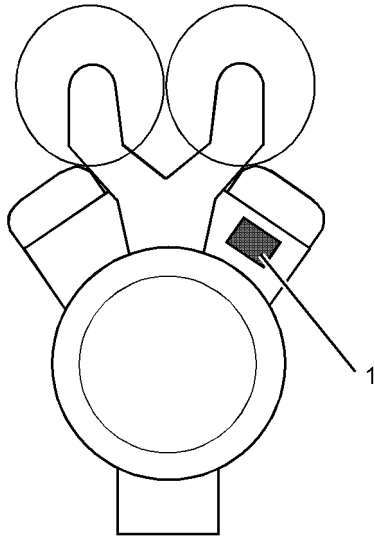


Illustration 16

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The location of the serial number plate for vee-form engines

The serial number plate (1) on a vee-form engine is located on the rear face of the cylinder block (bank A). See Illustration 16.

Operation Section

Lifting and Storage

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Product 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.

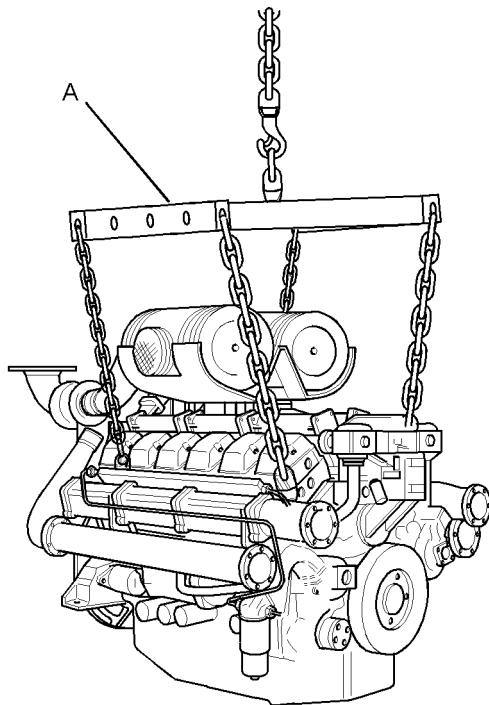


Illustration 17
Typical example

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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.

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

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Product Storage

Refer to Perkins Engine Company limited, Stafford 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 month for diesel engines and 12 month protection for gas engines. This is for engines that are transported by a container or a truck. Level "A" is for the transportation of items that are within the United kingdom and within Europe.

Level "B "

This level is additional to level "A". Level "B" will give protection under normal storage condition from -15° to $+55^{\circ}\text{C}$ (5° to 99°F) and "90%" relative humidity for two years. Level "B" is for the transportation of items overseas.

Level "C "

In order to protect the product to Level "C", contact Perkins Engines Company Limited Stafford.

Gauges and Indicators

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Gauges and Indicators

Gauges are supplied by the OEM. For more information about the gauge package, see the OEM information.

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

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

NOTICE

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



Engine Oil Pressure – The range for the engine oil pressure is 415 to 450 kPa (60 to 65 psi).



Jacket Water Coolant Temperature – Typical water temperature into the engine is 71°C (160°F). Higher temperatures may occur under certain conditions. The water temperature reading may vary according to load. The reading should never exceed 96°C (204°F).

1. A high water temperature switch is installed in the cooling system.
2. A low oil pressure switch is installed in the oil gallery of the engine.
3. A high pressure Backfire switch is installed to the inlet manifold of the engine.

Features and Controls

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Performance Parameters

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Air/Fuel Ratio

The correct air/fuel ratio is very important for the following considerations:

- Margin of detonation
- Control of emissions
- Engine performance
- Achieving optimum service life for the engine
- Compliance with legal requirements

If the air/fuel ratio is not appropriate for the fuel and the operating conditions, a failure of the engine may occur. The service life of the turbochargers, the valves, and other components may be reduced.

Fuel Supply Pressure and Temperature

The gas supply to the control valve for the air/fuel ratio must be between 5 to 25 kPa (0.72 to 3.6 psi). If a higher pressure is required a separate gas regulator must be installed into the fuel line.

The temperature of the gas into the air/fuel ratio control system must be between 5 to 40 °C (41 to 104°F).

Note: No zero pressure regulator is required with the air/fuel ratio control system for the 4016-61TRS engine.

Air, Charge Cooler Water Temperature and Altitude

Refer to technical data sheet for the charts for the derate in order to determine the maximum temperatures into the engine and the altitude derate.

Sensors and Electrical Components

Electronic Ignition System (EIS)

The Electronic Ignition System includes the following components:

- The control module for the ignition
- Timing sensor
- Ignition coil on each cylinder
- Spark plugs
- Ignition harness

WARNING

The ignition system generates high voltage. Do not come in contact with the ignition system with the engine in operation. This voltage can cause personal injury or death.

The EIS control module is a sealed unit with no serviceable parts. The timing sensor uses the magnets that are mounted on the camshaft in order to generate the timing pulses. One pulse for each cylinder plus an index magnet in order to indicate the start of each cycle. The EIS control module has a output to each ignition coil. To initiate combustion in each cylinder, the EIS sends a pulse to the primary winding of the ignition coil. The coil increases the voltage on the secondary winding which creates a spark across the spark plug electrode.

The electronic ignition system provides control for the following activities:

- Ignition timing
- Ignition energy
- Protection from detonation

Switches

The engine is installed with the following switches.

- High cooling water temperature switch
- Low oil pressure switch
- High pressure switch for the manifold

Governor

The engine is installed with a digital governor that includes the following components:

- Digital governor
- Actuators and throttle valves
- Magnetic pickup
- Wiring harness

The governor uses the magnetic pickup to sense engine speed from the flywheel gear teeth. This signal is fed into the governor, which drives an actuator. This is connected to the throttle valves in order to control the amount of combustion gas/air.

A DC Desk service tool with the appropriate software key and cable are required in order to perform any adjustments to the system.

Detonation System

The equipment for the detonation system senses detonation or knock which may be caused by poor gas or may be caused by high combustion temperatures.

The detonation system includes the following components:

- Detonation sensor on each cylinder
- Control module for detonation
- Wiring harness

The detonation system operates by measuring vibrations on the crankcase. The signal is processed in order to eliminate normal engine vibrations. If detonation above a predetermined level is detected the ignition timing is retarded. If detonation ceases, the ignition timing that is retarded will be gradually brought back to a normal value. If the engine continues detonation the detonation system will operate in order to stop the engine.

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Alarms and Shutoffs

The OEM will supply this system. Refer to the OEM for more information.

Engines may be equipped with optional engine protective devices that are not included in this section. This section contains some general information about the function of typical engine protective devices.

Alarms and shutoffs are electronically controlled. The operation of all alarms and shutoffs utilize components which are actuated by a sensing unit. The alarms and shutoffs are set at critical operating temperatures, pressures, or speeds in order to protect the engine from damage.

The alarms function in order to warn the operator when an abnormal operating condition occurs. The shutoffs function in order to shut down the engine when a more critical abnormal operating condition occurs. The shutoffs help to prevent damage to the engine.

Shutoffs may cause unburned gas to remain in the air inlet and in the exhaust manifold.

WARNING

Unburned gas in the air inlet and exhaust system may ignite when the engine is started. Personal injury and/or property damage may result.

Before starting an engine that may contain unburned gas, purge the unburned gas from the air inlet and exhaust system. Refer to the topic on purging unburned gas in the “Starting the Engine” section.

If an engine protective device shuts off the engine, always determine the cause of the shutoff. Make the necessary repairs before attempting to start the engine.

Become familiar with the following information:

- Types of the alarm and shutoff controls
- Locations of the alarm and shutoff controls
- Conditions which cause each control to function
- Resetting procedure that is required before starting the engine

Testing Alarms and Shutoffs

Alarms must function properly in order to 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.

NOTICE

During testing, abnormal operating conditions must be simulated.

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

Periodic testing of engine protective devices for proper operation is recommended maintenance. **To prevent damage to the engine, only authorized service personnel should perform the tests.**

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Control Panel

All 4016TRS engines are supplied with a remote mounted control panel. This unit contains the following components and integrated wiring.

- Ignition system
- Detonation system
- The system for governing engine speed

The control panel is connected to the engine via 4 harness assemblies.

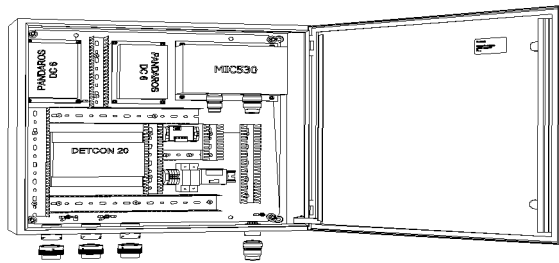


Illustration 18

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Engine Starting

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Before Starting Engine

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

- For the maximum service life of the engine, make a thorough inspection within the engine compartment before the engine is started. Look for the following items: oil leaks, coolant leaks, loose bolts, and excessive dirt and/or grease. Remove any excess dirt and/or grease buildup. Repair any faults that were identified during the inspection.
- Inspect the cooling system hoses for cracks and for loose clamps.
- Inspect the alternator and accessory drive belts for cracks, breaks, and other damage.
- Inspect the wiring for loose connections and for worn wires or frayed wires.
- Open the fuel supply valve (if equipped).
- Do not start the engine or move any of the controls if there is a "DO NOT OPERATE" warning tag or similar warning tag attached to the start switch or to the controls.
- Ensure that the areas around the rotating parts are clear.
- All of the guards must be put in place. Check for damaged guards or for missing guards. Repair any damaged guards. Replace damaged guards and/or missing guards.
- Check electrical cables and check the battery for poor connections and for corrosion.
- Reset all of the shutoffs or alarm components (if equipped).
- Check the engine lubrication oil level. Maintain the oil level between the "Min" mark and the "Max" mark on the engine oil level gauge.
- Check the coolant level. Observe the coolant level in the header tank (if equipped). Maintain the coolant level to the "FULL" mark on the header tank.

- Observe the air cleaner service indicator. Service the air cleaner when the diaphragm enters the red zone, or when the red piston locks in the visible position.
- Remove any electrical loads.

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Cold Weather Starting

A jacket water heater is required for starting when the temperature is below 10 °C (50 °F). The temperature of the jacket water should be maintained at 40 °C (104 °F).

Note: A oil pan immersion heater must not be installed.

The 4016-61TRS engine is equipped with Multitorch spark plugs. Under certain circumstances, it is possible for condensation to develop within the nozzle for the spark plug. This may cause difficulty in engine starting. If this occurs, conduct the following procedure:

1. Remove the spark plugs from four of the engines cylinders, refer to Disassembly and Assembly, "Spark Plugs - Remove and Install"
2. Use a suitable tool in order to heat the tip of the spark plug.
3. Replace the spark plugs, refer to Disassembly and Assembly, "Spark Plugs - Remove and Install"
4. Start the engine.

Extra battery capacity may be necessary in order to start the engine.

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Starting the Engine

WARNING

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

NOTICE

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

WARNING

Unburned gas in the air inlet and exhaust system may ignite when the engine is started. Personal injury and/or property damage may result.

Before starting an engine that may contain unburned gas, purge the unburned gas from the air inlet and exhaust system. Refer to the topic on purging unburned gas in the “Starting the Engine” section.

The OEM will supply this system. Refer to the OEM for more information.

Note: The OEM must ensure that using the “EMERGENCY STOP” button will shut off both the fuel and the ignition.

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

Ensure that no one will be endangered before the engine is started and when the engine is started.

Perform the procedures that are described in this Operation and Maintenance Manual, “Before Starting Engine” (Operation Section).

Final Checks and First Engine Start

Note: The fuel system must comply with all local regulations.

The OEM will supply this system. Refer to the OEM for more information.

1. The starting and the stopping of the engine must be on no load.
2. The procedure for starting and stopping a radiator cooled and CHP gas engine will be determined by the OEM relative to each individual engine installation.
3. Operate the engine at rated speed for ten minutes.
4. Inspect the engine for leaks in the oil system and the coolant systems.

5. Stop the engine and check the engine oil and the engine coolant level.
6. Operate the engine under normal working conditions. Check the gauges in order to see the condition of the engine.
7. If the engine fails to start after two attempts turn off the gas supply and investigate the cause.

Purging Unburned Gas

The following events cause unburned gas to remain in the air inlet and in the exhaust manifold:

- Emergency stop
- Engine overspeed
- Unsuccessful successive attempts to start the engine

Unburned gas may remain in the air inlet and exhaust system after several unsuccessful attempts to start the engine. The unburned gas may increase to a concentration that may ignite during a successive attempt to start the engine.

Perform the following procedure in order to purge the unburned gas:

1. Turn the manual gas shutoff valve to the CLOSED position.
2. Disable the ignition system.
3. Turn the engine control switch to the START position. Crank the engine for a minimum of six seconds.
4. Enable the ignition system.
5. Turn the manual gas shutoff valve to the OPEN position.
6. Start the engine. Refer to the engine starting procedure and refer to OEM in order to start the engine.

Engine Starting Procedure

Note: If the engine fails to start after the maximum cranking time, the engine will be shut down. Before attempting to restart the engine, investigate the cause. Follow the procedure for purging unburned gas once the cause has been detected.

Note: The starting procedure may differ because of the OEM system that is installed.

1. The signal is received.

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2. Check that the gas pressure is in limits. If the gas pressure is incorrect a warning is activated and the electrical system will shut down. If the gas pressure is in limits, go to the next step.
3. Activate the governor.
4. Activate the starting motor.
5. Operate the starting motor for three seconds in order to purge the system.
6. Activate the gas valve and activate the ignition. Continue to operate the starting motor.
7. After the engine is started disengage the starting motor.

Note: If the engine fails to start after the maximum cranking time, the engine will be shut down.

8. The engine is now operating.

Operation of the Generator Set Control Panel

For information on operation for a specific generator set control panel, refer to the Operation and Maintenance Manual for the generator and the control panel.

Automatic Starting

WARNING

When the engine is in the AUTOMATIC mode, the engine can start at any moment. To avoid personal injury, always remain clear of the the engine when the engine is in the AUTOMATIC mode.

Manual starting

Refer to the OEM manual for information on the controls in order to manually start the engine.

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Starting with Jump Start Cables

Do not use jump start cables in order to start the engine. Charge the batteries or replace the batteries. Refer to Operation and Maintenance Manual, "Battery - Replace".

After Starting Engine

For new installations and engines that are recently rebuilt, check and adjust the air/fuel ratio, refer to Systems Operation Testing and Adjusting, "Air/Fuel Ratio Control - Adjust". Monitor the engine in order to detect any unusual engine performance through the load range of the engine.

Check for leaks in the air and in the fluid systems.

Engine Operation

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Engine Operation

Proper operation and maintenance are key factors in attaining the maximum service life and economy for the engine. Follow the instructions in this Operation and Maintenance Manual and Systems Operation, Testing and Adjusting in order to minimize operating costs and maximize the service life of the engine.

Observe the gauges and the instrument panel frequently during engine operation and record the data in a log regularly. Compare the data to the specifications for normal engine operation. Comparing the data over time will help to detect changes in engine performance.

Investigate any significant change in the readings. Monitor the engine operation and take action when discrepancies are found.

Partial load and Low Load Operation

Extended operation below 50% of the base power load will cause the following results:

- Carbon formation in the cylinder
- Detonation
- Power loss
- Poor performance
- Accelerated wear of components
- Increased oil consumption
- Glazing of the cylinder bore

Engine Stopping

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Emergency Stopping

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The OEM will supply the system.

In the event of an emergency or in the event of an engine overspeed, switch off the ignition, the gas valve and the governor.

NOTICE

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

Pressing the Emergency Stop Button may cause unburned gas to remain in the air inlet and in the exhaust manifold.

 **WARNING**

Unburned gas in the air inlet and exhaust system may ignite when the engine is started. Personal injury and/or property damage may result.

Before starting an engine that may contain unburned gas, purge the unburned gas from the air inlet and exhaust system. Refer to the topic on purging unburned gas in the “Starting the Engine” section.

Typical Procedure in Order to Stop the Engine

Note: The stopping procedure will differ because of the different types of OEM controls that can be installed.

1. In order to stop the engine, switch off the gas valve.
2. With the engine stopped, switch off the ignition and switch off the governor.

If another engine fault occurs switch off the gas valve.

Manual Stop Procedure

In order to manually stop the engine, refer to the OEM for information. The procedure will depend on the system that has been installed.

NOTICE

Stopping the engine immediately after the engine has been operating under a load can result in overheating and accelerated wear of the engine components.

Allow the engine to gradually cool before stopping the engine.

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After Stopping Engine

- Check the engine oil level. Maintain the oil level between the “MIN” and “MAX” marks on the oil level gauge.
- If necessary, perform minor adjustments. Repair any leaks and tighten loose bolts.
- Note the service hour reading. Perform the maintenance that is scheduled in this Operation and Maintenance Manual, “Maintenance Interval Schedule” (Maintenance Section).

NOTICE

Only use antifreeze/coolant mixtures recommended in the Refill Capacities and Recommendations section of this manual. Failure to do so can cause engine damage.

- Allow the engine to cool. Check the coolant level.
- If freezing temperatures are expected, check the coolant for protection against freezing. The cooling system must be protected against freezing to the lowest expected outside temperature. Add the proper coolant/water mixture, if necessary.
- Perform all required periodic maintenance on all driven equipment. Refer to the instructions that are provided by the OEM of the driven equipment.

Maintenance Section

Refill Capacities

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Fluid Recommendations

General Lubricant Information

Engine Oil

The engine oil recommendation for an application can change due to advances in the specification of the oil. For a list of recommended lubricating oils, refer to the latest issue of Perkins service bulletin 48.

Oil analysis

The oil analysis will complement the preventive maintenance program.

The oil analysis is a diagnostic tool that is used to determine oil performance and component wear rates. Contamination can be identified and measured 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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Fluid Recommendations (Coolant 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.

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 5.

Table 5

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

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

- Local water utility company
- Agricultural agent
- Independent laboratory

Additives

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

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

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

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

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

- Plugging of radiators, coolers, and small passages

Glycol

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

- Boiling
- Freezing
- Cavitation of the water pump

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

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

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

Most conventional antifreezes use ethylene glycol. Propylene glycol may also be used. In a 1:1 mixture with water, ethylene and propylene glycol provide similar protection against freezing and boiling. See Tables 6 and 7.

Table 6

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

NOTICE

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

Table 7

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

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

Coolant Recommendations

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

- ASTM D4985 _____ ASTM specification for coolant specification

The following two coolants are used in Perkins diesel engines:

Preferred – Perkins ELC

Acceptable – A commercial heavy-duty antifreeze 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 antifreeze. This ratio may be increased to 1:2 water to glycol if extra freezing protection is required.

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

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

Table 8

Coolant Service Life	
Coolant Type	Service Life
Perkins ELC	6,000 Service Hours or Three Years
Commercial Heavy-Duty Antifreeze 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

ELC

Perkins provides ELC for use in the following applications:

- Heavy-duty spark ignited gas engines

- Heavy-duty diesel engines
- Automotive applications

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

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

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

ELC Cooling System Maintenance

Correct additions to the Extended Life Coolant

NOTICE

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

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

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

NOTICE

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

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 the cooling system is refilled, operate the engine until the coolant level reaches the normal operating temperature and until the coolant level stabilizes. As needed, add the coolant mixture in order to fill the system to the specified level.

Changing to Perkins ELC

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant into a suitable container.
2. Dispose of the coolant according to local regulations.
3. Flush the system with clean water in order to remove any debris.
4. Use Perkins cleaner to clean the system. Follow the instruction on the label.
5. Drain the cleaner into a suitable container. Flush the cooling system with clean water.
6. Fill the cooling system with clean water and operate the engine until the engine is warmed to 49° to 66°C (120° to 150°F).

NOTICE

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

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

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

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

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

ELC Cooling System Contamination

NOTICE

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

ELC cooling systems can withstand contamination to a maximum of ten percent of conventional heavy-duty antifreeze 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 Antifreeze and SCA

NOTICE

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

NOTICE

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

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

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

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

Refer to Table 9 for part numbers and for quantities of SCA.

Table 9

Perkins Liquid SCA	
Part Number	Quantity
21825735	10

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

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

Use the equation that is in Table 10 to determine the amount of Perkins SCA that is required when the cooling system is initially filled.

Table 10

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 11 is an example for using the equation that is in Table 10.

Table 11

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 antifreeze of all types REQUIRE periodic additions of an SCA.

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

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

Use the equation that is in Table 12 to determine the amount of Perkins SCA that is required, if necessary:

Table 12

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 13 is an example for using the equation that is in Table 12.

Table 13

Example Of The Equation For Adding The SCA To The Heavy-Duty Coolant For Maintenance		
Total Volume of the Cooling System (V)	Multiplication Factor	Amount of SCA that is Required (X)
15 L (4 US gal)	$\times 0.014$	0.2 L (7 oz)

Cleaning the System of Heavy-Duty Antifreeze

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

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

i02885763

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 this Manual, "Maintenance Section" for more information on fluid recommendations.

4016-61TRS

Table 14

4016-61 TRS Refill Capacities		
Compartment or System	Liters	Quarts
Crankcase Oil Sump	257	271
Total Lubrication System	286	302

Cooling System

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

4016-61TRS

Table 15

4016-61 TRS Refill Capacities		
Compartment or System	Liters	Quarts
Engine block only	95	100

i02896508

Maintenance Interval Schedule

Note: These intervals apply for engines that are powered by natural gas only. For other gases, consult Perkins Applications Engineering (Stafford) for more information.

When Required

Battery - Replace	38
Cooling System Coolant - Change	40
Engine Crankcase Breather - Clean/Replace	46
Engine Oil Filter (Auxiliary) - Change	48
Engine Oil Filter - Change	49
Fuel Filtration System - Service	56
Overhaul (In-Frame)	59
Overhaul (Major)	59
Overhaul (Top End)	60
Overhaul Considerations	61
Radiator - Clean	62
Water Temperature Regulator - Replace	63

Daily

Control Panel - Inspect	40
Cooling System Coolant Level - Check	42
Driven Equipment - Inspect/Replace/Lubricate ...	44
Engine Air Cleaner Service Indicator - Inspect	45
Engine Oil Level - Check	50
Engine Protective Devices - Check	51
Exhaust Piping - Inspect	55
Fuel System Fuel Filter Differential Pressure - Check	56
Hoses and Clamps - Inspect/Replace	56
Walk-Around Inspection	62

Every Week

Jacket Water Heater - Check	58
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Initial 100 Service Hours

Alternator Pulley - Check	37
Fan Drive Pulley - Check	55

Every 250 Service Hours

Engine Oil Sample - Obtain	50
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Initial 500 Service Hours

Engine Oil - Change	48
Engine Oil Filter (Auxiliary) - Change	48
Engine Oil Filter - Change	49
Engine Valve Lash and Bridge - Adjust	52
Ignition System Spark Plugs - Inspect/Replace	

Every 500 Service Hours or 1 Year

Battery Electrolyte Level - Check	39
Belts - Inspect/Adjust/Replace	39
Belts - Inspect/Adjust/Replace	39

Every 1000 Service Hours

Engine - Clean	44
Engine Valve Lash and Bridge - Adjust	52

Every 1000 Service Hours or 1 Year

Crankshaft Vibration Damper - Inspect	43
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Every 2000 Service Hours

Alternator - Inspect	37
Engine Air Cleaner Element - Replace	45
Engine Crankcase Breather - Clean/Replace	47
Engine Oil - Change	48
Engine Oil Filter (Auxiliary) - Change	48
Engine Oil Filter - Change	49
Ignition System Spark Plugs - Inspect/Replace	

Every Year

Carburetor Air/Fuel Ratio - Check/Adjust	40
Engine Speed/Timing Sensor - Clean/Inspect	51

Every 4000 Service Hours

Cylinders - Inspect	44
Driven Equipment - Check	44
Ignition System Timing - Check/Adjust	58
Inlet Air System - Inspect	58

Every 7500 Service Hours

Water Pump - Inspect	63
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Every 8000 Service Hours

Aftercooler Core - Inspect/Clean	37
Cooling System Coolant - Test/Add	42

Every 8000 Service Hours or 1 Year

Engine Mounts - Check	47
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Every 16 000 Service Hours or 6 Years

Turbocharger - Inspect	62
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i03178662

Alternator - Inspect

This section refers to the alternator for charging the battery. For information about the generator alternator, refer to the OEM for the appropriate information.

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.

i03109422

Aftercooler Core - Inspect/Clean (Air Charge Cooler)

1. Remove the core. Refer to the Disassembly and Assembly Manual, "Aftercooler Core - Remove" for the procedure.
2. Turn the aftercooler core on one side in order to remove debris. Remove the debris that is accessible.
3. Remove the drain plug.
4. Steam clean the core in order to remove any residue. Flush the fins of the aftercooler core. Remove any other trapped debris from the inside and from the outside of the core.

Note: Do not use high pressure when the fins are cleaned. High pressure can damage the fins.

5. Wash the core with hot, soapy water.

6. Flush the core thoroughly in order to remove residue and remaining debris. Flush the core with clean, fresh water until the water that is exiting the core is clear and free of debris.

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.

7. Dry the core with compressed air. Direct the air in the reverse direction of the normal flow.
8. Prior to installation, inspect any O-rings or seals for damage. If necessary, replace the O-rings or seals.
9. Inspect the core for trapped debris and cleanliness. If it is necessary, remove the debris and repeat the cleaning procedure.
10. Inspect the core for damage and perform a pressure test in order to detect leaks.
11. Install the core. Refer to Disassembly and Assembly Manual, "Aftercooler Core - Install" for the procedure.

For more information on cleaning the core, consult your Perkins dealer.

i02888334

Alternator Pulley - Check

1. Isolate the electrical supply to the engine.

i02429553

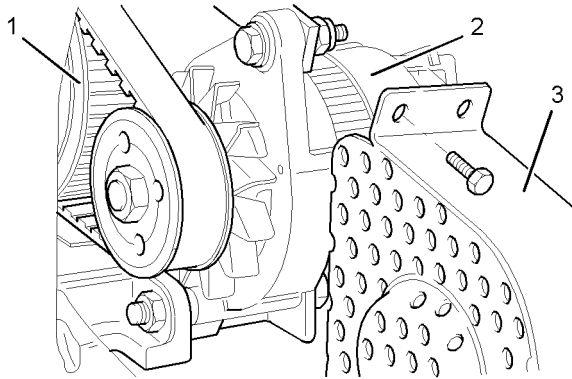


Illustration 19

g01237956

Typical example

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

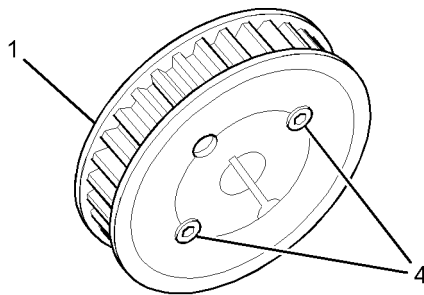


Illustration 20

g01233693

Typical example

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

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.

1. Refer to the OEM for instruction for switching the engine to the OFF position.
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. Ensure that the NEGATIVE “-” battery terminal is disconnected first.
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. Ensure that all the battery connections are clean and free from corrosion.
7. Install the new battery.

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

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

i02747977

i03104621

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.

i03104600

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

The OEM supplies this system. Refer to the OEM for the appropriate information.

Belts - Inspect/Adjust/Replace (Alternator Belt)

Inspection

1. Isolate the electrical supply to the engine.

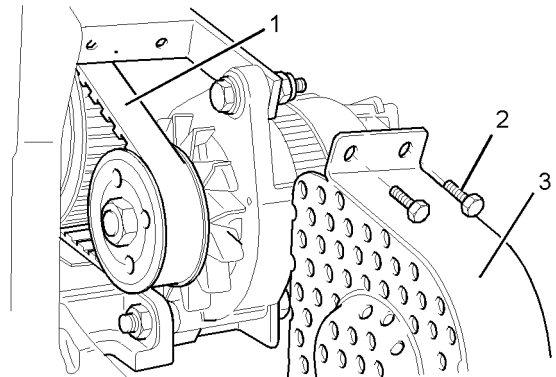


Illustration 21

g01233715

Typical example

2. Remove the bolts (2) and remove the guard (3).
3. Inspect the belt (1) for cracks. Inspect the belt for contamination. If necessary, replace the belt. Refer to "Replacement" for more information.

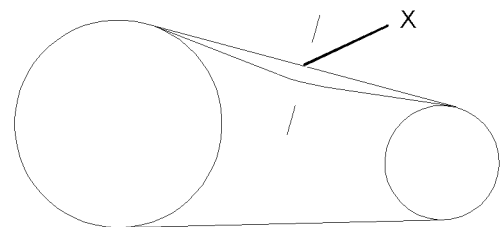


Illustration 22

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 bolts (2).

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.

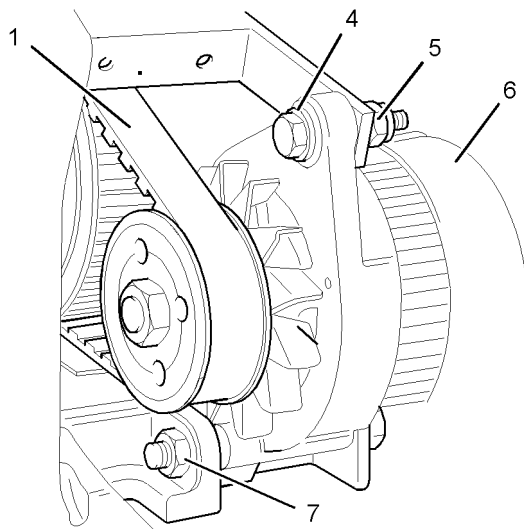


Illustration 23

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.

i02894971

Carburetor Air/Fuel Ratio - Check/Adjust

An engine failure may occur if the air/fuel ratio is not appropriate for the fuel and for the operating conditions. The service life of the turbocharger, of the valves, and of the other components may be reduced.

Refer to the Systems Operation, Testing and Adjusting for the correct procedure.

i02450196

Control Panel - Inspect

Inspect the condition of the panel. If a component is damaged, ensure that the component is repaired or that the component is replaced. If equipped, ensure that the electronic displays are operating properly. Inspect the wiring for good condition. Ensure that the wiring connections are secure.

Refer to the OEM for more information.

i02888193

Cooling System Coolant - Change

Refer to the OEM for information on cogeneration engines.

Jacket Water System Drain

1. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap.
2. Open the drain cock or remove the drain plug on the radiator or the heat exchanger.

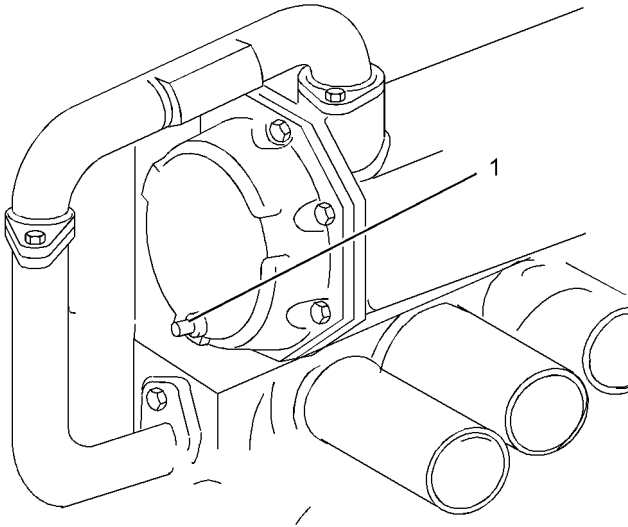


Illustration 24

g01515804

Typical example

3. Open the drain cock (1) on the engine oil cooler.
4. Allow the system to drain.

Jacket Water System Fill

Refer to the OEM for information on cogeneration engines.

Note: The cooling system must be filled slowly. Refer to Perkins Engines Stafford for more information.

1. Close the drain cock or install the drain plug on the radiator or the heat exchanger. Close the drain cock on the engine oil cooler (1).
2. Slowly refill the cooling system. Check that the coolant level is within 25 mm (1.0 inch) of the bottom of the filler pipe.
3. Install the cooling system filler cap.
4. Start the engine. Operate the engine until the engine is at the correct operating temperature. Inspect the cooling system for leaks.
5. Stop the engine and allow the engine to cool. Loosen the cooling system filler cap slowly in order to relieve any pressure. Remove the cooling system filler cap. Check that the level of coolant is correct. If necessary, add more coolant. Refer to this manual, "Cooling System Coolant Level Check".
6. In order to check the specific gravity of the coolant, refer to this manual, "Coolant System Coolant - Test/Add".

Charge Water System Drain

1. Stop the engine and allow the engine to cool. Open the charge water drain cock (OEM installation).
2. Remove the drain plugs (2 & 3) on each of the charge coolers and remove the cooling system filler cap.

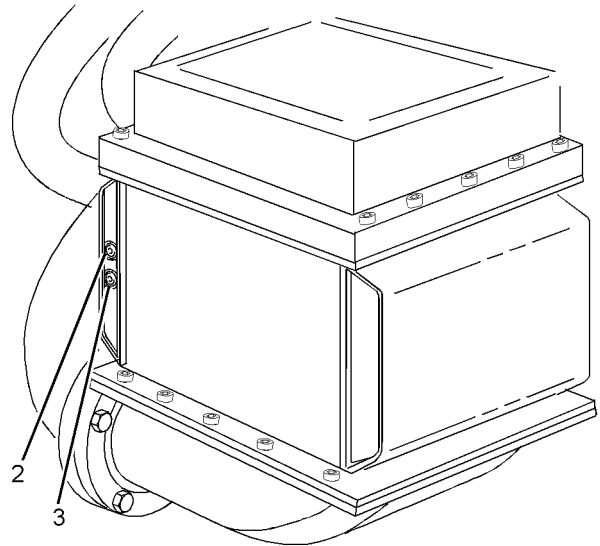


Illustration 25

g01515913

Typical example

3. Allow the system to drain.

Charge Water System Fill

Note: The cooling system must be filled slowly. Refer to Perkins engines Stafford for more information.

1. Close the drain cock on the charge water circuit (OEM installation). Install the drain plugs (2 & 3) into each charge cooler.
2. Loosen the vent plug (2) in order to release any air from the system. When the coolant runs free of air, tighten the vent plug.
3. Install the charge water system filler cap.
4. Follow steps 4 to 6 on jacket water system in order to complete charge water refill.

i02894972

Cooling System Coolant - Test/Add

Check the specific gravity of the coolant

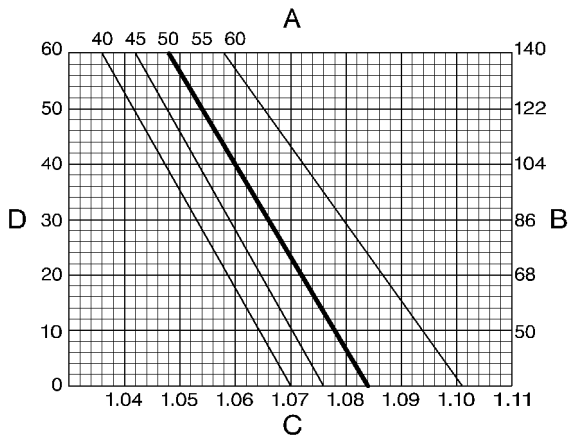


Illustration 26

g00997964

The chart for the Specific gravity

A = Percentage of antifreeze by volume

B = The temperature of the mixture in °F

C = Specific gravity

D = The temperature of the solution in °C

The following procedure must be used to measure coolant that contains antifreeze:

1. Operate the engine until the coolant temperature opens the thermostat. Continue to run the engine until the coolant has circulated around the cooling system.
2. Stop the engine.
3. Allow the engine to cool until the temperature is below 60 °C (140 °F).

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.

4. Remove the filler cap of the cooling system.
5. Drain some of the coolant from the cooling system into a suitable container.
6. Use a special hydrometer that will check the temperature and the specific gravity of the coolant, and follow the manufacturer's instructions.

Note: If a special thermo-hydrometer for coolant is not available, put an hydrometer and a separate thermometer into the antifreeze mixture and check the readings on both instruments. Compare the readings with the data in illustration 26.

Note: If necessary, fill the system or replenish the coolant in the system with premixed coolant of the correct strength. Refer to the Operation and Maintenance Manual, "Fluid recommendations". Perkins POWERPART antifreeze with a concentration of 50% will give protection against frost to a temperature of -35 °C (-31 °F). The solution will also protect against corrosion. This is especially important when there are aluminum components in the cooling circuit.

7. Adjust the strength of the mixture if it is necessary.

i02888192

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.

Refer to the OEM for information on cogeneration engines.

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

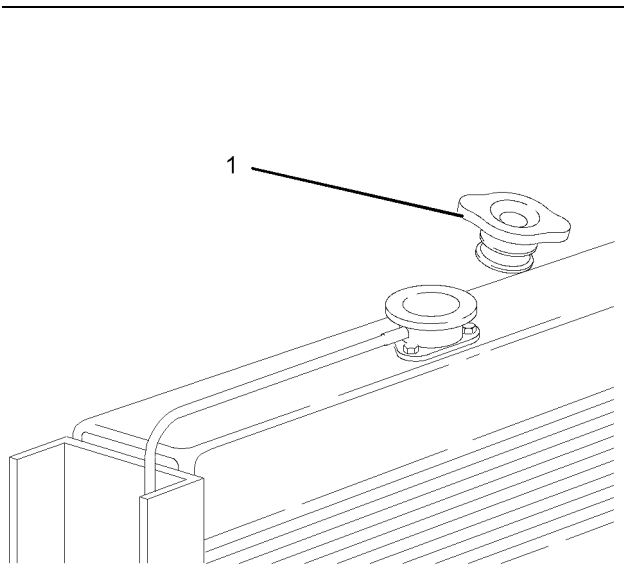


Illustration 27

g01228685

Typical example

1. Remove the cooling system filler cap (1) or (2) slowly in order to relieve pressure.

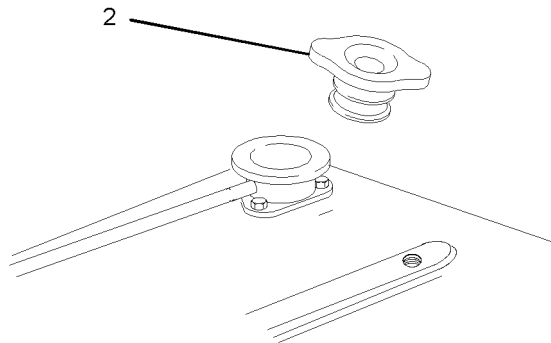


Illustration 28

g01229602

Typical example

2. Maintain the coolant level within 25 mm (1.0 inch) of the bottom of the filler cap.

3. Clean the cooling system filler cap and inspect the gasket. If the gasket is damaged, discard the old filler cap and install a new filler cap. If the gasket is not damaged, use a suitable pressurizing pump in order to pressure test the filler cap. The correct pressure is stamped on the face of the filler cap. If the filler cap does not retain the correct pressure, install a new filler cap.

i02895011

Crankshaft Vibration Damper - Inspect

The crankshaft vibration damper limits the torsional vibration of the crankshaft. The visconic damper has a weight that is located inside a fluid filled case.

Damage to the crankshaft vibration damper or failure of the damper can increase torsional vibrations. This can result in damage to the crankshaft and to other engine components. A deteriorating damper can cause excessive gear train noise at variable points in the speed range.

A damper that gets hot could be due to excessive torsional vibration. Monitor the temperature of the damper during operation.

Note: If you use an infrared thermometer to monitor the temperature of the damper, use the thermometer during operation with similar loads and speeds. Keep a record of the data. If the temperature begins to rise, reduce the interval for inspecting the damper.

If the temperature of the damper reaches 100 °C (212 °F), consult your Perkins dealer.

Inspect the damper for evidence of dents, cracks, and leaks of the fluid.

If a fluid leak is found, replace the damper. The fluid in the damper is silicone. Silicone has the following characteristics: transparent, viscous, smooth, and sticky.

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

- The damper is dented, cracked, or leaking.
- The paint on the damper is discolored from heat.
- The engine has had a failure because of a broken crankshaft.
- There is a large amount of gear train wear that is not caused by a lack of oil.

- The damper has been dropped.

i02453750

i02978267

Cylinders - Inspect

Use a borescope to inspect the cylinders. The inspection will provide information about the internal condition of the engine.

A borescope with a lens that can be angled up and down is recommended. This type of borescope provides a clear view of the combustion chamber and of the bottom deck of the cylinder head. Photographic documentation or video documentation is also recommended. Consult your Perkins dealer for information on available borescopes.

To perform this procedure, insert the borescope through the openings for the spark plugs. Use the borescope to look for the following conditions:

- Valve wear
- Marks on the piston crown
- Deposits on the valve seat
- Deposits on the valve face
- Polishing of the cylinder walls
- Scratching of the cylinder walls
- Deposits on the cylinder walls that are above the upper limit of the piston stroke

Note: If you use a borescope be aware of the effect of magnification. Minor scratches and marks can be misunderstood. This can result in unnecessary maintenance.

i02453747

Driven Equipment - Check

To minimize bearing problems and vibration of the engine crankshaft and the driven equipment, the alignment between the engine and driven equipment must be maintained properly.

Check the alignment according to the instructions that are provided by the following manufacturers:

- OEM of the coupling
- OEM of the driven equipment

Driven Equipment - Inspect/Replace/Lubricate

Observe the driven equipment during operation. Look for the following items:

- Unusual noise and vibration
- Loose connections
- Damaged parts

Perform any maintenance that is recommended by the OEM of the driven equipment. Refer to the literature of the OEM of the driven equipment for the following service instructions.

- Inspection
- Lubricating grease and lubricating oil requirements
- Specifications for adjustment
- Replacement of components
- Requirements for ventilation

i02895015

Engine - Clean

WARNING

Personal injury or death can result from high voltage.

Moisture could create paths of electrical conductivity.

Make sure the unit is off line (disconnected from utility and/or other generators), locked out and tagged "Do Not Operate".

NOTICE

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

NOTICE

Do not point high pressure water cleaners directly on to electrical components.

A clean engine provides the following benefits:

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

i02947520

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 element if the service indicator is triggered. Refer to this manual, "Engine Air cleaner Service Indicator - Inspect" for more information.

Clean the air intake precleaner (if equipped) before maintenance is performed on the air filter. Refer to , "Engine Air Precleaner - Check/Clean" for more information.

severe operating conditions may require more frequent service of the air filter.

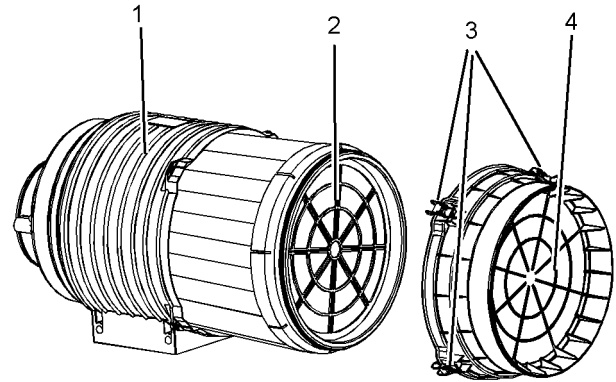


Illustration 29

g01461009

Typical example

1. Remove the retaining clips (3). Remove the cover (4).
 2. Remove the old element (2). Dispose of the old element.
- Note:** Ensure that dirt can not enter the air filter assembly.
3. Install a new element into the air filter housing (1). Install the cover (4). Fit the retaining clips (3).

i02888185

Engine Air Cleaner Service Indicator - Inspect

Some engines may be equipped with a different service indicator.

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

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

Observe the service indicator.

Replace the air filter element if the indicator is triggered by the following event:

- The red piston locks in the visible position.

Test the Service Indicator

Service indicators are important instruments.

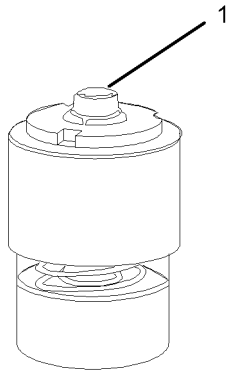


Illustration 30
Typical service indicator

g01223729

In order to reset the indicator, you must press the button (1).

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

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

i02888182

Engine Crankcase Breather - Clean/Replace

Open Breather

1. Ensure that the power supply is disconnected from the engine.
2. Remove the wing nut (1) and the cover (2).

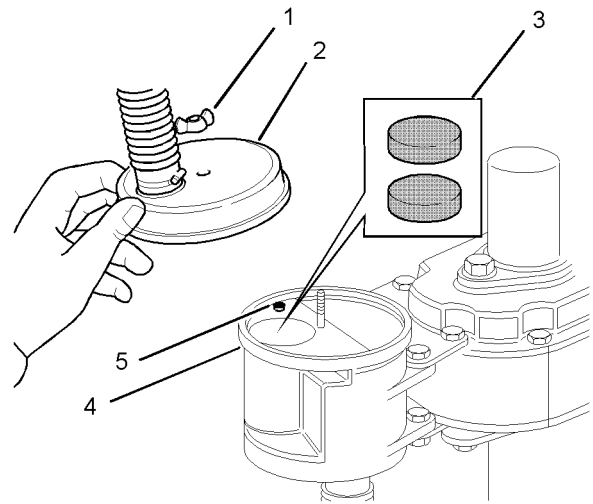


Illustration 31
Typical example

g01224945

3. Remove the filter elements (3) from the breather body (4).
4. By using a suitable cleaning fluid, 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. Clean the cover and clean the body of the breather.
6. Install the filter elements (3) to the breather body (4).
7. Ensure that the seal in the cover (2) is free from damage. If necessary, replace the seal.
8. Align the cover (2) with the dowel (5). Install the cover to the breather body (4).
9. Install the wing nut (1). Tighten the wing nut securely.
10. Connect the power supply to the engine. Operate the engine and check for leaks.

i02978569

Engine Crankcase Breather - Clean/Replace

Closed Breather System

Ensure that the power supply is disconnected from the engine.

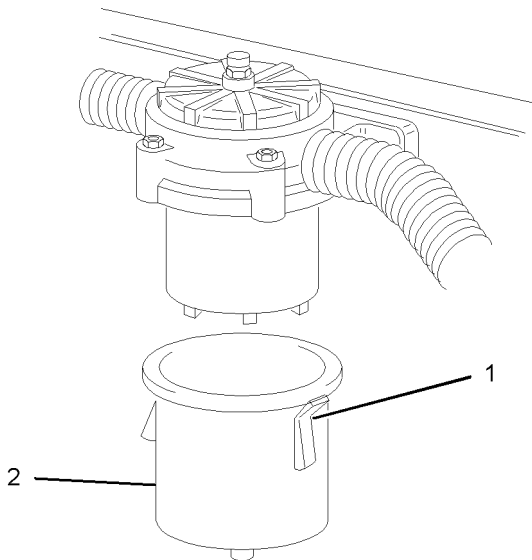


Illustration 32

g01224943

Typical example

1. Release the four clips (1). Remove the bowl (2) and remove the old filter element. Discard the old filter element in accordance with local regulations.

Note: The filter element is removed by pulling down on the filter element.

2. Ensure that the seal (3) is installed onto the new filter element (4).

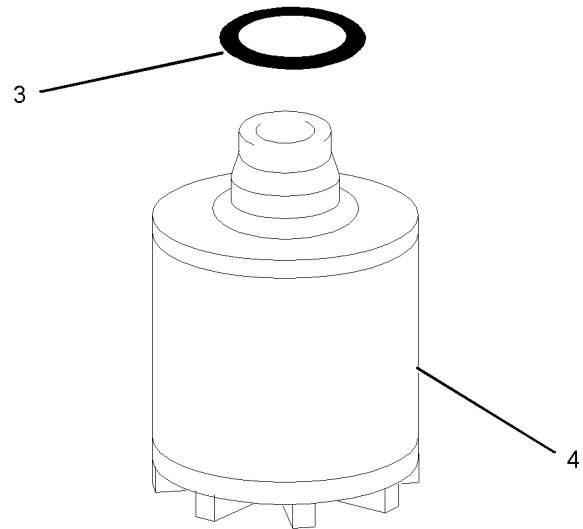


Illustration 33

g01235923

Typical example

3. Install the new filter element. Align the clips (1). Install the bowl (2).

Connect the power supply to the engine. Operate the engine and check for leaks.

i03032640

Engine Mounts - Check

Misalignment of the engine and the driven equipment will cause extensive damage. 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 proper 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.

i02888179

Engine Oil - Change

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

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.

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

1. Remove the drain plug and the sealing washer (4). Allow the engine oil to drain.
2. Replace the sealing washer, if necessary. Install the drain plug. Tighten the plug to 68 N-m (50 lb ft).

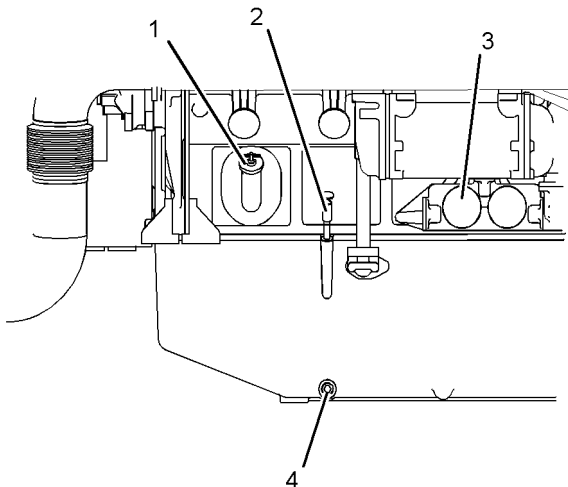


Illustration 34
Typical example

g01441987

3. Replace the engine oil filters (3). Refer to Operation and Maintenance Manual, “Engine Oil Filter - Change or Engine Oil Filter (Auxiliary) - Change” in order to change the engine oil filter.

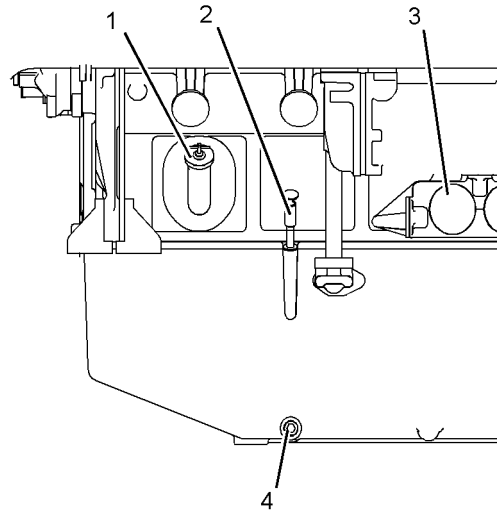


Illustration 35

g01441988

Typical example

4. Remove the filler cap (1). Fill the engine with the required amount of engine oil. Refer to Operation and Maintenance Manual, “Refill Capacities”.
5. Check the oil gauge (dipstick) (2). Ensure that the engine oil is on the correct mark.
6. Operate the engine and check for engine oil leaks. Stop the engine. Check the engine oil level. Add engine oil, if necessary. Refer to Operation and Maintenance Manual, “Engine Oil Level - Check”.

i02888172

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.

i02888171

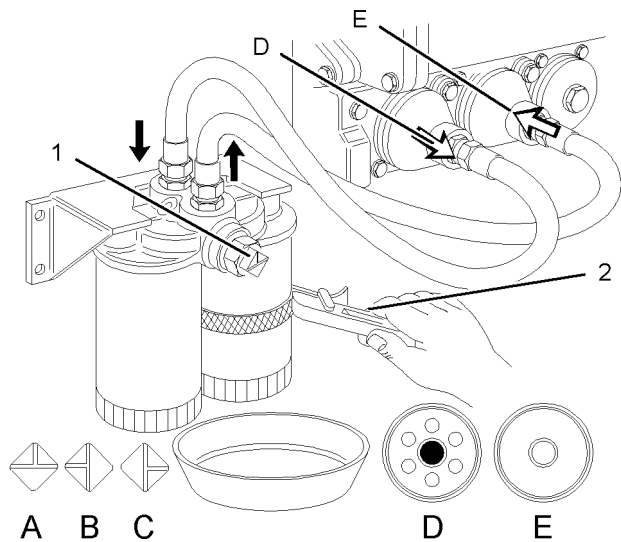


Illustration 36

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.

Engine Oil Filter - Change

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

Replace the Oil Filter

Table 16

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.

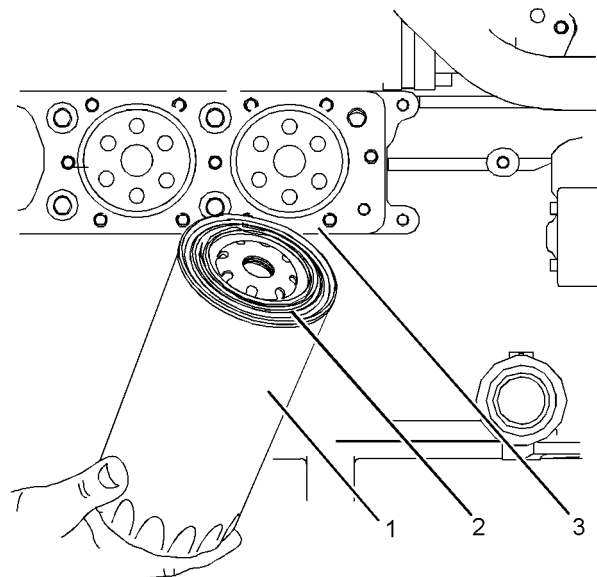


Illustration 37

g01442022

Typical example

1. Use Tooling (A) in order to remove the oil filters (1).
2. Ensure that the sealing face of the filter base (3) is clean.

3. Lubricate the sealing rings (2) with clean engine oil.
4. Install the new oil filters (1).

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.
4. Inspect the oil filters for oil leaks.
5. Stop the engine. Check the engine oil level. Add engine oil, if necessary. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check"

i02888170

Engine Oil Level - Check

WARNING

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

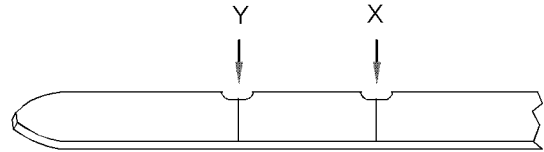


Illustration 38

g01165836

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

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.

1. Maintain the oil level between the "MIN" mark (Y) and the "MAX" mark (X) on the engine oil dipstick. Do not fill the crankcase above the "MAX" mark (X).

NOTICE

If you operate the engine with the oil level above the "MAX" mark, this may cause your crankshaft and balance weights to be dipped in oil. If you drive the crankshaft and balance weights through oil, excessive drag will occur and this will increase the load on the engine. Air bubbles will be created when the crankshaft and balance weights are driven through oil. This will reduce the lubricating characteristics of the oil and result in a loss of power.

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

i02888169

Engine Oil Sample - Obtain

Replacement Program for the Engine Oil and Filter

The life of the lubricating oil and filter is governed by the engine load and quality of the gas that is supplied.

i02430590

In order to determine the optimum program for the oil and filter service, use the oil analysis program that follows.

Initiating an Oil analysis Program

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.

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

Every 250 Hours

Run the engine for the first 500 hours. Replace the engine oil and the engine oil filter. Every 250 hours obtain an oil sample.

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: The engine oil and the engine oil filter must be replaced at 2000 hours.

Critical Parameters for the Lubricating Oil

- viscosity at 100 °C cSt max 20% above original value
- Insolubles 1.5% wt.max
- Total base number 60% less than new oil value
- Nitration 30 abs/cm max
- Oxidation 30 abs/cm max
- Water 0.2% vol max
- Iron - Fe less than 20 ppm
- Copper - Cu less than 40 ppm

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

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.

i02948519

Engine Speed/Timing Sensor - Clean/Inspect

Ensure that all power is disconnected to the engine before performing these procedures.

Table 17

Required Tools			
Tool	Part Number	Part Name	Qty
A	SE252	Engine cranking device	1

Speed Sensor

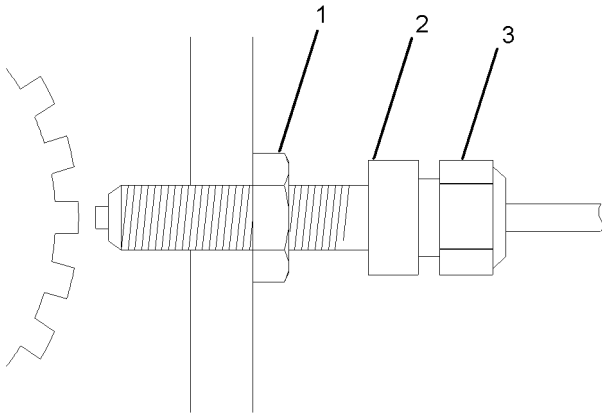


Illustration 39 g01234089
Typical example

1. Remove the connection (3). Loosen the locknut (1).
2. Remove the sensor (2). Clean any debris from the sensor.
3. Install tooling (A).
4. Rotate the engine in order to align one teeth to the tapped hole. By hand, install the sensor. When light contact is made with the teeth you must stop. Unscrew the sensor half of one turn. This will give a clearance of 0.5 to 0.8 mm (0.02 to 0.03 inch).
5. Tighten the locknut. Do not allow the sensor to rotate. Connect the connection (3).
6. Remove tooling (A).

Timing Sensor

The timing sensor is a hall effect sensor that is located in the gear case.

1. Remove the connection for the timing sensor (not shown). Loosen the locknut (1).

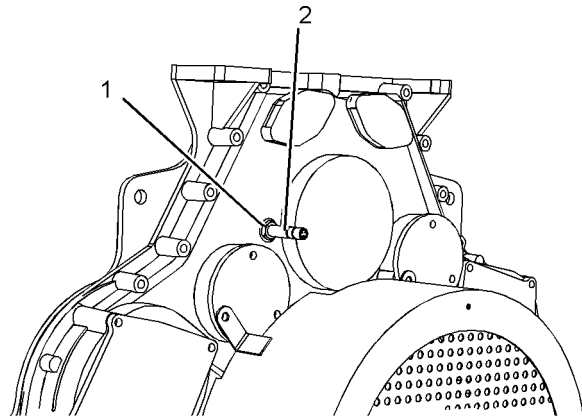


Illustration 40 g01554776
Typical example

2. Remove the sensor (2). Clean any debris from the sensor.
3. Install tooling (A).
4. Screw in the timing sensor by hand until light contact is made with the timing disc. unscrew the sensor. Unscrew one complete turn in order to give a clearance of 1 mm (0.04 inch).
5. Tighten the locknut. Do not allow the sensor to rotate. Connect the connection for the timing sensor.
6. Remove tooling (A).

Connect the power to the engine.

i02888165

Engine Valve Lash and Bridge - Adjust

Ensure that all power is disconnected to the engine.

Monitoring the Valve Recession

Table 18

Required Tools			
Tool	Part Number	Part Name	Qty
A	-	Valve recession measurement tool	1
B	-	Depth micrometer	1

Every 1000 service hours record the valve lash. The monitoring of the valve seat wear should be carried out before any adjustment of the valve lash.

In order to measure the protrusion of the valve stems, use the following procedure:

1. Remove the valve mechanism covers from all cylinders.
 2. Remove the bridge assembly for all the inlet valves.
 3. Remove the bridge assembly for all the exhaust valves.
 4. Remove the rocker assemblies.
 5. Install Tooling (A) to the stud for the bridge assembly.
- Note:** Tooling (A) must be located correctly onto the cylinder head.
6. Tooling (B) is used in order to measure the distance from the top of Tooling (A) to the top of the valve stem.
 7. Record this measurement for all valves.

Also, record the average engine load factor for the previous 1000 hours.

When you fit a new cylinder head assembly, conduct the measurement procedure in order to establish a baseline for the protrusion of the valve stem. Keep a log of the protrusions of the valve stems over the life of the engine. Plan for a top end overhaul as the valve recession approaches the following maximum limits:

- Inlet valves 2 mm (0.08 inch)
- Exhaust valves 1 mm (0.04 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 19

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 total valve recession on the inlet is 0.65 mm (0.026 inch) and the exhaust is 0.45 mm (0.018 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).

Adjusting the Valve Lash and Bridge

Table 20

Required Tools			
Tool	Part Number	Part Name	Qty
C	SE252	Engine cranking device	1

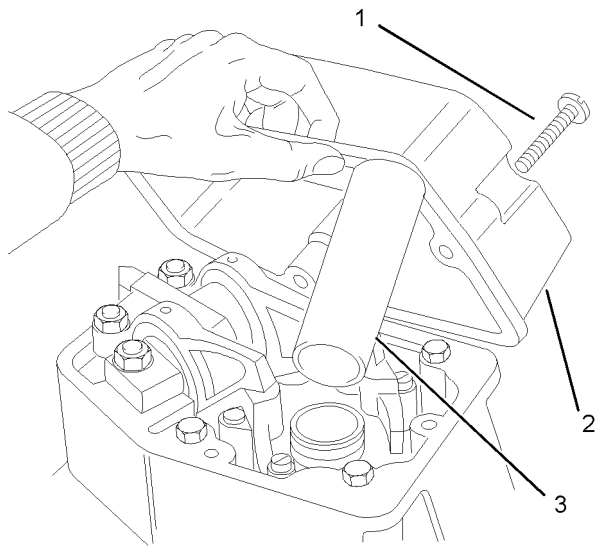


Illustration 41

g01235020

Typical example

1. Remove the spark plug. Refer to this manual, "Ignition System Spark Plugs - Check/Adjust/Replace".
2. Remove the setscrews (1) and remove the cover (2). Discard the old joint.
3. Remove the spark plug tube (3).
4. Install tooling (C) in order to rotate the crankshaft.

Adjust the bridge

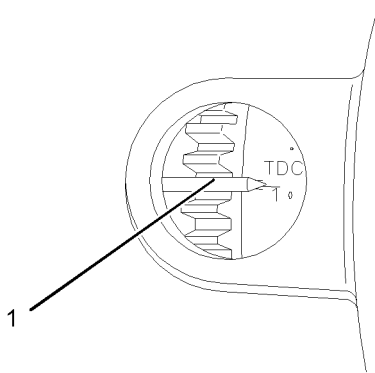


Illustration 42

g01235025

Typical example

1. Use the timing pointer (1) in order to set the engine to top dead center. Refer to this manual, "Specifications" for the sequence of piston position for valve lash.
2. Rotate the crankshaft to the required position.

3. Ensure that there is clearance between the rocker arm and bridge pad.

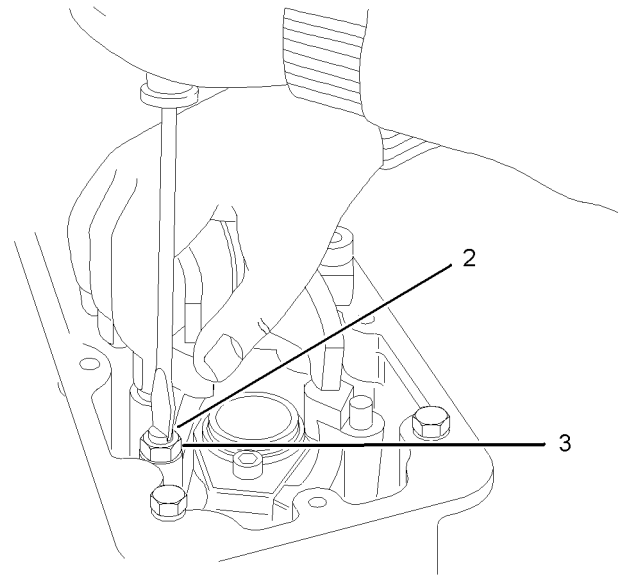


Illustration 43

g01235021

Typical example

4. Loosen the locknut (3). Adjust the screw (2) so that the fixed side of the bridge contacts the valve. Apply hand pressure to the bridge. Refer to illustration 43.
5. Adjust the screw so that light contact is made with the valve. Tighten the locknut (3) to a torque of 35 N·m (25 lb ft). Ensure that the screw has not rotated.

Valve lash

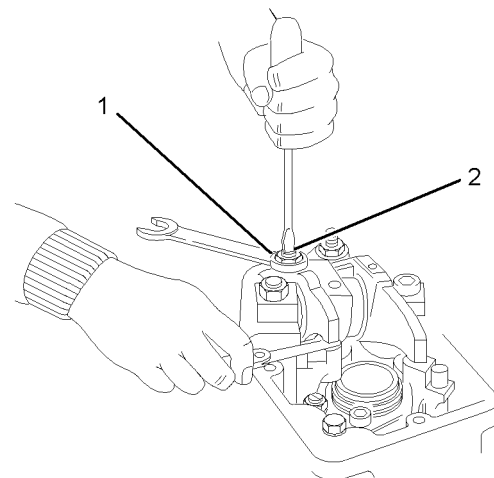


Illustration 44

g01235023

Typical example

1. Rotate the crankshaft to the required position. Refer to this manual, "Specifications" for the sequence of piston position for valve lash.

Note: The bridge adjustment must be checked before adjustment is performed on the valve lash.

2. Use a suitable feeler gauge in order to check the valve lash. If adjustment is required loosen the locknut (1). Adjust the screw (2) so that the correct clearance is obtained.
3. Tighten the lock screw to a torque of 35 N·m (25 lb ft).

Install the Cover

1. Install the spark plug tube.
2. Install a new joint. Align the cover to the cylinder head. Install the setscrew and tighten securely.
3. Install the lead for the spark plug.
4. Remove tooling (C). Connect the power supply to the engine.

i02430592

Exhaust Piping - Inspect

WARNING

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

Inspect the components of the exhaust system. Repair the components or replace the components if any of the following conditions occur:

- Damage
- Cracks
- Leaks
- Loose connections

Consult your Perkins dealer for assistance.

i02887782

Fan Drive Pulley - Check

1. Isolate the electrical supply to the engine.

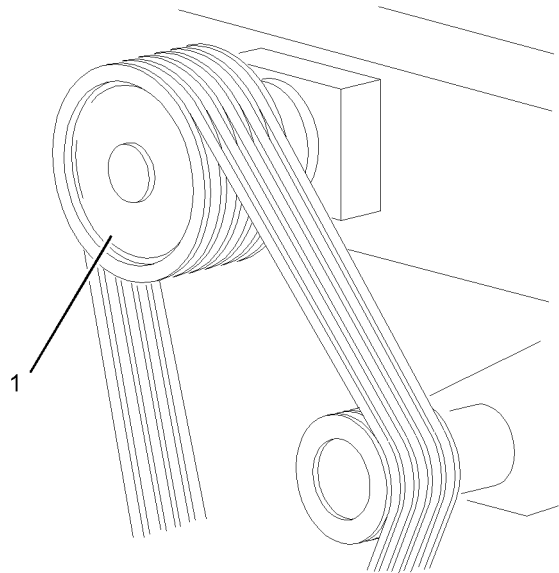


Illustration 45

g01238304

Typical example

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

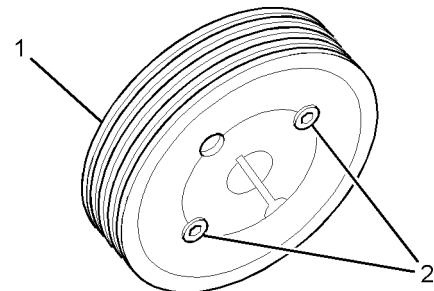


Illustration 46

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.

i02478666

Fuel Filtration System - Service

Engines that use bio-gas may require special equipment for processing the fuel. Service the fuel filtration system according to the instructions that are provided by the OEM of the equipment.

i02478685

Fuel System Fuel Filter Differential Pressure - Check

A fuel filter differential pressure gauge may be installed in order to determine when the fuel filter requires service.

A fuel filter differential pressure gauge indicates the difference in fuel pressure between the inlet side and the outlet side of the fuel filter. The differential pressure increases as the fuel filter becomes plugged.

Operate the engine at the rated speed and at the normal operating temperature. Check the fuel filter differential pressure. Service of the fuel filter depends on the pressure of the fuel system:

- For the service of the fuel filter on the low pressure gas fuel system, refer to the OEM for information.
- For the service of the fuel filter on the high pressure gas fuel system, refer to the OEM for information.

i02430593

Hoses and Clamps - Inspect/Replace

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

- Cracking
- Softness
- Loose clamps

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

NOTICE

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

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 heat set. Heat setting causes 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

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.
8. Refill the cooling system.
9. Clean the cooling system filler cap. Inspect the cooling system filler cap's gaskets. Replace the cooling system filler cap if the gaskets are damaged. Install the cooling system filler cap.
10. Start the engine. Inspect the cooling system for leaks.

i02887646

Ignition System Spark Plugs - Inspect/Replace

Table 21

Required Tools			
Tool	Part Number	Part Name	Qty
A	484 / 49	Spark plug removal tool	1

Inspect the Spark Plug

Inspect the spark plug closely for damage. The condition of the spark plug can indicate the operating condition of the engine.

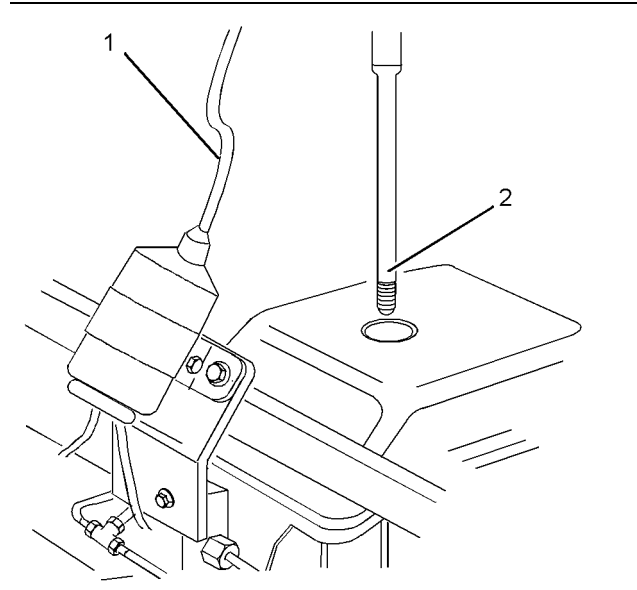


Illustration 47

g01507793

1. Remove the lead (1) for the spark plug from the ignition coil.
2. Install tooling (A). Remove the spark plug (2).

Replace the Spark Plug

The spark plug is not a serviceable part. A replacement spark plug must be used.

Table 22

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610178	Cylinder head spark plug thread cleaning tool	1

Ensure that the threads in the cylinder head are not damaged. Clean the threads in the cylinder head by using tooling (B).

Install the spark plug by using tooling (A). Tighten the spark plug by hand and then tighten the spark plug to a torque of 50 N·m (36 lb ft).

On the initial start-up of a new engine or an engine that has been serviced, it is possible for condensation to have built up in the spark plugs. If this occurs, refer to this manual, "Cold Weather Starting".

i02887641

Ignition System Timing - Check/Adjust

After maintenance has been performed on the ignition system, check the timing of the ignition system. Adjust the timing, if necessary.

The optimum ignition timing for a gas engine varies according to several factors:

- Compression ratio of the engine
- Inlet air temperature
- Methane number of the gas

Note: Refer to this manual, "Plate Locations and Film Locations" in order to find the correct ignition timing for the engine.

1. Install a timing light to the lead on number One A cylinder for the 4016TRS Gas.

Note: The leads for the timing light must not come in contact with the exhaust manifold.

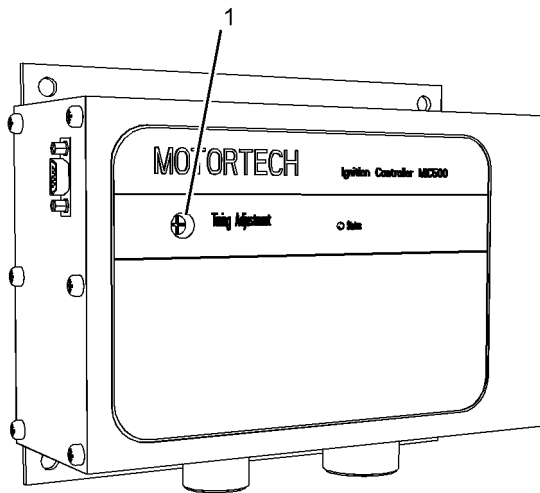


Illustration 48

g01521796

Typical example

2. Operate the engine and check the timing marks on the flywheel.
3. If necessary, adjust the ignition timing. Remove the cap (not shown) that covers the screw for timing adjustment (1). By using a suitable tool, rotate the screw (1) in order to adjust the ignition timing.

4. Install the cap when the ignition timing is correct. Remove the timing light.
- Rotating the screw (1) clockwise retards the ignition timing.
 - Rotating the screw (1) counterclockwise advances the ignition timing.

i02895042

Inlet Air System - Inspect

Inspect the components of the air inlet system for the following conditions:

- Cracks
- Leaks
- Loose connections

Inspect the following components:

- Piping between the air cleaner and the turbochargers
- Turbochargers
- Piping between the turbochargers and the aftercoolers
- Aftercoolers
- Piping between the air/fuel ratio and the gas mixer units
- Piping between the closed circuit breather and the turbochargers
- Connection of the aftercooler to the air inlet manifolds
- Connection of the air inlet manifolds to the cylinder heads

Ensure that all of the connections are secure. Ensure that the components are in good condition.

i03140143

Jacket Water Heater - Check

Jacket water heaters help to improve startability in ambient temperatures that are below 10 °C (50 °F). All installations that require automatic starting should have jacket water heaters.

Check the operation of the jacket water heater. For an ambient temperature of 0 °C (32 °F), the heater should maintain the jacket water coolant temperature at approximately 40 °C (104 °F).

i02895045

Overhaul (In-Frame)

Scheduling an In-Frame Overhaul

Scheduling an in-frame overhaul normally depends on the following conditions:

- An increase of oil consumption
- An increase of crankcase blowby
- A decrease or a variation of cylinder compression
- A reduction in the detonation margin
- An increase in throttle position

Each individual condition may not indicate a need for an overhaul. However, evaluating these conditions together is the most accurate method of determining when an overhaul is necessary.

The engine does not require an overhaul if the engine is operating within acceptable limits for oil consumption, crankcase blowby, and cylinder compression.

Periodically measure each of these conditions. The first measurement should occur during the engine commissioning. This establishes a baseline for future measurements. Additional measurements are scheduled at regular intervals in order to determine a schedule for the next in-frame overhaul.

Note: Oil consumption will be initially high. This will be reduced when the rings are seated to the bore.

Note: These indications do not require an engine to be shut down for service. These indications only mean that an engine should be scheduled for service in the near future. If the engine operation is satisfactory, an immediate overhaul is not a requirement.

Monitor the engine as the engine accumulates service hours.

Usually, an in-frame overhaul does not require removal of the engine. Instead, the service is performed with the engine in place.

In-Frame Overhaul Information

An in-frame overhaul includes all of the work that is done for a top end overhaul. Additionally, some other components that wear are replaced. The condition of components is inspected. Those components are replaced, if necessary.

Your Perkins dealer can provide these services and components. Your Perkins dealer can ensure that the components are operating within the appropriate specifications.

i02895678

Overhaul (Major)

Scheduling a Major Overhaul

Generally, a major overhaul is performed at 32000 hours. The need for a major overhaul is determined by several factors. Some of those factors are the same factors that determine the in-frame overhaul:

- An increase of oil consumption
- An increase of crankcase blowby
- A decrease and variation of cylinder compression
- A reduction in the detonation margin
- An increase in throttle position

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 your Perkins dealer 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

A major overhaul includes all of the work that is done for top end overhauls and in-frame overhauls. In some cases, the engine is relocated for disassembly. Components that wear are disassembled and inspected. If necessary, the parts are replaced. The crankshaft is measured for wear. The crankshaft may require regrinding. Alternatively, the crankshaft may be replaced with a Perkins replacement part. Your Perkins dealer can provide these services and components. Your Perkins dealer can ensure that the components are operating within the appropriate specifications.

If you elect to perform an overhaul without the services of a Perkins dealer, be aware of the following recommendations.

Replacing of Components

Replace the following components during the major overhaul.

- Connecting rod bearings
- Cylinder liners
- Piston rings
- Turbochargers
- Cylinder heads
- Oil pump
- Joints and bolts
- Gaskets and seals
- Main bearings
- Water temperature regulators

Rebuilding or Replacing of Components

Rebuild the following components during the major overhaul.

- Carburetor
- Engine Water pumps

Inspecting Components

Inspect the following components:

- Chargecooler
- Camshafts
- Camshaft bearings
- Camshaft followers
- Connecting rods
- Crankshaft
- Gear train and bearings
- Governor
- Inlet air piping
- Oil cooler
- Pistons
- Ignition coils
- Valve train that includes the rocker gear

i02960029

Overhaul (Top End)

Scheduling a Top End Overhaul

Table 23

Required Tools			
Tool	Part Number	Part Name	Qty
A	-	Valve recession measurement tool	1
B	-	Depth micrometer	1

Top end overhauls are scheduled according to the valve recession. Valve recessions are calculated by measuring the protrusions of the valve stems. Measure the valve recession at every 1000 running hours. This measurement gives an accurate indication of valve wear. This information can be used to predict when a cylinder head must be replaced.

Anticipated replacement intervals for the cylinder head are 12,000 hours for the 4016-61TRS2 engine, and 16,000 hours for the 4016-61TRS1 engine.

In order to measure the protrusion of the valve stems, use the following procedure:

1. Remove the valve mechanism covers from all cylinders.
2. Remove the bridge assembly for all the inlet valves.
3. Remove the bridge assembly for all the exhaust valves.
4. Remove the rocker assemblies.
5. Install Tooling (A) to the stud for the bridge assembly.

Note: Tooling (A) must be located correctly onto the cylinder head.

6. Tooling (B) is used in order to measure the distance from the top of Tooling (A) to the top of the valve stem.
7. Record this measurement for all valves.

Also, record the average engine load factor for the previous 1000 hours.

When you fit a new cylinder head assembly, conduct the measurement procedure in order to establish a baseline for the protrusion of the valve stem. Keep a log of the protrusions of the valve stems over the life of the engine. Plan for a top end overhaul as the valve recession approaches the following maximum limits:

- Inlet valves 2 mm (0.08 inch)
- Exhaust valves 1 mm (0.04 inch)

Do not allow the recession of the valves to exceed these limits.

i02896454

Overhaul Considerations

Overhaul Information

An overhaul is replacing the major worn components of the engine. An overhaul is a maintenance interval that is planned. The engine is rebuilt with certain rebuilt parts or new parts that replace the worn parts.

An overhaul also includes the following maintenance:

- Inspection of all the parts that are visible during the disassembly
- Replacement of the seals and gaskets that are removed

- Cleaning of the internal passages of the engine and the engine block

It is not practical to wait until the engine exhibits symptoms of excessive wear or failure. It is not less costly to wait. A planned overhaul before failure may be the best value for the following reasons:

- Costly unplanned downtime can be avoided.
- Many original parts can be reused according to the guidelines for reusable parts.
- The service life of the engine can be extended without the risk of a major catastrophe due to engine failure.
- Achieve the best cost/value relationship per hour of extended service life.

Overhaul Intervals

Top end overhauls are determined by the recession of the valves. In-frame overhauls are determined by the following conditions:

- An increase of oil consumption
- An increase of crankcase blowby
- A decrease or a variation of cylinder compression
- A reduction in the detonation margin
- An increase in the throttle position

Major overhauls are determined by the in-frame tests, and by results of oil analysis.

Some other factors that are important for determining the overhaul intervals include the following considerations:

- Performance of preventive maintenance
- Use of recommended lubricants
- Use of recommended coolants
- Use of recommended fuels
- Operating conditions
- Operation within acceptable limits
- Engine load
- Engine speed

Overhaul Inspection

If the parts are not within the inspection specifications, the parts should be replaced. The use of parts that are not in wear limits could result in unscheduled downtime and/or costly repairs. This can also contribute to increased fuel consumption and reduction of engine efficiency.

Your Perkins dealer can provide the parts that are needed to rebuild the engine at the least possible cost.

Overhaul recommendation

Perkins recommends a scheduled overhaul in order to minimize downtime. A scheduled overhaul will provide the lowest cost and the greatest value. Schedule an overhaul with your Perkins dealer.

i02481257

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 of the fan's air flow. Hold the nozzle approximately 6 mm (0.25 inch) away from the fins. Slowly move the air nozzle in a direction that is parallel with the tubes. This 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). In order to clean a radiator with dual cores, one core will need to be removed from the radiator. This will allow access to both sides of the core.

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.

Inspect the fins for damage. Bent fins may be repaired. Inspect these items for good condition: welds, mounting brackets, air lines, connections, clamps, and seals. Make repairs, if necessary.

i02885745

Turbocharger - Inspect

Do not inspect the turbocharger. The turbocharger must be replaced.

i02885738

Walk-Around Inspection

Inspect the Engine for Leaks and for Loose Connections

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

For maximum engine service life, thoroughly inspect the engine room before starting the engine. Look for items such as leaks, loose bolts, loose connections and trash buildup. Make repairs, as needed.

- The guards must be in the proper 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, 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 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.

- Ensure that cooling lines are properly clamped. Check for leaks. Check the condition of all pipes.
- Inspect the water pumps for coolant leaks. Refer to this manual, "Water Pump - Inspect".

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

- Inspect the lubrication system for leaks at the front crankshaft seal, the rear crankshaft seal, the oil pan, the oil filters and the valve covers.

WARNING

NEVER use a flame to check for gas leaks. Use a gas detector.

An open flame can ignite mixtures of air and fuel. This will cause explosion and/or fire which could result in severe personal injury or death.

- Check the fuel system for leaks. Look for loose fuel line clamps.
- Inspect the piping for the air inlet system and the elbows for cracks and for loose clamps.
- Inspect the wiring and the wiring harnesses for loose connections and for worn wires or frayed wires.
- Inspect the ground straps for good connections and for good condition.
- Check the condition of the gauges. Replace any gauge that is damaged. Replace any gauge that can not be calibrated.
- Inspect the exhaust system for leaks. If a leak is found, make repairs.

i02885735

Water Pump - Inspect

A failed water pump might cause severe engine overheating problems that could result in cracks in the cylinder heads, a piston seizure or other potential damage to the engine.

Refer to the latest issue of Perkins service bulletin 157 for more information on inspecting the water pump.

i02885734

Water Temperature Regulator - Replace

If Equipped, Remove the Water Temperature Regulator (Thermostat)

1. Drain sufficient coolant from the cooling system in order to remove the water temperature regulator (4). Remove the outlet hose (1).

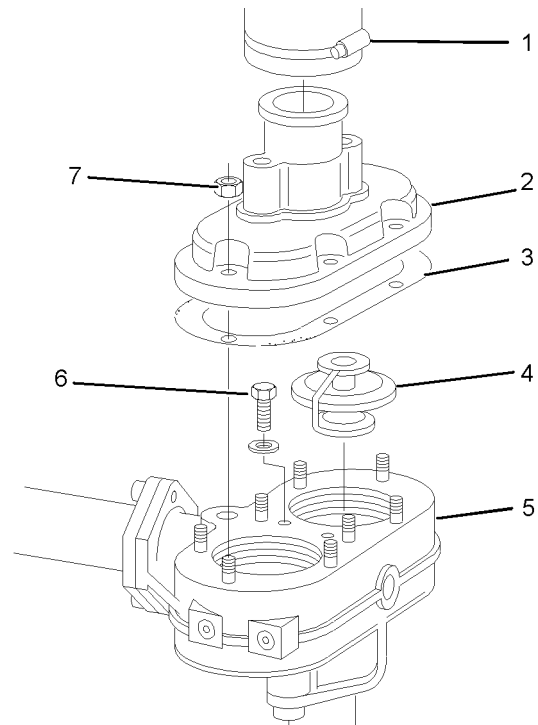


Illustration 49

g01240519

Typical example

2. Remove the retaining nuts (7) and lift off the top cover (2). Discard the joint (3).
3. Remove the setscrew and washer (6). Then remove the elements (4) from the housing (5).

Check

Visually inspect the elements for damage.

1. Fill a suitable container with coolant. Place the element in the container.

Note: If the valve (1) is open at ambient temperature the elements must be renewed.

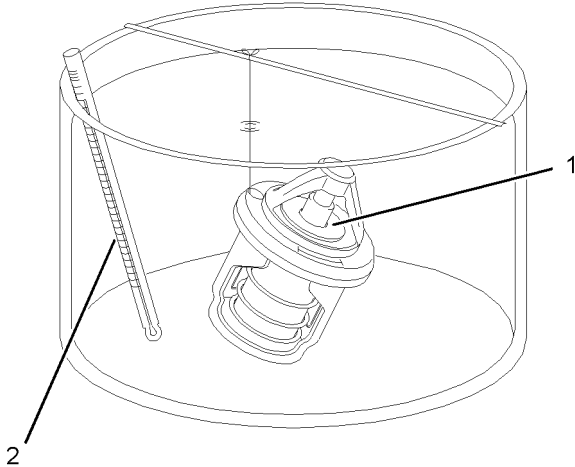


Illustration 50

g01240533

Typical example

2. Heat the coolant gradually. Use a thermometer (2) in order to check the temperature of the coolant. The opening temperature of the valve is 71 °C (160 °F). Ensure that the valve starts the process of opening at this temperature. Ensure that the valve opens to the full amount.
3. If the valve does not open or the valve does not open to the full amount discard the old element.

Replace

1. Clean the mating face of the housing (5), and clean the mating face of the cover (2).

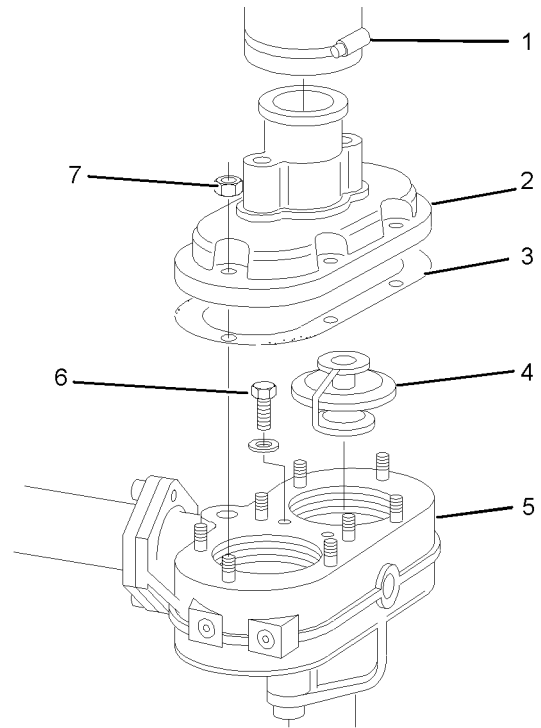


Illustration 51

g01240519

Typical example

2. Install both elements (4) into the housing. Install the setscrew and washer (6).
3. Install a new joint (3) and install the top cover. Evenly torque all the retaining nuts (7) to a torque of 50 N·m (37 lb ft).
4. Install the outlet hose (1) and tighten the hose clip.
5. Fill the cooling system with the correct amount of coolant. Refer to this manual , "Cooling System Coolant Level - Check". Operate the engine and check for leaks.

Reference Information Section

Reference Materials

i02484851

Maintenance Records

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

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

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

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

i02885832

Valve Data Sheet

Table 25

Engine Model		Serial Number	Service Hours		-
Cylinder	Cylinder Pressure	Valve Location	Current Measure	Reset size	Wear
1		Inlet			
		Inlet			
		Exhaust			
		Exhaust			
2		Inlet			
		Inlet			
		Exhaust			
		Exhaust			
3		Inlet			
		Inlet			
		Exhaust			
		Exhaust			
4		Inlet			
		Inlet			
		Exhaust			
		Exhaust			
5		Inlet			
		Inlet			
		Exhaust			
		Exhaust			
6		Inlet			
		Inlet			
		Exhaust			
		Exhaust			
7		Inlet			
		Inlet			
		Exhaust			
		Exhaust			
8		Inlet			
		Inlet			
		Exhaust			
		Exhaust			

(continued)

(Table 25, contd)

9	Inlet			
	Inlet			
	Exhaust			
	Exhaust			
10	Inlet			
	Inlet			
	Exhaust			
	Exhaust			
11	Inlet			
	Inlet			
	Exhaust			
	Exhaust			
12	Inlet			
	Inlet			
	Exhaust			
	Exhaust			
13	Inlet			
	Inlet			
	Exhaust			
	Exhaust			
14	Inlet			
	Inlet			
	Exhaust			
	Exhaust			
15	Inlet			
	Exhaust			
	Inlet			
	Exhaust			
16	Exhaust			
	Inlet			
	Exhaust			
	Exhaust			

i02885737

Warranty Information

The engine installation and the service interval for the engine must be approved. The engine must be operated with the approved fuel, lubricant and coolant. Refer to Perkins Engines Stafford for more information.

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Product and Dealer Information

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

Delivery Date: _____

Product Information

Model: _____

Product Identification Number: _____

Engine Serial Number: _____

Transmission Serial Number: _____

Generator Serial Number: _____

Attachment Serial Numbers: _____

Attachment Information: _____

Customer Equipment Number: _____

Dealer Equipment Number: _____

Dealer Information

Name: _____ Branch: _____

Address: _____

Dealer Contact

Phone Number

Hours

Sales: _____

Parts: _____

Service: _____

