Engine Operation Manual

For Engine Models

4IRD5T
4IRD5AE
4IRD5TE
6IRF8AE4
6IRF8AE
6IRF8TE

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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.

Introduction

Forward

THIS MANUAL CONTAINS INFORMATION to operate and service the engine:

READ THIS MANUAL carefully to learn how to operate and service your engine correctly. Failure to do so could result in personal injury or equipment damage.

THIS MANUAL SHOULD BE CONSIDERED a permanent part of your engine and should remain with the engine when you sell it.

MEASUREMENTS IN THIS MANUAL are given in both metric and customary U.S. unit equivalents. Use only correct replacement parts and fasteners. Metric and inch fasteners may require a specific metric or inch wrench.

WRITE ENGINE SERIAL NUMBERS and option codes in the spaces indicated in the Record Keeping Section. Accurately record all the numbers. Your dealer also needs these numbers when you order parts. File the identification numbers in a secure place off the engine.

SETTING FUEL DELIVERY beyond published factory specifications or otherwise overpowering will result in loss of warranty protection for this engine.

CERTAIN ENGINE ACCESSORIES such as radiator, air cleaner, and instruments are optional equipment on Ingersoll-Rand OEM Engines. An equipment manufacturer other than of Ingersoll -Rand may provide these accessories. This operator's manual applies only to the engine and those options available through the Ingersoll-Rand distribution network.

Contents

Record Keeping

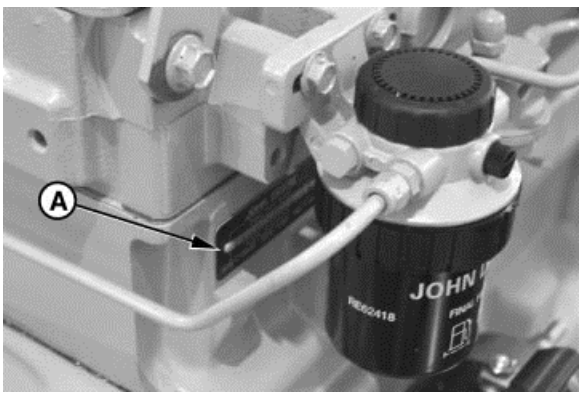
A medallion is located on the rocker arm cover, which identifies each engine.

Engine Serial Number Plate

Each engine has a 13-digit engine serial number. The first two digits identify the factory that produced the engine.

- "CD" = Saran, France
- "PE" = Torreon, Mexico
- "T0" = Dubuque, Iowa
- "J0" = Rosario, Argentina

The engine's serial number plate (A) is located on the right-hand side of cylinder block behind the fuel filter.



Record Engine Serial Number

Record all of the numbers and letters found on your engine serial number plate in the spaces provided below.

This information is very important for repair parts or warranty information.

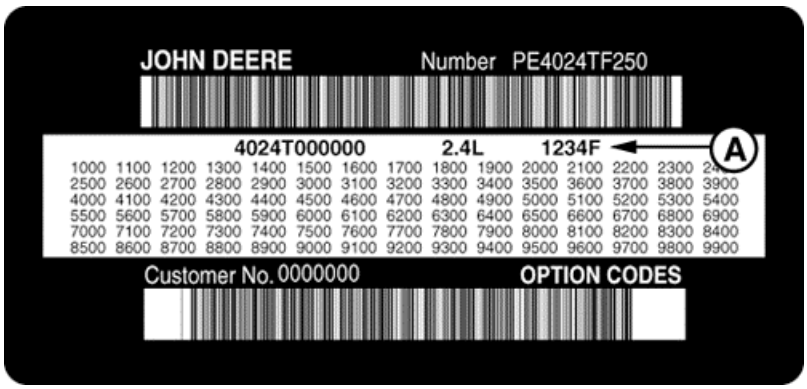
Engine Serial Number (B)

Engine Model Number (C)

Coefficient of Absorption Value (D)
(Saran Engines Only)

Engine Serial Plate

Engine Option Codes



In addition to the serial number plate, OEM engines have an engine option code label affixed to the rocker arm cover. These codes indicate which of the engine options were installed on your engine at the factory. When in need of parts or service, furnish your authorized servicing dealer or engine distributor with these numbers.

The engine option code label includes an engine base code (A). This base code must also be recorded along with the option codes.

The first two digits of each code identify a specific group, such as alternators. The last two digits of each code identify one specific option provided on your engine, such as a 12-volt, 70-amp alternator.

NOTE: These option codes are based n the latest information available at the time of publication. The right is reserved to make changes at any time without notice.

If an engine is ordered without a particular component, the last two digits of that functional group option code will be 99, 00, or XX. The list on the next page shows only the first two digits of the code numbers. For future reference such as ordering repair parts, it is important to have these code numbers available. To ensure this availability, enter the third and fourth digits shown on your engine option code label in the spaces provided on the following page.

NOTE: Your engine option code label may not contain all option codes if an option has been added after the engine left the producing factory.

Option Codes	Description	Option Codes	Description
11	Rocker Arm Cover	46	Cylinder Block and Camshaft
12	Oil Filler	47	Crankshaft and Bearings
13	Crankshaft Pulley	48	Connecting Rods and Pistons
14	Flywheel Housing	49	Valve Actuating Mechanism
15	Flywheel	50	Oil Pump
16	Fuel Injection System	51	Cylinder Head With Valves
17	Air Inlet	52	Auxiliary Gear Drive
18	Air Cleaner	55	Shipping Stand
19	Oil Pan	56	Paint Option
20	Coolant Pump	57	Coolant Pump Inlet
21	Thermostat Cover	59	Oil Cooler
22	Thermostat	60	Alternator Fan Drive Pulley
23	Fan Drive	62	Alternator Mounting
24	Fan Belt	64	Exhaust Elbow
25	Fan	65	Turbocharger
26	Engine Coolant Heater	66	Coolant Temperature Switch
27	Radiator	67	Speed Sensor
28	Exhaust Manifold	68	Crankshaft Rear Damper
29	Crankcase Vent System	69	Engine Serial Number Plate
30	Starter Motor	74	Air Conditioning (Freon) Compressor
31	Alternator	75	Air Restriction Indicator
32	Instrument Panel	76	Oil Pressure Switch
33	Tachometer	78	Air Compressor
35	Fuel Filter	86	Fan Pulley
36	Front Plate	87	Belt Tensioner
37	Fuel Transfer Pump	88	Oil Filter
39	Thermostat Housing	92	Test Certificate
40	Oil Dipstick	95	Special Equipment (Factory Installed)
43	Starting Aids	97	Special Equipment (Field Installed)
44	Timing Gear Cover	98	Lift Straps for Engine
45	Balancer Shafts	99	Service Only Parts and Kits

If option code label is lost or destroyed, consult your servicing dealer or engine distributor selling the engine for a replacement.

_____ **Engine Base Code**

Record Fuel Injection Pump Model Number

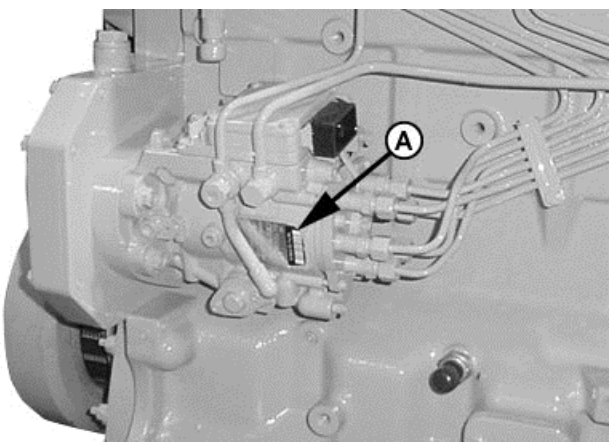
Record the fuel injection pump model and serial information found on the serial number plate (A).

Model No._____ RPM_____

Manufacturer's No._____

Serial No._____

A—Serial Number Plate



Safety

Recognize Safety Information

This is a safety-alert symbol. When you see this symbol on your machine or in this manual, be alert to the potential for personal injury.

Follow recommended precautions and safe operating practices.

Understand Signal Words

A signal word—DANGER, WARNING, or CAUTION—is used with the safety-alert symbol. DANGER identifies the most serious hazards.

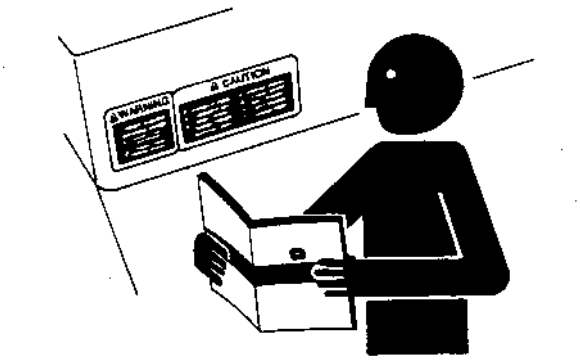
DANGER or WARNING safety signs are located near specific hazards. General precautions are listed on CAUTION safety signs.

CAUTION also calls attention to safety messages in this manual.

Indicates important set-up, operating or maintenance information.

Follow Safety Instructions

Carefully read all safety messages in this manual and on your machine safety signs. Keep safety signs in good condition. Replace missing or damaged safety signs. Be sure new equipment components and repair parts include the current safety signs. Replacement safety signs are available from your Ingersoll-Rand dealer.



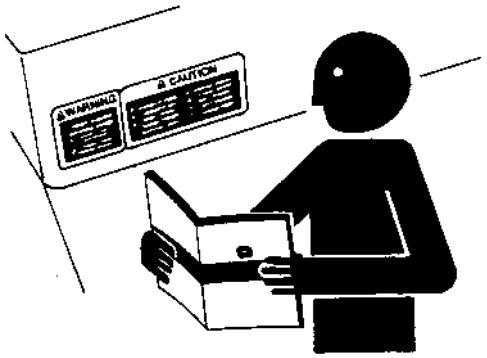
Learn how to operate the machine and how to use controls properly. Do not let anyone operate without instruction.

Keep your machine in proper working condition. Unauthorized modifications to the machine may impair the function and/or safety and affect machine life.

If you do not understand any part of this manual and need assistance, contact your Ingersoll-Rand dealer.

Replace Safety Signs

Replace missing or damaged safety signs. See the machine operator's manual for correct safety sign placement.



Prevent Bypass Starting

Avoid possible injury or death from engine runaway.

Do not start engine by shorting across starter terminal.

Start engine only from operator's station.

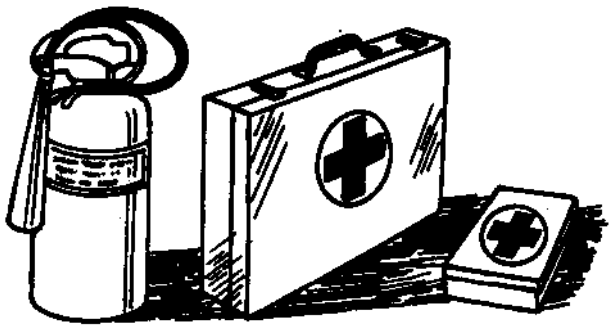
Handle Fuel Safely—Avoid Fires

Handle fuel with care: it is highly flammable. Do not refuel the machine while smoking or when near open flame or sparks.

Always stop engine before refueling machine. Fill fuel tank outdoors.

Prevent fires by keeping machine clean of accumulated trash, grease, and debris. Always clean up spilled fuel.

Prepare for Emergencies



Be prepared if a fire starts.

Keep a first aid kit and fire extinguisher handy.

Keep emergency numbers for doctors, ambulance service,
hospital, and fire department near your telephone.

Handle Fluids Safely—Avoid Fires

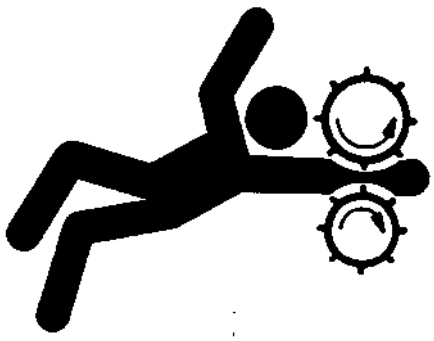
When you work around fuel, do not smoke or work near heaters or other fire hazards.

Store flammable fluids away from fire hazards. Do not incinerate or puncture pressurized containers.
Make sure engine is clean of trash, grease, and debris. Do not store oily rags; they can ignite and burn spontaneously.

DO NOT USE Starting Fluids

DO NOT USE ether-starting fluids with these air inlet heater - equipped engines as it could cause an extreme explosion with possible personnel injury.

Service Engines Safely



Tie long hair behind your head. Do not wear a necktie, scarf, loose clothing, or necklace when you work near engine tools or moving parts. If these items were to get caught, severe injury could result.

Remove rings and other jewelry to prevent electrical shorts and entanglement in moving parts.

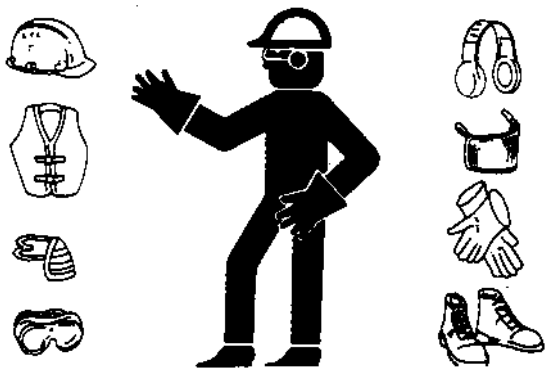
Wear Protective Clothing

Wear close fitting clothing and safety equipment appropriate to the job.

Prolonged exposure to loud noise can cause impairment or loss of hearing.

Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.

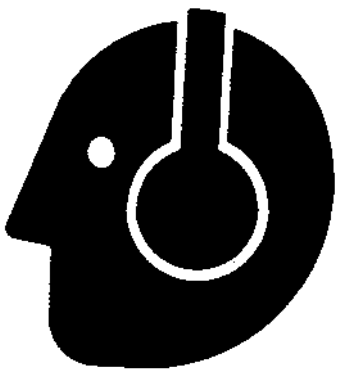
Operating equipment safely requires the full attention of the operator. Do not wear radio or music headphones while operating machine.



Protect Against Noise

Prolonged exposure to loud noise can cause impairment or loss of hearing.

Wear a suitable hearing protective device such as earmuffs or earplugs to protect against objectionable or uncomfortable loud noises.



Handle Chemical Products Safely

Direct exposure to hazardous chemicals can cause serious injury. Potentially hazardous chemicals used with Ingersoll-Rand equipment include such items as lubricants, coolants, paints, and adhesives.

A Material Safety Data Sheet (MSDS) provides specific details on chemical products: physical and health hazards, safety procedures, and emergency response techniques.

Check the MSDS before you start any job using a hazardous chemical. That way you will know exactly what the risks are and how to do the job safely. Then follow procedures and recommended equipment.

(See your Ingersoll-Rand dealer for MSDS's on chemical products used with Ingersoll-Rand equipment.)

Practice Safe Maintenance

Understand service procedure before doing work. Keep area clean and dry.

Never lubricate, service, or adjust machine while it is moving. Keep hands, feet, and clothing from power-driven parts. Disengage all power and operate controls to relieve pressure. Lower equipment to the ground. Stop the engine. Remove the key. Allow machine to cool.

Securely support any machine elements that must be raised for service work.

Keep all parts in good condition and properly installed. Fix damage immediately. Replace worn or broken parts. Remove any buildup of grease, oil, or debris.

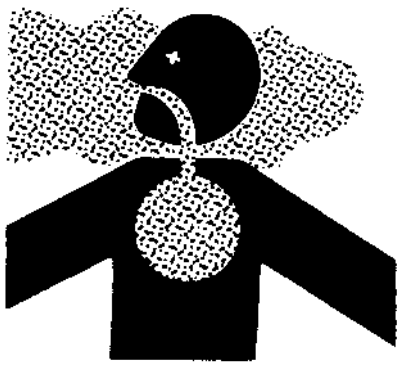
On self-propelled equipment, disconnect battery ground cable (-) before making adjustments on electrical systems or welding on machine.

On towed implements, disconnect wiring harnesses from tractor before servicing electrical system components or welding on machine.

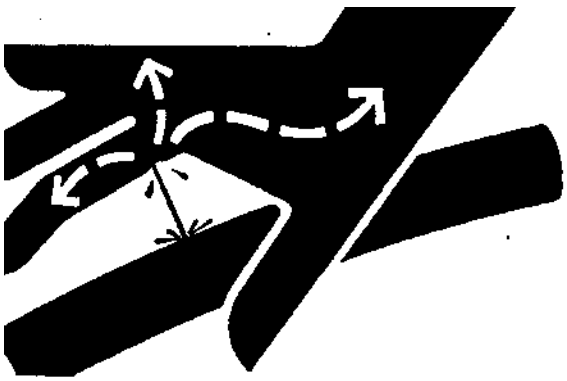
Work In Ventilated Area

Engine exhaust fumes can cause sickness or death. If it is necessary to run an engine in an enclosed area, remove the exhaust fumes from the area with an exhaust pipe extension.

If you do not have an exhaust pipe extension, open the doors and get outside air into the area



Avoid High-Pressure Fluids



Escaping fluid under pressure can penetrate the skin causing serious injury.

Avoid the hazard by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure.

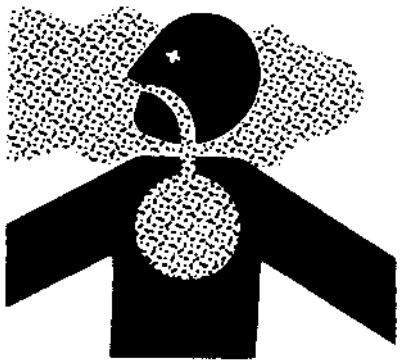
Search for leaks with a piece of cardboard. Protect hands and body from high-pressure fluids.

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable medical source.

Avoid Heating Near Pressurized Fluid Lines

Flammable spray can be generated by heating near pressurized fluid lines, resulting in severe burns to yourself and bystanders. Do not heat by welding, soldering, or using a torch near pressurized fluid lines or other flammable materials. Pressurized lines can be accidentally cut when heat goes beyond the immediate flame area.

Remove Paint Before Welding or Heating



Avoid potentially toxic fumes and dust.
Hazardous fumes can be generated when welding, soldering, or using a torch to heats paint. Remove paint before heating:

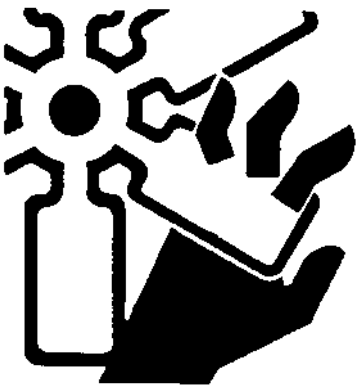
- Remove paint a minimum of 76 mm (3 in.) from area to be affected by heating.
- If you sand or grind paint, avoid breathing the dust. Wear an approved respirator.
- If you use solvent or paint stripper, remove stripper with soap and water before welding. Remove solvent or paint stripper containers and other flammable material from area. Allow fumes to disperse at least 15 minutes before welding or heating.

Do not use a chlorinated solvent in areas where welding will take place.

Do all work in an area that is well ventilated to carry toxic fumes and dust away.

Dispose of paint and solvent properly.

Install Fan Guards



Rotating cooling system fans can cause serious injury. Keep fan guards in place at all times during engine operation.

Wear close fitting clothes.

Stop the engine and be sure fan is stopped before making adjustments or connections, or cleaning near the front of the engine.

Avoid Hot Parts

Avoid skin contact with exhaust manifolds, turbochargers and mufflers. Keep flammable materials clear of the turbocharger.

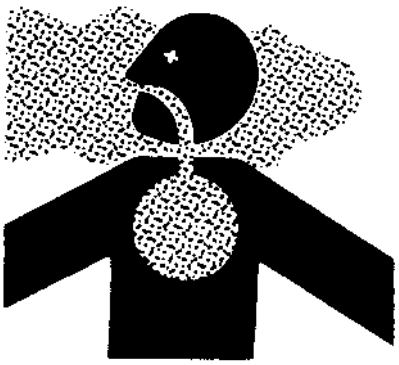
External dry exhaust parts become very hot during operation. Turbochargers may reach temperatures as high as 500°C (932°F) under full load, and naturally aspired exhaust manifolds may reach 600°C (1112°F) under full load. This may ignite paper, cloth or wooden materials. Parts on engines that have been at full load and reduced to no load idle will maintain approximately 150°C (302°F).

Service Cooling System Safely

Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

Avoid Harmful Asbestos Dust



Avoid breathing dust that may be generated when handling components containing asbestos fibers. Inhaled asbestos fibers may cause lung cancer.

Components in products that may contain asbestos fibers are brake pads, brake band and lining assemblies, clutch plates, and some gaskets. The asbestos used in these components is usually found in a resin or sealed in some way. Normal handling is not hazardous as long as airborne dust containing asbestos is not generated.

Avoid creating dust. Never use compressed air for cleaning. Avoid brushing or grinding material containing asbestos. When servicing, wear an approved respirator. A special vacuum cleaner is recommended to clean asbestos. If not available, apply a mist of oil or water on the material containing asbestos.

Keep bystanders away from the area.

Prevent Battery Explosions

Keep sparks, lighted matches, and open flame away from the top of battery. Battery gas can explode.

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

Do not charge a frozen battery; it may explode. Warm the battery to 16°C (60°F).

Prevent Acid Burns

Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into eyes.

Avoid the hazard by:

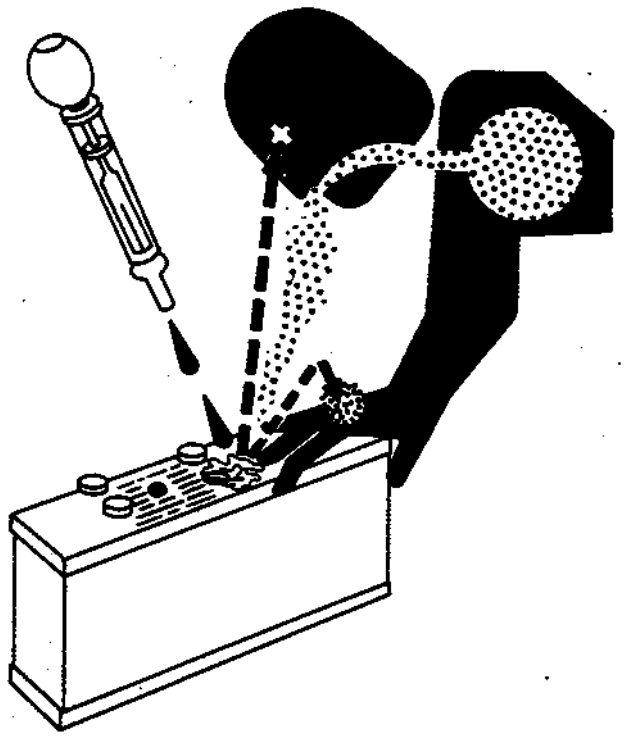
1. Filling batteries in a well-ventilated area.
2. Wearing eye protection and rubber gloves.
3. Avoiding breathing fumes when electrolyte is added.
4. Avoiding spilling or dripping electrolyte.
5. se proper jump-start procedure.

If you spill acid on yourself:

1. Flush your skin with water.
2. Apply baking soda or lime to help neutralize the acid.
3. Flush your eyes with water for 15—30 minutes. Get medical attention immediately.

If acid is swallowed:

1. Do not induce vomiting.
2. Drink large amounts of water or milk, but do not exceed 2 L (2 quarts).
3. Get medical attention immediately.

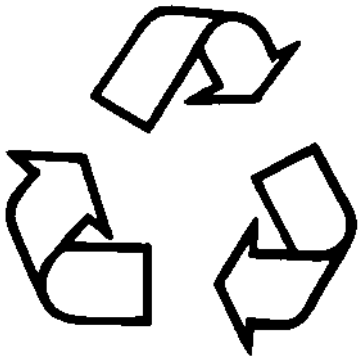


Protect Against High Pressure Spray

Spray from high-pressure nozzles can penetrate the skin and cause serious injury. Keep spray from contacting hands or body.

If an accident occurs, see a doctor immediately. Any high-pressure spray injected into the skin must be surgically removed within a few hours or gangrene may result.

Dispose of Waste Properly



Improperly disposing of waste can threaten the environment and ecology. Potentially harmful wastes used with Ingersoll-Rand equipment include such items as oil, fuel, coolant, brake fluid, filters, and batteries.

Use leak proof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them.

Do not pour waste onto the ground, down a drain, or into any water source.

Inquire on the proper way to recycle or dispose of waste from your local environmental or recycling center, or from your Ingersoll-Rand dealer.

Live With Safety

Before returning machine to customer, make sure machine is functioning properly, especially the safety systems. Install all guards and shields.

Fuels, Lubricants, and Coolant

Diesel Fuel

Consult your local fuel distributor for properties of the diesel fuel available in your area.

In general, diesel fuels are blended to satisfy the low temperature requirements of the geographical area in which they are marketed.

Diesel fuels specified to EN 590 or ASTM D975 are recommended.

Required fuel properties

In all cases, the fuel must meet the following properties:

Cetane number of 45 minimum. Cetane number greater than 50 is preferred, especially for temperatures below -20°C (-4°F) or elevations above
1500 m (5000 ft).

Cold Filter Plugging Point (CFPP) below the expected low temperature OR **Cloud Point** at least 5°C (9°F) below the expected low temperature.

Fuel lubricity should pass a minimum load level of
3100 grams as measured by ASTM D6078 or, maximum scar diameter of 0.45 mm as measured by ASTM D6079.

Sulfur content:

Diesel fuel quality and fuel sulfur content must comply with all existing regulations for the area in which the engine operates.

Sulfur content less than 0.05% (500 ppm) is preferred.

If diesel fuel with sulfur content greater than 0.05% (500 ppm) is used, crankcase oil service intervals may be affected. (See recommendation for Diesel Engine Oil.)

DO NOT use diesel fuel with sulfur content greater than 1.0%.

NOTICE

DO NOT mix used engine oil or any other type of lubricating oil with diesel fuel.

Lubricity of Diesel Fuel

Diesel fuel must have adequate lubricity to ensure proper operation and durability of fuel injection system components.

Diesel fuels for highway use in the United States and Canada require sulfur content less than 0.05% (500 ppm).

Diesel fuel in the European Union requires sulfur content less than 0.05% (500 ppm).

Experience shows that some low sulfur diesel fuels may have inadequate lubricity and their use may reduce performance in fuel injection systems due to inadequate lubrication of injection pump components. The lower concentration of aromatic compounds in these fuels also adversely affects injection pump seals and may result in leaks.

Use of low lubricity diesel fuels may also cause accelerated wear, injection nozzle erosion or corrosion, engine speed instability, hard starting, low power, and engine smoke.

Fuel lubricity should pass a minimum load level of 3100 gram as measured by the ASTM D6078 or maximum scar diameter of 0.45 mm as measured by ASTM D6079.

ASTM D975 and EN 590 specifications do not require fuels to pass a fuel lubricity test.

Diesel Fuel Storage

Handle fuel carefully. Do not fill the fuel tank when engine is running.

DO NOT smoke while you fill the fuel tank or service the fuel system.

Fill the fuel tank at the end of each day's operation to prevent water condensation and freezing during cold weather.

DO NOT store diesel fuel in galvanized containers. Diesel fuel stored in galvanized containers reacts with zinc coating on container to form zinc flakes. If fuel contains water, a zinc gel will also form. The gel and flakes will quickly plug fuel filters, damage injection nozzles and injection pump.

DO NOT use brass-coated containers for fuel storage. Brass is an alloy of copper and zinc.

Store diesel fuel in plastic, aluminum, and steel containers specially coated for diesel fuel storage.

Avoid storing fuel over long periods of time. If fuel is stored for more than a month prior to use, or there is a slow turnover in fuel tank or supply tank, add a fuel conditioner to stabilize the fuel and prevent water condensation. Fuel conditioner also reduces fuel gelling and controls wax separation during cold weather.

The fuel tank is vented through the filler cap. If a new filler cap is required, always replace with an original vented cap.

Bio-Diesel Fuel

Consult your local fuel distributor for properties of the bio-diesel fuel available in your area.

Bio-diesel fuels may be used ONLY if the bio-diesel fuel properties meet the latest edition of ASTM D6751, DIN 51606, EN14214 or equivalent specification.

It has been found that bio-diesel blends up to 5% by volume in petroleum diesel fuel (or B5) may improve lubricity and with no harmful effects.

When using a blend of bio-diesel fuel, the engine oil level must be checked daily when the air temperature is -10°C (14°F) or lower. If the oil becomes diluted with fuel, shorten oil change intervals accordingly.

NOTICE

Raw pressed vegetable oils are NOT acceptable for use for fuel in any concentration in Ingersoll-Rand equipment engines.

These oils do not burn completely, and will cause engine failure by leaving deposits on injectors and in the combustion chamber.

A major environmental benefit of bio-diesel fuel is its ability to biodegrade. This makes proper storage and handling of bio-diesel fuel especially important. Areas of concern include:

- Quality of new fuel
- Water content of the fuel
- Problems due to aging of the fuel

Potential problems resulting from deficiencies in the above areas when using bio-diesel fuel in concentrations above 5% may lead to the following symptoms:

- Power loss and deterioration of performance
- Fuel leakage
- Corrosion of fuel injection equipment
- Coked and/or blocked injector nozzles, resulting in engine misfire
- Filter plugging
- Lacquering and/or seizure of internal components
- Sludge and sediments
- Reduced service life of engine components

Handling And Storing Bio-Diesel Fuel

Handle fuel carefully. Do not fill the fuel tank when engine is running.
DO NOT smoke while you fill the fuel tank or service the fuel system.

Fill the fuel tank at the end of each day's operation to prevent water condensation and freezing during cold weather.

Keep all storage tanks as full as practicable to minimize condensation.

Ensure that all fuel tank caps and covers are installed properly to prevent moisture from entering.

Monitor water content of the fuel regularly.

Fuel filter may require more frequent replacement due to premature plugging.

Check engine oil level daily prior to starting engine. A rising oil level may indicate fuel dilution of the engine oil.

The fuel tank is vented through the filler cap.
If a new filler cap is required, always replace it with an original vented cap.

When fuel is stored for an extended period or if there is a slow turnover of fuel, add a fuel conditioner to stabilize the fuel and prevent water condensation. Contact your fuel supplier for recommendations.

Filling Fuel Tank

⚠CAUTION

Handle fuel carefully. Do not fill the fuel tank when engine is running.

DO NOT smoke while filling fuel tank or servicing fuel system.

NOTICE

The fuel tank is vented through the filler cap.
If a new filler cap is required, always replace it with an original vented cap.

Fill fuel tank at the end of each day's operation to prevent condensation in tank, as moist air-cools, condensation may form and freeze during cold weather.

Minimizing the Effect of Cold Weather on Diesel Engines

Diesel engines are designed to operate effectively in cold weather.

However, for effective starting and cold weather operation, a little extra care is necessary. The information below outlines steps that can minimize the effect that cold weather may have on starting and operation of your engine. See your authorized engine distributor or servicing dealer for additional information and local availability of cold weather aids.

Use Grade No. 1-D Fuel

When temperatures fall below 5°C (40°F), Grade No. 1-D fuel is best suited for cold weather operation. Grade No. 1-D fuel has a lower cloud point and a lower pour point.

Cloud point is the temperature at which wax will begin to form in the fuel and this wax causes fuel filters to plug. **Pour point** is the temperature at which fuel begins to thicken and becomes more resistant to flow through fuel pumps and lines.

NOTICE

On an average, Grade No. 1-D fuel has a lower BTU (heat content) rating than Grade No. 2-D fuel. When using Grade No. 1-D fuel you may notice a drop in power and fuel efficiency, but should not experience any other engine performance effects. Check the grade of fuel being used before troubleshooting for low power complaints in cold weather operation.

Air Inlet Heater Aids

Air Heaters in the air inlet are standard equipment to aid in cold weather starting at temperatures below 0°C (32°F). (See Cold Weather Starting in section).

Coolant Heaters

Engine block heaters (coolant) are an available option to aid cold weather starting.

Seasonal Viscosity Oil and Proper Coolant Concentration

Use seasonal grade viscosity engine oil based on expected air temperature range between oil changes and a proper concentration of low silicate antifreeze as recommended. (See DIESEL ENGINE OIL and ENGINE COOLANT REQUIREMENTS later in this section).

Diesel Fuel Flow Additive

NOTICE

Treat fuel with a cold weather diesel fuel conditioner **when outside temperature drops below 0°C (32°F). For best results, use with untreated fuel. Follow all recommended instructions on label.**

Winter fronts

Use of fabric, cardboard, or solid winter fronts is not recommended with any engine. Their use can result in excessive engine coolant, oil, and charge air temperatures. This can lead to reduced engine life, loss of power and poor fuel economy. Winter fronts may also put abnormal stress on fan and fan drive components potentially causing premature failures.

If winter fronts are used, they should never totally close off the grill frontal area. Approximately 25% area in the center of the grill should remain open at all times. At no time should the air blockage device be applied directly to the radiator core.

Radiator Shutters

If equipped with a thermostatically controlled radiator shutter system, this system should be regulated in such a way that the shutters are completely open by the time the coolant reaches 93°C (200°F) to prevent excessive intake manifold temperatures. Manually controlled systems are not recommended.

If air-to-air after cooling is used, the shutters must be completely open by the time the intake manifold air temperature reaches the maximum allowable temperature out of the charge air cooler.

For more information, see your Ingersoll-Rand distributor or servicing dealer.

Diesel Engine Break-In Oil

New engines are filled at the factory with engine break-in oil.

Change the oil and filter after the first 100 hours of operation of a new or rebuilt engine.

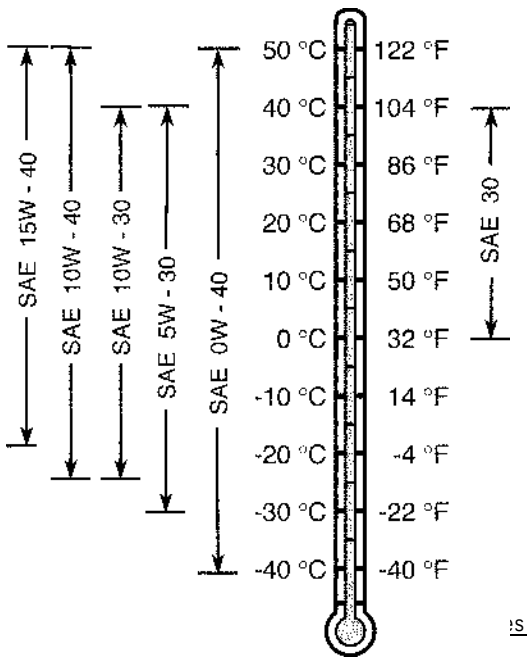
During the break-in period use a SAE 10W-30 DIESEL ENGINE oil meeting one of the following during the first 100 hours of operation to maintain the specified oil level.

- API Service Category CE
- API Service Category CD
- API Service Category CC
- ACEA Oil Sequence E2
- ACEA Oil Sequence E1

Diesel Engine Oil

Use oil viscosity based on the expected air temperature range during the period between oil changes. The following oil is preferred:

- Oils meeting ACEA Specification E4/E5



Other oils may be used if they meet one or more of the following:

- API Service Classification CI-4
- API Service Classification CH-4
- ACEA Specification E3

Multi-viscosity diesel engine oils are preferred.

Diesel fuel quality and sulfur content must comply with all existing emissions regulations for the area in which the engine operates.

If diesel fuel with sulfur content greater than 0.05% (500 ppm) is used, reduce the oil and filter change interval by 100 hours.

If diesel fuel with sulfur content greater than 0.5% (5000 ppm) is used, reduce the service interval by 50%.

Diesel fuel with sulfur content greater than 1.0% (10,000 ppm) is not recommended.

Extended service intervals may apply when Ingersoll-Rand preferred engine oils are used. Consult your Ingersoll-Rand dealer for more information.

NOTICE

DO NOT use break-in oils in these engines.

Mixing of Lubricants

In general, avoid mixing different brands or types of oil. Oil manufacturers blend additives in their oils to meet certain specifications and performance requirements.

Mixing different oils can interfere with the proper functioning of these additives and degrade lubricant performance.

Consult your Ingersoll-Rand distributor or servicing dealer to obtain specific information and recommendations.

Oil Filters

Filtration of oils is critical to proper operation and lubrication. Always change filters regularly as specified in this manual. Use Ingersoll-Rand filters to meet factory performance specifications.

Alternative and Synthetic Lubricants

Conditions in certain geographical areas may require lubricant recommendations different from those printed in this manual.

Some Ingersoll-Rand brand coolants and lubricants may not be available in your location.

Consult your Ingersoll-Rand dealer to obtain information and recommendations.

Synthetic lubricants may be used if they meet the performance requirements as shown in this manual.

The temperature limits and service intervals shown in this manual apply to both conventional and synthetic oils.

Re-refined base stock products may be used if the finished lubricant meets the performance requirements.

Lubricant Storage

Your equipment can operate at top efficiency only when clean lubricants are used.
Use clean containers to handle all lubricants. Whenever possible, store lubricants and containers in an area protected from dust, moisture, and other contamination. Store containers on their side to avoid water and dirt accumulation.

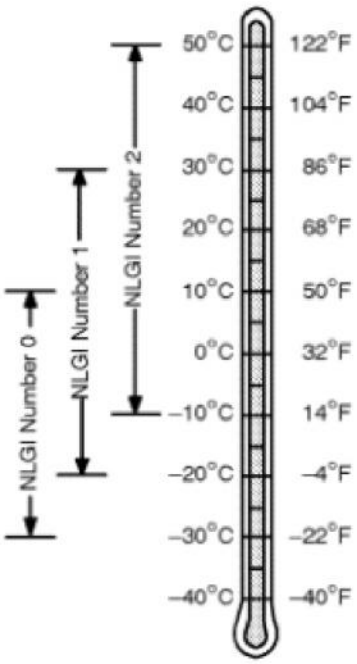
Make certain that all containers are properly marked to identify their contents.

Properly dispose of all old containers and any residual lubricant they may contain.

Grease

Use grease based on NLGI consistency numbers and the expected air temperature range during the service interval.

- NLGI Performance Classification GC-LB



NOTICE

Some types of grease thickener are not compatible with others. Consult your Ingersoll-Rand dealer before mixing different types of grease.

Diesel Engine Coolant

The engine cooling system is filled to provide year-round protection against corrosion and cylinder liner pitting, and winter freeze protection to -37°C (-34°F).

Low silicate ethylene glycol base coolants may be used if they meet one of the following specifications:

- ASTM D5345 (prediluted coolant)
- ASTM D4985 (coolant concentrate) in a 40 to 60% mixture of concentrate with quality water

Coolants meeting these specifications require use of supplemental coolant additives, formulated for heavy-duty diesel engines, for protection against corrosion and cylinder wall erosion and pitting.

A 50% mixture of ethylene glycol engine coolant in water provides freeze protection to -37°C (-34°F). If protection at lower temperatures is required, consult your Ingersoll-Rand dealer for recommendations.

Water quality is important to the performance of the cooling system. Distilled, deionized, or demineralized water is recommended for mixing with ethylene glycol base engine coolant concentrate.

NOTICE

Do not use cooling system sealing additives or antifreeze that contains sealing additives.

Coolant Drain Intervals

Drain the factory fill engine coolant, flush the cooling system, and refill with new coolant after the first 2 years or 2400 hours of operation. Subsequent drain intervals are determined by the coolant used for service. At each interval, drain the coolant, flush the cooling system, and refill with new coolant.

Diesel Engine Coolants, Supplemental Additive Information

Engine coolants are a combination of three chemical components: ethylene glycol (antifreeze), inhibiting coolant additives, and quality water.

Coolant Specifications

Some products are fully formulated coolants that contain all three components in their correct concentrations. Do not add an initial charge of supplemental coolant additives to these fully formulated products.

Some coolant concentrates contain both ethylene glycol antifreeze and inhibiting coolant additives. Mix these products and quality water, but do not add an initial charge of supplemental coolant additives.

Coolants meeting ASTM D5345 (prediluted coolant) or ASTM D4985 (coolant concentrate) require an initial charge of supplemental coolant additives.

Replenish Coolant Additives

The concentration of coolant additives is gradually depleted during engine operation. Periodic replenishment of inhibitors is required. Follow the recommendations in this manual for the use of supplemental coolant additives.

Why Use Supplemental Coolant Additives?

Operating without proper coolant additives will result in increased corrosion, cylinder wall erosion and pitting, and other damage to the engine and cooling system. A simple mixture of ethylene glycol and water will not give adequate protection.

Use of supplemental coolant additives reduces corrosion, erosion, and pitting. These chemicals reduce the number of vapor bubbles in the coolant and help form a protective film on cylinder wall surfaces. This film acts as a barrier against the harmful effects of collapsing vapor bubbles.

Avoid Automotive-Type Coolants

Never use automotive-type coolants (such as those meeting ASTM D3306 or ASTM D4656). These coolants do not contain the correct additives to protect heavy-duty diesel engines. They often contain a high concentration of silicates and may damage the engine or cooling system.

Water Quality

Water quality is important to the performance of the cooling system. Distilled, deionized, or demineralized water is recommended for mixing with ethylene glycol base engine coolant concentrate. All water used in the cooling system should meet the following minimum specifications for quality:

Chlorides	<40 mg/L
Sulfates	<100 mg/L
Total Dissolved Solids	<340 mg/L
Total Hardness	<170 mg/L
PH	5.5 to 9.0

Freeze Protection

The relative concentrations of ethylene glycol and water in the engine coolant determine its freeze protection limit.

Ethylene Glycol	Freeze Protection Limit
40%	-24°C (-12°F)
50%	-37°C (-34°F)
60%	-52°C (-62°F)

DO NOT use a coolant-water mixture greater than 60% ethylene glycol.

Testing Diesel Engine Coolant

Maintaining adequate concentrations of glycol and inhibiting additives in the coolant is critical to protect the engine and cooling system against freezing, corrosion, and cylinder wall erosion and pitting.

Test the coolant solution at intervals of 12 month or less and whenever excessive coolant is lost through leaks or overheating.

Supplemental Coolant Additives

The concentration of coolant additives is gradually depleted during engine operation. For all recommended coolants, replenish additives between drain intervals by adding a supplemental coolant additive every 12 months or as determined necessary by coolant testing.

If other coolants are used, consult the coolant supplier and follow the manufacturer's recommendation for use of supplemental coolant additives.

The use of non-recommended supplemental coolant additives may result in additive dropout and gelation of the coolant.

Add the manufacturer's recommended concentration of supplemental coolant additive. DO NOT add more than the recommended amount.

Operating in Warm Temperature Climates

Diesel engines use Ingersoll-Rand equipment are designed to operate using glycol base engine coolants.

Always use a recommended glycol base engine coolant, even when operating in geographical areas where freeze protection is not required.

NOTICE

Water may be used as coolant in emergency situations only.

Foaming, hot surface aluminum and iron corrosion, scaling, and cavitation will occur when water is used as the coolant, even when coolant conditioners are added.

Drain cooling system and refill with recommended glycol base engine coolant as soon as possible.

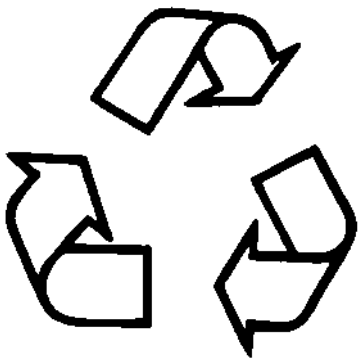
Disposing of Coolant

Improperly disposing of engine coolant can threaten the environment and ecology.

Use leak proof containers when draining fluids. Do not use food or beverage containers that may mislead someone into drinking from them.

Do not pour waste onto the ground, down a drain, or into any water source.

Inquire on the proper way to recycle or dispose of waste from your local environmental or recycling center, or from your Ingersoll-Rand distributor or servicing dealer.



Engine Operating Guidelines

Normal Engine Operation

Before starting, fill engine with oil and coolant meeting specifications. (See DIESEL ENGINE OIL and DIESEL ENGINE COOLANT SPECIFICATIONS in Fuels, Lubricants, and Coolant section.)

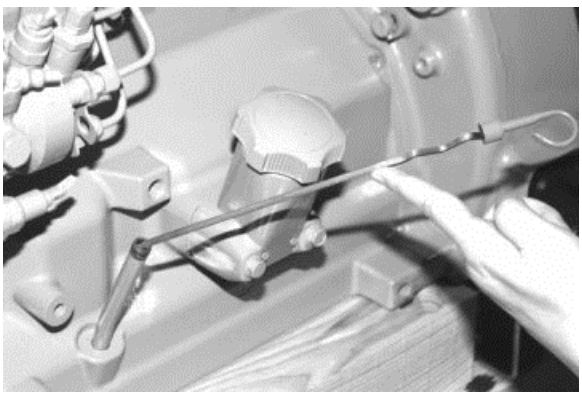
- Observe engine coolant temperature and engine oil pressure. Temperatures and pressures will vary between engines and with changing operating conditions, temperatures, and loads.
- Normal engine coolant operating temperature range is 90° – 100° C (194° – 212° F). If coolant temperature rises above 105° C (221° F), reduce load on engine. Unless temperature drops quickly, stop engine and determine cause before resuming operation.
- Operate the engine under a lighter load and at slower than normal speed for first 15 minutes after start-up. DO NOT run engine at slow idle.
- Stop engine immediately if there are any signs of part failure. Symptoms that may be early signs of engine problems are:
    - Sudden drop in oil pressure
    - Abnormal coolant temperatures
    - Unusual noise or vibration
    - Sudden loss of power
    - Excessive black exhaust
    - Excessive fuel consumption
    - Excessive oil consumption
    - Fluid leaks

Engine Break-In Service

The engine is ready for normal operation. However, extra care during the first 100 hours of operation will result in more satisfactory long-term engine performance and life. DO NOT exceed 100 hours of operation with break-in oil.

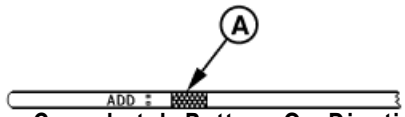
1. This engine is factory-filled with ENGINE BREAK-IN OIL (SAE 10W-30). Operate the engine at heavy loads with minimal idling during the break-in period.

2. If the engine has significant operating time at idle, constant speeds, and/or light load usage, or makeup oil is required in the first 100-hour period, a longer break-in period may be required. In these situations, an additional 100-hour break-in period is recommended using a new change of ENGINE BREAK-IN OIL and a new Ingersoll-Rand oil filter.



NOTICE

DO NOT add makeup oil until the oil level is BELOW the ADD mark on dipstick.
ENGINE BREAK-IN OIL should be used to make up any oil consumed during the break-in period.



A—Crosshatch Pattern On Dipstick

3. Check engine oil level more frequently during engine break-in period. If oil must be added during this period, Ingersoll-Rand ENGINE BREAK-IN OIL is preferred. See ENGINE BREAK-IN OIL, in Fuels, Lubricants, and Coolant Section.

NOTICE

DO NOT fill above the crosshatch pattern (A) or the FULL mark whichever is present.
Oil levels anywhere within the crosshatch are considered in the acceptable operating range.

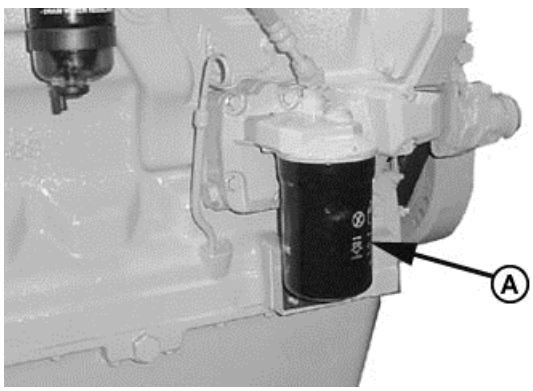
Specification

Engine[1]—Oil Pressure at Full Load Rated Speed - 345 ± 103 kPa (3.45 ± 1.03 bar) (50 ± 15 psi)
Minimum Oil Pressure at 850 rpm -105 kPa (1.05 bar) (15 psi)
Coolant Temperature Range - 82°–94°C (180°–202°F)

[1]At normal operating temperature of 115°C (240°F) oil sump.

4. During the first 20 hours, avoid prolonged periods of engine idling or sustained maximum load operation. If engine will idle longer than 5 minutes, stop engine.

5. Before the first 100 hours (maximum), change engine oil and replace engine oil filter (A). (See CHANGING ENGINE OIL AND REPLACING FILTER in Lubrication and Maintenance/500 Hour/12 Month Section.) Fill crankcase with seasonal viscosity grade oil. (See DIESEL ENGINE OIL, in Fuels, Lubricants, and Coolant Section.)



NOTICE

Some increase in oil consumption may be expected when low viscosity oils are used. Check oil levels more frequently.

6. If air temperature is below -10°C (14°F), use an engine block heater.

7. Check poly-vee belt for proper alignment and seating in pulley grooves.

Starting The Engine

⚠CAUTION

Before starting engine in a confined building, install proper outlet exhaust ventilation equipment. Always use safety approved fuel storage and piping.

NOTICE

If temperature is below 0° C (32° F), it may be necessary to use cold weather starting aids. (See COLD WEATHER OPERATION, later in this section).

1. Perform all prestarting checks outlined in Lubrication & Maintenance/Daily Section later in this manual.
2. Refer to the G80 Operation and Maintenance Manual for starting the generator set.
3. Warm-up engine for at least 5 minutes before applying a load.

Cold Weather Starting

When outside temperatures fall below 0°C (32° F) it may be necessary to consider using cold weather starting aids. Engines are equipped with air inlet heaters.

⚠CAUTION

NEVER USE ETHER as a starting aid with these glow plug-equipped engines. As it could cause an explosion and possible personnel injury.

Additionally, your Engine may be fitted with a block heater, and increased capacity battery and/or lower viscosity oil may also be used. See your local Ingersoll-Rand distributor or servicing dealer for recommendations.

1. Perform all prestarting checks outlined in Lubrication & Maintenance/Daily Section later in this manual.
2. Refer to the G80 Operation and Maintenance Manual for starting and utilize the glow plug position on the start switch by holding at that position for 15 seconds to activate the air intake heaters to warm the combustion chamber.
3. Warm-up engine for at least 5 minutes before applying a load.

Stopping the Engine

1. Refer to the G60 Operation and Maintenance Manual for stopping the generator set.

NOTICE

Make sure that exhaust stack cap (rain cap) is in place when engine is not running. This will prevent water and dirt from entering engine.

2. Fill fuel tank to minimize possible water condensation problems. Filling tanks at end of day drives out moisture-laden air

Using a Booster Battery or Charger

A 12-volt booster battery can be connected in parallel with battery (ies) on the unit to aid in cold weather starting. ALWAYS use heavy-duty jumper cables.

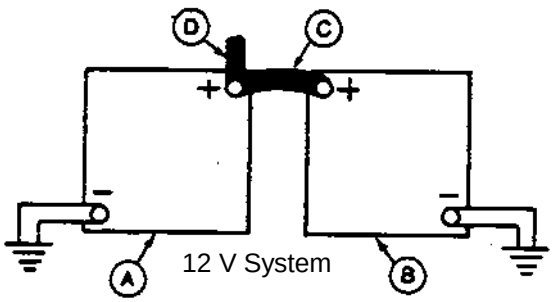
Exploding Battery

⚠CAUTION

Gas given off by battery is explosive. Keep sparks and flames away from battery. Before connecting or disconnecting a battery charger, turn charger off. Make last connection and first disconnection at a point away from battery. Always connect NEGATIVE (–) cable last and disconnect this cable first.

⚠WARNING

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. **Wash hands after handling.**

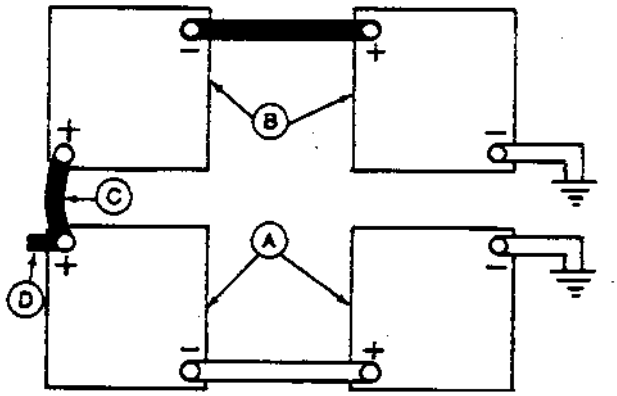


NOTICE

Be sure polarity is correct before making connections. Reversed polarity will damage electrical system. Always connect positive-to-positive **and negative to ground. Always use 12-volt booster battery for 12-volt electrical systems and 24-volt booster battery (ies) for 24-volt electrical systems.**

1. Connect booster battery or batteries to produce the required system voltage for your engine application.

A – 12-Volt Machine Battery (ies)
B – 12-Volt Booster Battery (ies)
C – Booster Cable
D – Cable to Starting Motor



24 V System

NOTICE

To avoid sparks, DO NOT allow the free ends of jumper cables to touch the engine.

2. Connect one end of jumper cable to the POSITIVE (+) post of the booster battery.
3. Connect the other end of the jumper cable to the POSITIVE (+) post of battery connected to starter.
4. Connect one end of the other jumper cable to the NEGATIVE (–) post of the booster battery.
5. ALWAYS complete the hookup by making the last connection of the NEGATIVE (–) cable to a good ground on the engine frame and away from the battery (ies).
6. Start the engine. Disconnect jumper cables immediately after engine starts. Disconnect NEGATIVE (–) cable first.

Lubrication and Maintenance

Observe Service Intervals

Using the hour meter as a guide, perform all services at the hourly intervals indicated on following pages. At each scheduled maintenance interval, perform all previous maintenance operations in addition to the ones specified. Keep a record of hourly intervals and services performed using charts provided in Lubrication and Maintenance Records Section.

Recommended service intervals are for normal operating conditions.
Service MORE OFTEN if engine is operated under adverse conditions.
Neglecting maintenance can result in failures or permanent damage to the engine.

Use Correct Fuels, Lubricants, and Coolant

Use only fuels, lubricants, and coolants meeting specifications outlined in the Fuels, Lubricants, and Coolant Section when servicing your engine.

Consult your Ingersoll-Rand distributor, servicing dealer or your nearest Ingersoll-Rand Parts Network for recommended fuels, lubricants, and coolant. Also available are necessary additives for use when operating engines in tropical, arctic, or any other adverse conditions.

Lubrication and Maintenance Service Interval Chart—Standard Industrial Engines

NOTICE

The service intervals below are for standard industrial engines.
See details in the Sections, which follow these charts.

Item	Lubrication and Maintenance Service Intervals			
	Daily	500 Hour/ 12 Month	2000 Hour/ 24 Month	As Required
Check Engine Oil and Coolant Level	•			
Check Fuel Filter/Water Bowl	•			
Check Air Cleaner Dust Unloader Valve & Indicator [a]	•			
Perform Visual Walk Around Inspection	•			
Change Engine Oil And Replace Oil Filter [b]		•		
Check Engine Mounts		•		
Service Battery		•		
Clean Crankcase Vent Tube		•		
Check Air Intake Hoses Connections & System		•		
Replace Fuel Filter and Bleed System		•		
Check Manual Belt Tensioner and Belt Wear				
Check Automatic Belt Tensioner and Belt Wear		•		
Check Engine Electrical Ground Connection		•		
Check Cooling System		•		
Coolant Solution Analysis – Add SCA's as required		•		
Pressure Test Cooling System		•		
Check Crankshaft Vibration Damper (6.8L Engines) [c]				
Flush and Refill Cooling System			•	
Test Thermostats			•	
Check and Adjust Valve Clearance			•	
Add Coolant				•
Replace Air Cleaner Elements				•
Replace Poly-Vee Belt				•
Check Fuses				•
Bleed Fuel System				•

[a] Replace primary air cleaner element when restriction indicator shows a vacuum of 625 mm (25 in.) H20.

[b] During engine break-in, change the oil and filter for the first time before 100 hours of operation.

[c] Replace crankshaft damper every 4500 hours or 60 months, whichever occurs first.

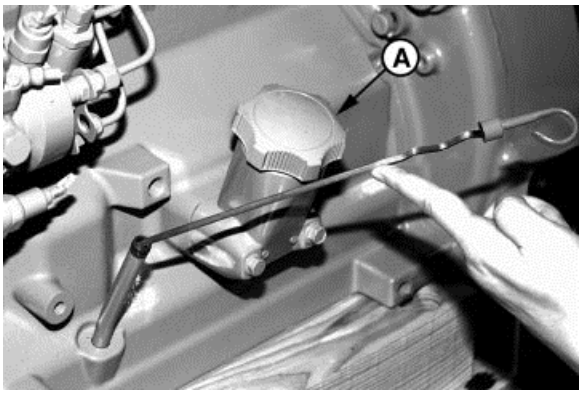
Lubrication & Maintenance/Daily

Daily Prestarting Checks

Do the following BEFORE STARTING THE ENGINE for the first time each day:

1. Check engine oil level on dipstick. Add as required, using seasonal viscosity grade oil. (See DIESEL ENGINE OIL in Fuels, Lubricants, and Coolant Section for oil specifications.)

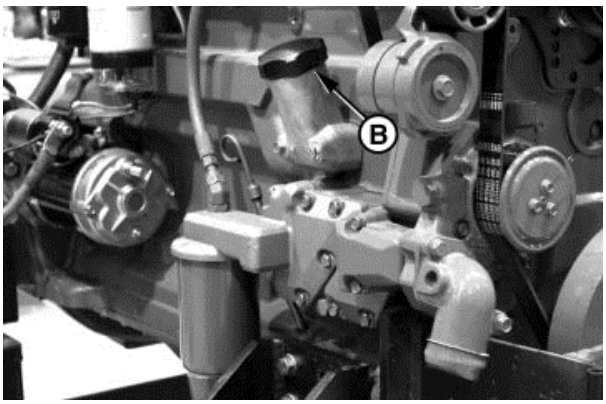
Depending on application, oil may be added at left (A) or right (B) side oil filler cap and rocker arm cover filler cap (C) locations.



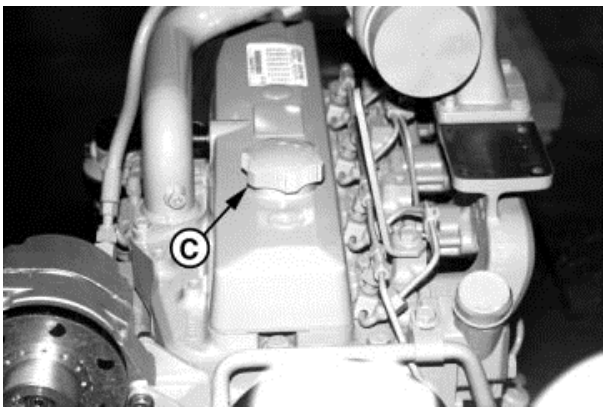
Left Side Oil Filler Cap

NOTICE

DO NOT add makeup oil until the oil level is BELOW the crosshatch marks on the dipstick.

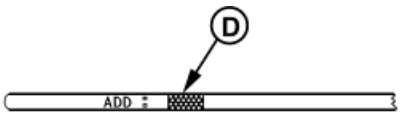


Right Side Oil Filler Cap



Valve Cover Oil Filler Cap

A—Left Side Oil Filler Cap
B—Right Side Oil Filler Cap
C—Cover Oil Filler Cap
D—Crosshatch On Dipstick



Crosshatch On Dipstick

NOTICE

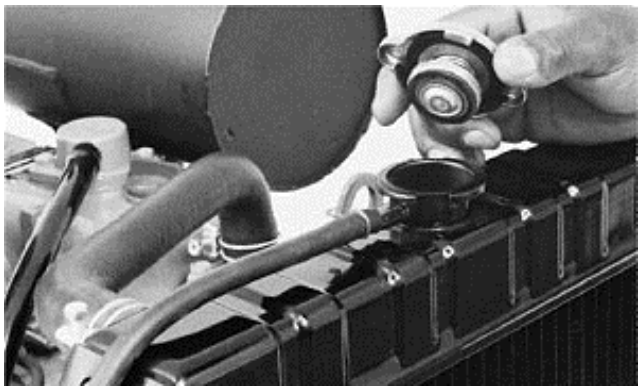
DO NOT fill above the top mark on the dipstick.
Oil levels anywhere within crosshatch (D) are considered in the acceptable operating range.

⚠CAUTION

Explosive release of fluids from pressurized cooling system can cause serious burns.

Only remove filler cap when engine is cold or when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

2. Check the coolant level when engine is cold. Coolant level should be at bottom of filler neck. Fill radiator (A) with proper coolant solution if level is low. (See ADDING COOLANT in Service As Required Section.) Check overall cooling system for leaks.



NOTICE

Refer to your vehicle's operator's manual for recommendations for non-Ingersoll-Rand supplied accessories.

3. Check the fuel filters for water or debris. If filter is fitted with a see-through bowl, drain as needed based on a daily visual inspection.

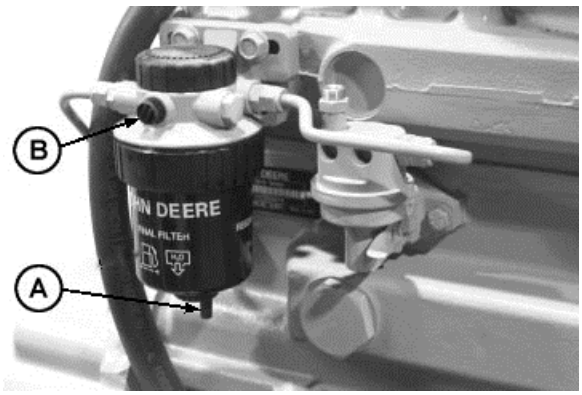
NOTICE

Drain water into a suitable container and dispose of properly.

a. Loosen drain plugs (A) at bottom of fuel filters or bowls, if equipped, two or three turns.

b. Loosen air bleed plug (B) two full turns on fuel filter mounting and drain water from bottom until fuel starts to drain out.

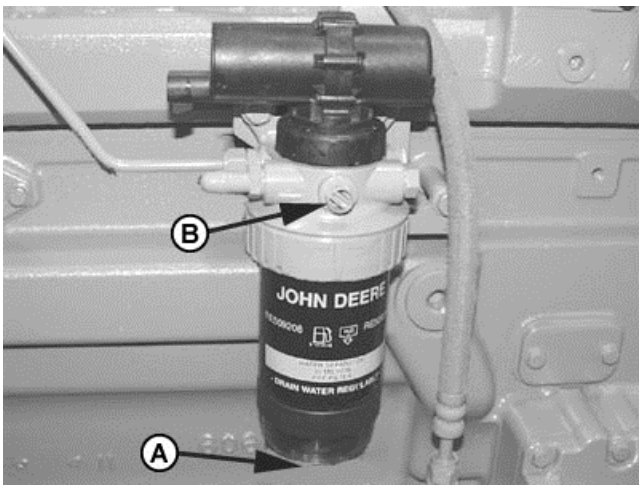
c. When fuel starts to drain out, tighten drain plugs securely.



Drain Final Fuel Filter

d. After draining water from the fuel filters, the filters must be primed by bleeding all air from the fuel system. See BLEEDING FUEL SYSTEM in Service As Required Section, later in this manual

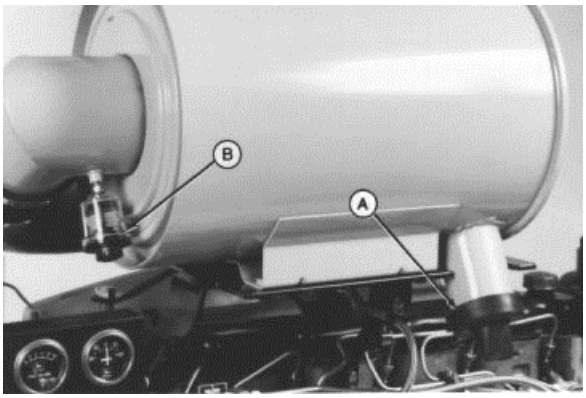
A—Drain Plug
B—Air Bleed Plug



Drain Primary Fuel Filter (If Equipped)

4. If the air cleaner has an automatic dust unloader valve (A), squeeze the unloader valve on air cleaner assembly to clear away any dust buildup.

If equipped with air intake restriction indicator gauge (B), check gauge to determine if air cleaner needs to be serviced.



Dust Unloader Valve and Indicator Gauge

NOTICE

Maximum air intake restriction is 6.25 kPa (0.06 bar) (1.0 psi) (25 in. H^2O).
A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.

5. Make a thorough inspection of the engine compartment. Look for oil or coolant leaks, worn fan and accessory drive belts, loose connections and trash build-up. Remove trash buildup and have repairs made as needed if leaks are found.

NOTICE

Wipe all fittings, caps, and plugs before performing any maintenance to reduce the chance of system contamination.

Inspect:

- Radiator for leaks and trash build-up.
- Air intake system hoses and connections for cracks and loose clamps.
- Fan, alternator, and accessory drive belts for cracks, breaks or other damage.
- Coolant pump for coolant leaks.

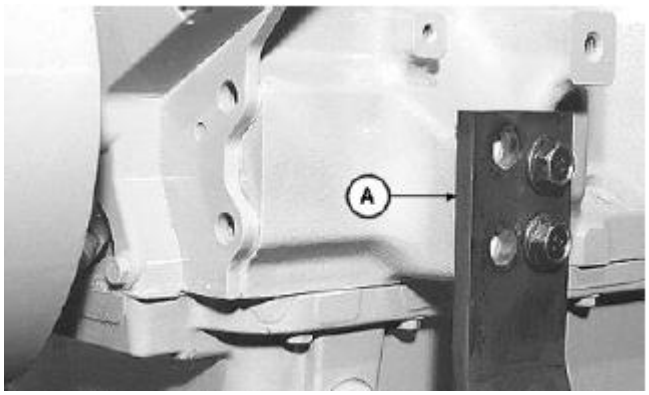
NOTICE

It is normal for a small amount of leakage to occur as the engine cools down and parts contract. Excessive coolant leakage may indicate the need to replace the coolant pump. Contact your engine distributor or servicing dealer for repairs.

Lubrication & Maintenance, 500 Hour/12 Month

Checking Engine Mounts

Engine mounting is the responsibility of the vehicle or generator manufacturer. Follow manufacturer's guidelines for mounting specifications.



NOTICE

Use only Grade SAE 8 or higher grade of hardware for engine mounting.

1. Check the engine mounting bracket, vibration isolators, and mounting bolts on support frame and engine block for tightness. Tighten as necessary.

2. Inspect overall condition of vibration isolators, if equipped. Replace isolators if rubber has deteriorated or mounts have collapsed, as necessary.

Servicing Battery

⚠CAUTION

Battery gas can explode. Keep sparks and flames away from batteries. Use a flashlight to check battery electrolyte level.

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

Always remove grounded NEGATIVE (–) battery clamp first and replace it last.

⚠WARNING

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. **Wash hands after handling.**

1. On regular batteries, check electrolyte level. Fill each cell to bottom of filler neck with distilled water.

NOTICE

Low-maintenance or maintenance-free batteries should require little additional service. However, electrolyte level can be checked by cutting the center section of the decal on the dash-line, and removing cell plugs. If necessary, add clean, soft water to bring the level to bottom of filler neck.

2. Keep batteries clean by wiping them with a damp cloth. Keep all connections clean and tight. Remove any corrosion, and wash terminals with a solution of 1 part baking soda and 4 parts water. Tighten all connections securely.

NOTICE

Coat battery terminals and connectors with a mixture of petroleum jelly and baking soda to retard corrosion.

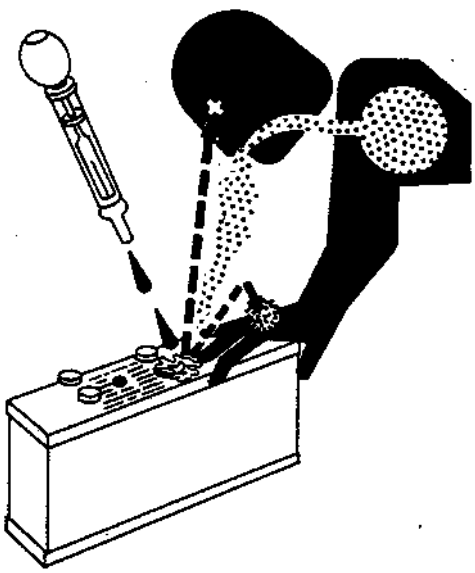
3. Keep battery fully charged, especially during cold weather. If a battery charger is used, turn charger off before connecting charger to battery(ies). Attach POSITIVE (+) battery charger lead to POSITIVE (+) battery post. Then attach NEGATIVE (–) battery charger lead to a good ground.

⚠CAUTION

Sulfuric acid in battery electrolyte is poisonous. It is strong enough to burn skin, eat holes in clothing, and cause blindness if splashed into eyes.

Avoid the hazard by:

1. **Filling batteries in a well-ventilated area.**
2. **Wearing eye protection and rubber gloves.**
3. **Avoiding breathing fumes when electrolyte is added.**
4. **Avoiding spilling or dripping electrolyte.**
5. **Use proper jump start procedure.**



If you spill acid on yourself:

1. **Flush your skin with water.**
2. **Apply baking soda or lime to help neutralize the acid.**
3. **Flush your eyes with water for 10–15 minutes. Get medical attention immediately.**

If acid is swallowed:

1. **Drink large amounts of water or milk.**
2. **Then drink milk of magnesia, beaten eggs, or vegetable oil.**
3. **Get medical attention immediately.**

4. In freezing weather, run engine at least 30 minutes to assure thorough mixing after adding water to battery.

If necessary to replace battery (ies), replacements must meet or exceed the following recommended capacities at -18°C (0°F):

Battery Specifications:

12-Volt Standard Duty Starter— Cold Cranking Amps - 640

12-Volt Heavy Duty Starter—Cold Cranking Amps - 800

24-Volt Standard Duty Starter— Cold Cranking Amps - 570

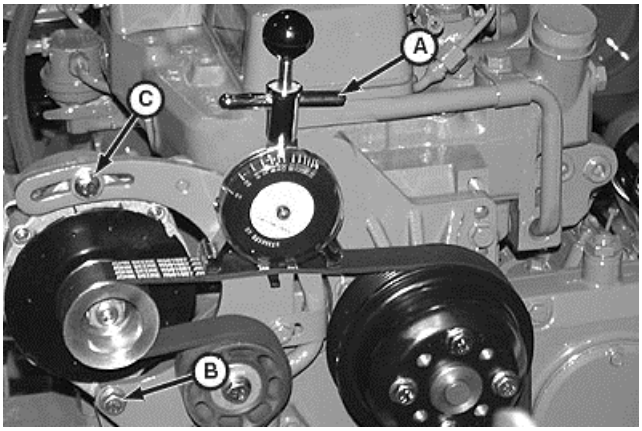
Manual Belt Tensioner Adjustment

NOTE: There are two types of manual tensioners shown.

NOTE: Inspect belts for cracks, fraying, or stretched-out areas. Replace if necessary.

As a reference check, twist belt in the middle of a 254—305 mm (10—12 in.) span with two fingers. A properly tensioned belt will turn 75—85 degrees. If belt turns more, it needs to be tightened. If belt turns less, it needs to be loosened.

NOTE: If timing gear cover or alternator bracket interfere with installation/centering of belt tension gauge (A), install gauge with face toward engine.

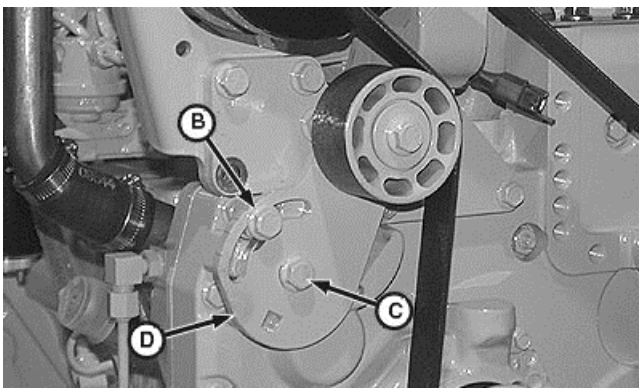


Check Belt Tension

1. Install JDG1341 Belt Tension Gauge (A) on belt, halfway between pulleys as shown. (JDG1341 Belt Tension Gauge available from local Ingersoll-Rand Dealer or Distributor.)

2. Loosen cap screws (B) and (C).

3. Slide alternator or tensioner bracket (D) in slot by hand to remove all excess slack in belt.



Adjust Belt Tension

NOTICE

Do not pry against alternator rear frame.

4. Stretch belt by prying outward on alternator front frame or tensioner bracket. Observing tension gauge, stretch the belt until specified tension is achieved.

A—Belt Tension Gauge
B—Cap Screw
C—Cap Screw
D—Tensioner Bracket

Specification

New Belt—Tension..... 470—650 N (105—145 lb-force)
Used Belt—Tension..... 400—580 N (90—130 lb-force)

5. Tighten cap screws (B) and (C).

NOTE: After ten minutes run-in, new belts are considered used. Belt tension must then be rechecked per used belt specifications.

6. Run engine for ten minutes and immediately re-check belt tension per used belt specification above.

7. Reset belt tension as necessary.

Manual Belt Tensioner Adjustment Using Belt Tension Tool (Alternate Method For Engines Without Auxiliary Drive)

NOTE: The JD1520 Belt Tension Tool may not be compatible with all alternators. In that case, use the preceding method for belt tensioning.

NOTE: Inspect belts for cracks, fraying, or stretched-out areas. Replace if necessary.

As a reference check, twist belt in the middle of a 254—305 mm (10—12 in.) span with two fingers. A properly tensioned belt will turn 75—85 degrees. If belt turns more, it needs to be tightened. If belt turns less, it needs to be loosened.

1. Loosen upper (A) and lower (B) alternator bracket cap screws. Lower cap screw must remain tight enough to prevent excessive alternator play but allow alternator to pivot by hand.

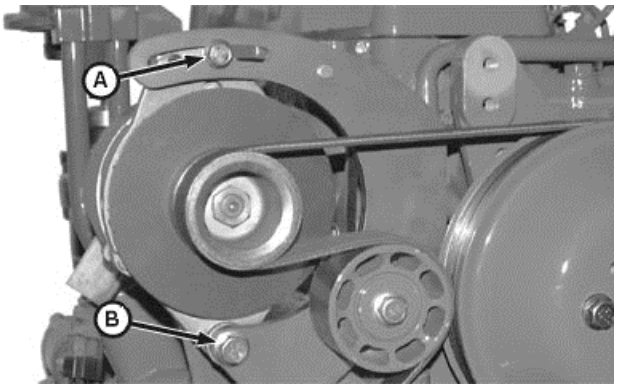
2. Insert JDG1520 Belt Tension Tool (C) behind belt (D) and over alternator mounting screw.

3. Place torque wrench (C) on belt tensioning tool (B) at 90° to tool. Pivot alternator (A) until desired torque is achieved according to specification using the following table.

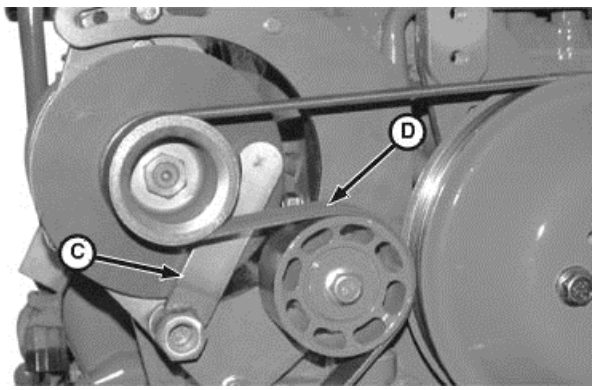
Specification

New Belt—Tension..... 470—650 N (105—145 lb-force)
Alternator Bracket and Cap Screws Alternator Bracket and Cap Screws
Used Belt—Tension..... 400—580 N (90—130 lb-force)

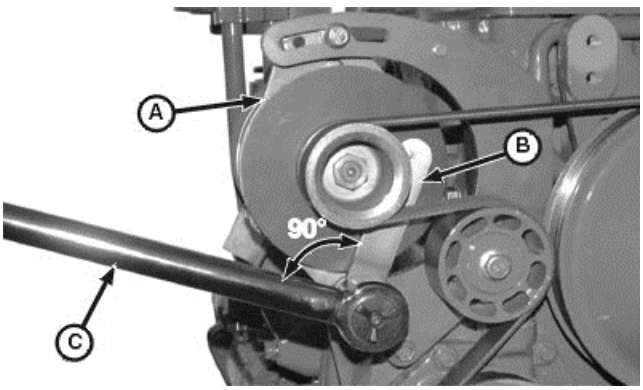
JDG1520 Belt Tensioning Tool Torque Table	
Desired Belt Tension N(lb-force)	**Applied Torque N•m (lb-ft)**
445 (100)	108 (90)
489 (110)	115 (85)
534 (120)	122 (90)
623 (140)	135 (100)



Alternator Bracket and Cap Screws



Belt Tension Tool



Belt Tension Tool and Torque Wrench

A—Alternator
B—Belt Tensioning Tool
C—Torque Wrench

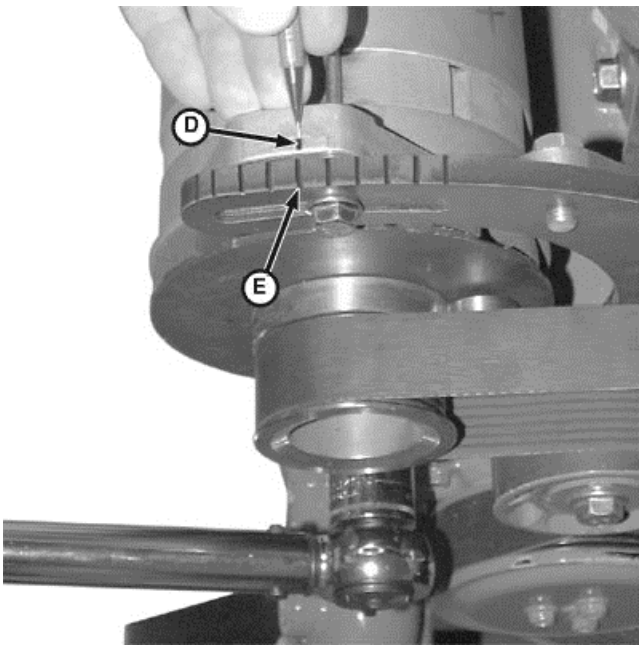
4. While holding tension with torque wrench (B), scribe a reference mark (D) on alternator in line with notch (E) on upper alternator bracket.

5. Continue to hold tension with torque wrench and tighten upper alternator bracket cap screw.

6. Check position of reference mark to see if alternator moved while tightening. If alternator moved, loosen upper alternator bracket cap screw and repeat the tension adjustment procedure.

7. Remove belt tension tool and tighten lower alternator bracket cap screw.

D—Reference Mark
E—Alternator Upper Bracket Notch



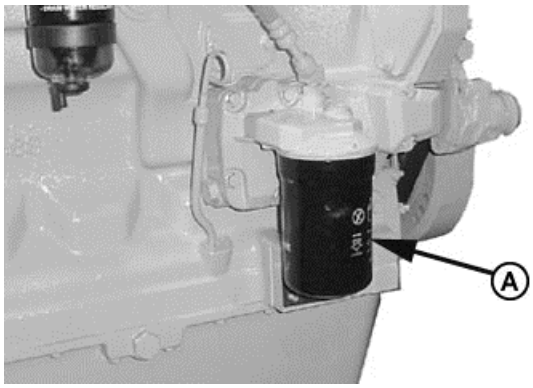
Scribe Reference Mark

Changing Engine Oil and Replacing Filter

NOTE: During break-in, change engine oil and filter for the first time before 100 hours maximum of operation.

To change engine oil and oil filter:

1. Run engine approximately 5 minutes to warm up oil. Shut engine off.
2. Remove oil pan drain plug (arrow).
3. Drain crankcase oil from engine while warm.



A—Oil Filter Element

NOTE: Drain plug location may vary, depending on the application.

4. Turn filter element (A) using a suitable filter wrench to remove. Discard oil filter element.

NOTE: Depending on engine application, oil filter may be located on either side of the engine in a high- or low-mount location.

NOTICE

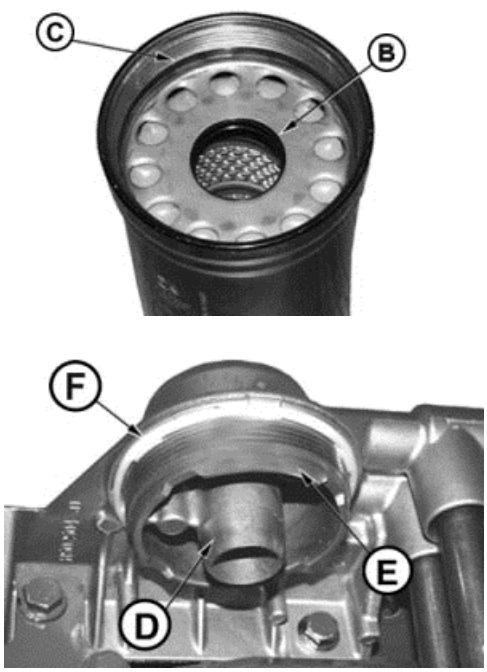
Filtration of oils is critical to proper lubrication. Always change filter regularly. Use filter meeting Ingersoll-Rand performance specifications.

5. Apply clean engine oil to the new filter at the inner (B) and outer (C) seals and to filter threads.
6. Wipe both sealing surfaces of the header (D, E) with a clean rag. Ensure dust seal (F) is in place, replace if damaged.

NOTICE

When installing filter element, HAND TIGHTEN only. A filter wrench may be used for REMOVAL ONLY.

7. Install and tighten oil filter by hand until firmly against dust seal (F). DO NOT apply an extra 3/4 to 1-1/4 turn after gasket contact as done with standard filters.
8. Tighten drain plug to specifications.



Oil Filter Seals

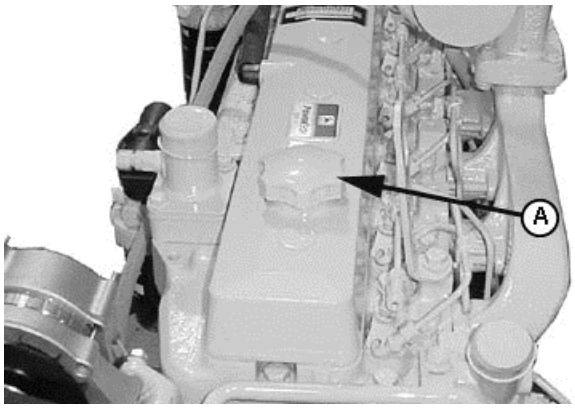
A—Oil Filter Element
B—Inner Seal
C—Outer Seal
D—Sealing Surface On Header
E—Sealing Surface On Header
F—Dust Seal

9. Fill engine crankcase with correct engine oil through rocker arm cover opening (A) or either side oil filler (B) depending on engine application. (See DIESEL ENGINE OIL in Fuels, Lubricants, and Coolant Section for determining correct engine oil.)

   To determine the correct oil fill quantity for your engine, see ENGINE CRANKCASE OIL FILL QUANTITIES in the Specifications Section of this manual.

NOTICE

Immediately after completing any oil change, crank engine for 30 seconds without permitting engine to start. This will help insure adequate lubrication to engine components before engine starts.



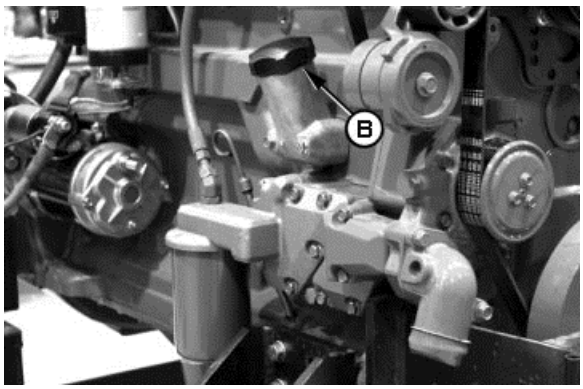
Rocker Arm Cover Oil Filler

NOTE: Crankcase oil capacity may vary slightly. ALWAYS fill crankcase within crosshatch marks on dipstick. DO NOT overfill.

10. Start engine and run to check for possible leaks.

11. Stop engine and check oil level after 10 minutes. Oil level reading should be within crosshatch of dipstick.

A—Rocker Arm Cover Oil Filler Opening
B—Oil Filler At Side Of Engine



Oil Filler At Side Of Engine

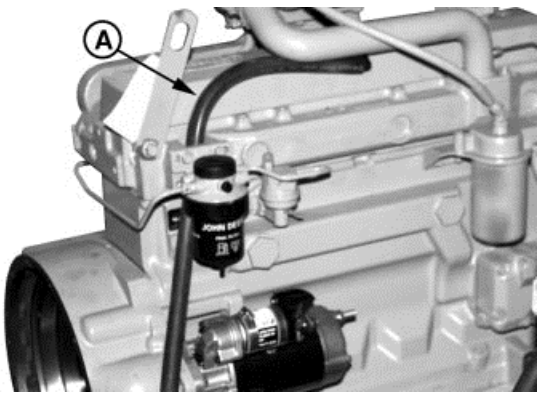
Cleaning Crankcase Vent System

Crankcase vent tube (If equipped)

If you operate the engine in dusty conditions, clean the tube at shorter intervals.

1. Remove and clean crankcase vent tube (A).

2. Install the vent tube. Be sure the O-ring fits correctly in the rocker arm cover for elbow adapter. Tighten hose clamp securely.



A—Crankcase Vent Tube

Closed Crankcase Ventilation System (If Equipped)

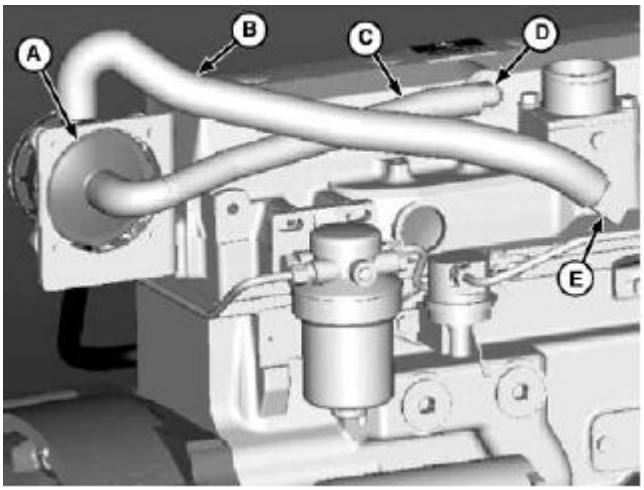
1. Inspect hoses (C,D and G) for kinks, blockage, or other damage.

2. Inspect check valve (H) for damage. (Valve is installed with black end toward crankcase).

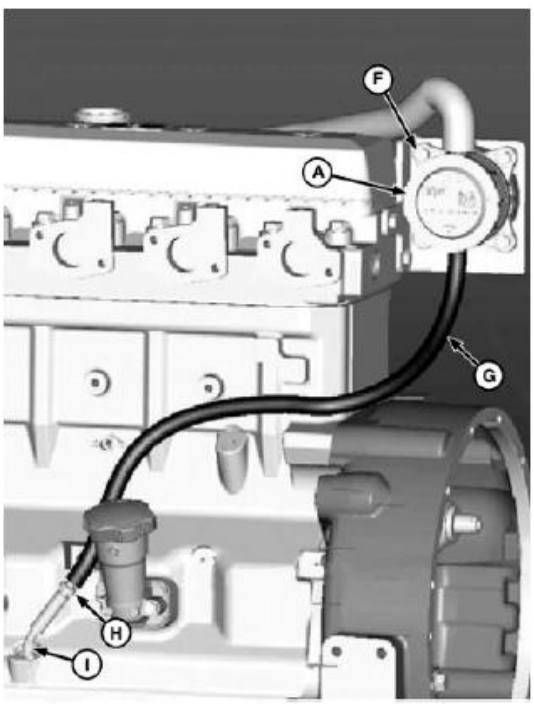
3. Verify that Crank case oil drain tube (I) is not plugged.

4. Inspect CCV valve (A) for cracks or other damage.

   A. Closed Crankcase Ventilation (CCV Valve)
   B. Hose, CCV Valve to Intake Manifold
   C. Hose, Valve Cover to CCV Valve
   D. Valve Cover Vent Fitting
   E. Intake Manifold Fitting
   F. Cap Screw, CCV Valve to Bracket
   G. Oil Drain Hose
   H. Check Valve
   I. Crank Oil Drain Tube



Closed Crankcase Vent



Closed Crankcase Vent

Checking Air Intake System

NOTICE

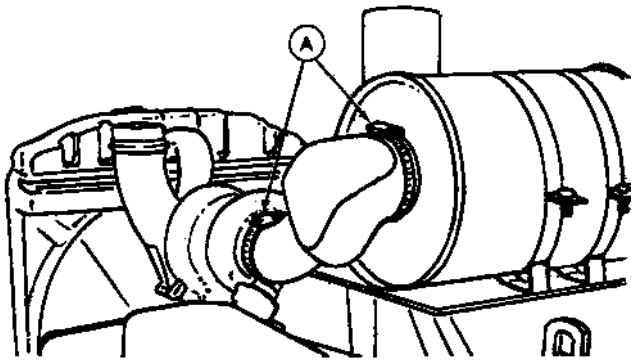
The air intake system must not leak. Any leak, no matter how small, may result in internal engine damage due to abrasive dirt and dust entering the intake system.

1. Inspect all intake hoses (piping) for cracks. Replace as necessary.

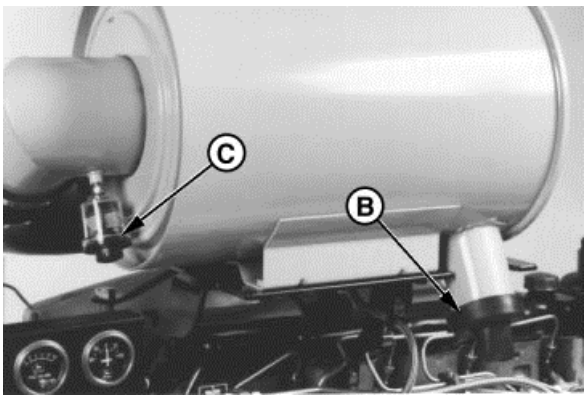
2. Check clamps (A) on piping which connect the air cleaner, engine and, if present, turbocharger. Tighten clamps as necessary. This will help prevent dirt from entering the air intake system through loose connections causing internal engine damage.

3. If engine has a rubber dust unloader valve (B), inspect the valve on bottom of air cleaner for cracks or plugging. Replace as necessary.

A—Clamps
B—Dust Unloader Valve amps
C—Air Restriction Indicator



Check Clamps



Underloader Valve and Air Restriction

NOTICE

ALWAYS REPLACE primary air cleaner element when air restriction indicator shows a vacuum of 625 mm (25 in.) H_2O, is torn, or visibly dirty.

4. Test air restriction indicator (C) for proper operation. Replace indicator as necessary.

NOTICE

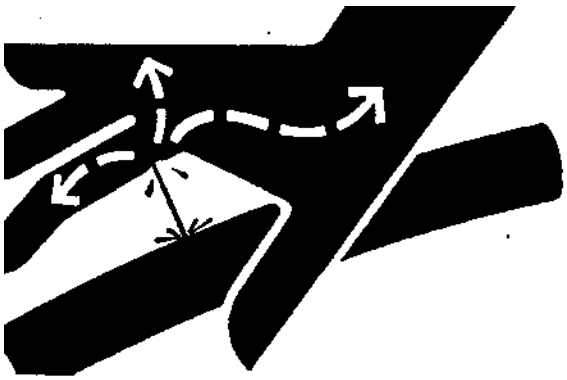
If not equipped with air restriction indicator, replace air cleaner elements at 500 Hours or 12 Months, whichever occurs first.

Replacing Fuel Filter Elements

Engines may be equipped with either a primary fuel filter (or pre-filter) with water bowl and a final filter, or only a final filter including water bowl. Both filters are replaced at the same 500-hour interval.

⚠CAUTION

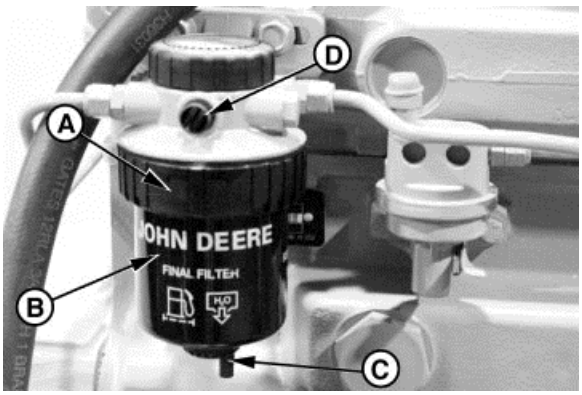
Escaping fluid under pressure can penetrate the skin causing serious injury. Relieve pressure before disconnecting fuel or other lines. Tighten all connections before applying pressure. Keep hands and body away from pinholes and nozzles, which **eject fluids under high pressure. Use a piece of cardboard or paper to search for leaks. Do not use your hand.**



If any fluid is injected into the skin, it must be surgically removed within a few hours by a doctor familiar with this type injury or gangrene may result.

1. Close fuel shut-off valve, if equipped.
2. Thoroughly clean fuel filter assemblies and surrounding areas.
3. Disconnect water sensor wiring (if equipped).
4. Loosen drain plugs (C) and drain fuel into a suitable container.

NOTE: Lifting up on retaining ring (A) as it is rotated helps to get it past raised locators.

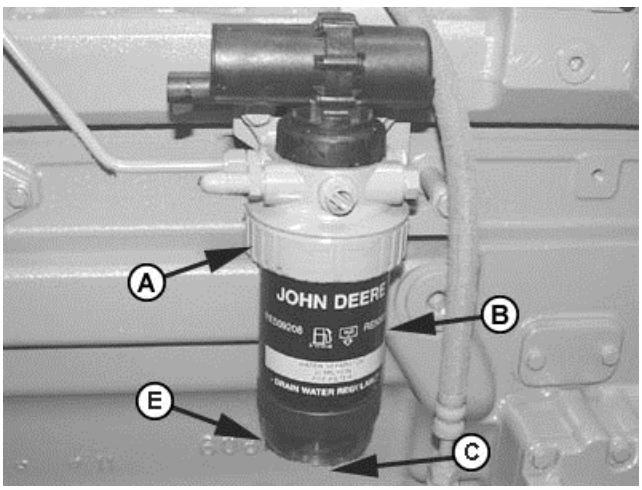


Final Fuel Filter

5. Firmly grasp the retaining ring (A) and rotate it counterclockwise 1/4 turn. Remove ring with filter element (B).
6. Inspect filter-mounting base for cleanliness. Clean as required.

NOTE: Raised locators on fuel filter canisters must be indexed properly with slots in mounting base for correct installation.

A—Retaining Ring
B—Filter Element
C—Drain Plug
D—Bleed Plug
E—Water Bowl



Primary Fuel Filter (or Pre-Filter, If Equipped)

7. Install new filter elements onto mounting bases. Be sure elements are properly indexed and firmly seated on bases. It may be necessary to rotate filters for correct alignment.

   If equipped with water separator bowl (E), remove filter element from separator bowl. Drain and clean separator bowl. Dry with compressed air. Install bowl onto new element. Tighten securely.

8. Align keys on filter element with slots in filter base.

9. Install retaining ring onto mounting base making certain dust seal is in place on filter base. Hand tighten ring (about 1/3 turn) until it “snaps” into the detent. DO NOT overtighten retaining ring.

NOTE: The proper installation is indicated when a "click" is heard and a release of the retaining ring is felt. A plug is provided with the new element for plugging the used element.

10. Reconnect water sensor wiring (if equipped).

11. Open fuel shut-off valve and bleed the fuel system. (See BLEEDING FUEL SYSTEM in Service As Required Section.) Tighten bleed plug (D).

Checking Belt Tensioner Spring Tension and Belt Wear (Automatic Tensioner)

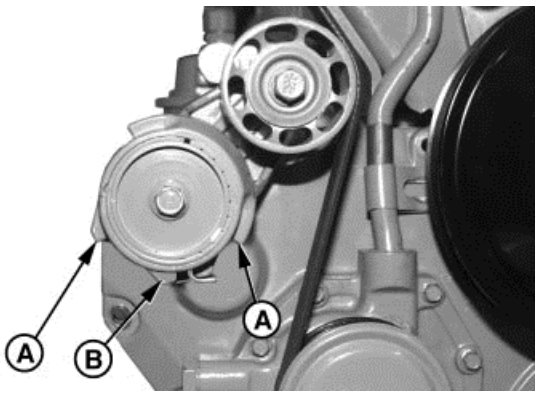
Belt drive systems equipped with automatic (spring) belt tensioners cannot be adjusted or repaired. The automatic belt tensioner is designed to maintain proper belt tension over the life of the belt. If tensioner spring tension is not within specification, replace tensioner assembly.

Checking Belt Wear

The belt tensioner is designed to operate within the limit of arm movement provided by the cast stops (A and B) when correct belt length and geometry is used.

1. Visually inspect cast stops (A and B) on belt tensioner assembly.

2. If the tensioner stop on swing arm (A) is hitting the fixed stop (B), check mounting brackets (alternator, belt tensioner, idler pulley, etc.) and the belt length. Replace belt as needed (see REPLACING FAN AND ALTERNATOR BELTS in Service As Required Section).



A—Cast Stops
B—Cast Stop

Checking Tensioner Spring Tension

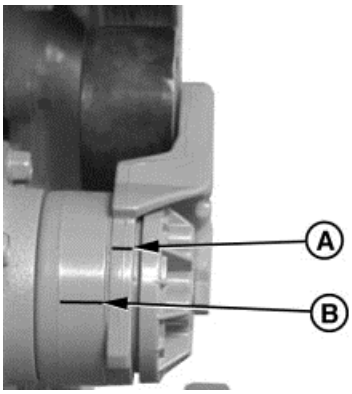
A belt tension gauge will not give an accurate measure of the belt tension when automatic spring tensioner is used. Measure tensioner spring tension using a torque wrench and procedure outlined below:

1. Release tension on belt using a breaker bar and socket on tension arm. Remove belt from pulleys.
2. Release tension on tension arm and remove breaker bar.
3. Put a mark (A) on swing arm of tensioner as shown.
4. Measure 21 mm (0.83 in.) from (A) and put a mark (B) on tensioner mounting base.
5. Install torque wrench (C) so that it is aligned with centers of pulley and tensioner. Rotate the swing arm using a torque wrench until marks (A and B) are aligned.
6. Record torque wrench measurement and compare with specification below. Replace tensioner assembly as required.

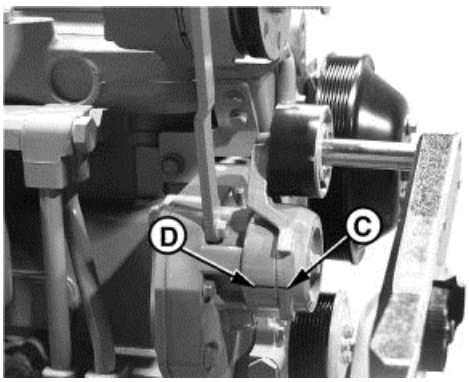
Specification

Spring Tension—Torque - 18-22 N•m (13-16 lb-ft)

NOTE: Threads on belt tensioner roller cap screw are LEFT-HAND threads

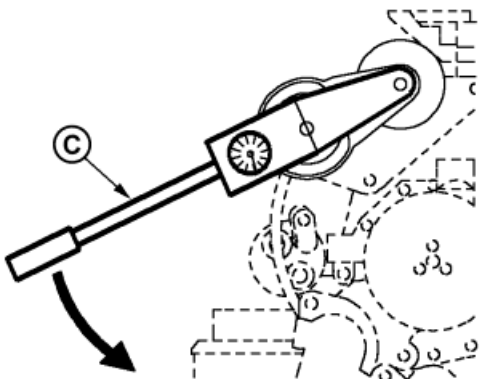


Marks on Tensioner



Align Marks

A—Mark On Swing Arm
B—Mark On Tensioner Mounting Base
C—Torque Wrench



Align Torque Wrench With Pulley and

Checking Engine Electrical Ground Connections

Keep all engine ground connections clean and tight to prevent electrical arcing, which can damage electronic components.

Also see precautions in Troubleshooting Section when welding on engine or machine.

Checking Cooling System

Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

Air must be expelled from cooling system when system is refilled. Loosen temperature-sending **unit fitting at rear of cylinder head or plug in thermostat housing to allow air to escape when filling system. Retighten fitting or plug when all the air has been expelled.**

1. Visually check entire cooling system for leaks. Tighten all clamps securely.

2. Thoroughly inspect all cooling system hoses for hard, flimsy, or cracked condition. Replace hoses if any of the above conditions are found.

Replenishing Supplemental Coolant Additives (SCA s) Between Coolant Changes

NOTE: If system is to be filled with coolant that does not contain SCAs, the coolant must be precharged.

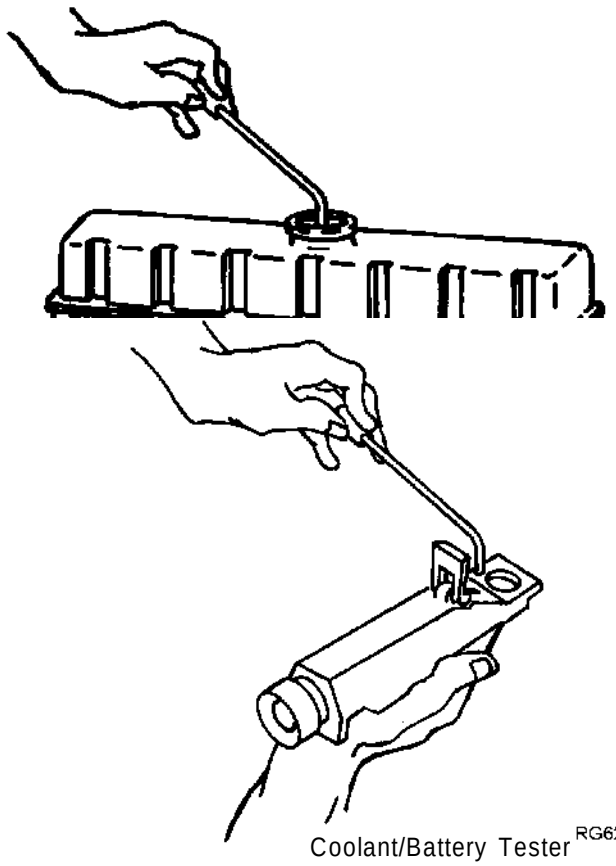
Through time and use, the concentration of coolant additives is gradually depleted during engine operation. The cooling system must be recharged with additional supplemental coolant additives available in the form of liquid coolant conditioner.

Maintaining the correct coolant conditioner concentration (SCAs) and freeze point is essential in your cooling system to protect against rust, liner pitting and corrosion, and freeze-ups due to incorrect coolant dilution.

DO NOT mix one brand of SCA with a different brand.

Test the coolant solution every 500 hours or 12 months of operation using a Coolant/Battery Tester. If a Coolant/Battery Tester is not available, recharge the system per instructions printed on the conditioner label.

IMPORTANT: ALWAYS maintain coolant at correct level and concentration. DO NOT operate engine without coolant even for a few minutes.



Coolant/Battery Tester RG6262

If frequent coolant makeup is required, the glycol concentration should be checked with a Coolant/Battery Tester to ensure that the desired freeze point is maintained. Follow manufacturer's instructions provided with Coolant/Battery Tester.

Add the manufacturer's recommended concentration of supplemental coolant additive. DO NOT add more than the recommended amount.

The use of non-recommended supplemental coolant additives may result in additive drop-out and gelation of the coolant.

If other coolants are used, consult the coolant supplier and follow the manufacturer's recommendation for use of supplemental coolant additives.

See DIESEL ENGINE COOLANTS AND SUPPLEMENTAL ADDITIVE INFORMATION for proper mixing of coolant ingredients before adding to the cooling system.

Testing Diesel Engine Coolant

Maintaining adequate concentrations of glycol and inhibiting additives in the coolant is critical to protect the engine and cooling system against freezing, corrosion, and cylinder liner erosion and pitting.

Test the coolant solution at intervals of 12 months or less and whenever excessive coolant is lost through leaks or overheating.

Coolant Test Strips

Coolant test strips are available from your Ingersoll-Rand dealer. These test strips provide a simple, effective method to check the freeze point and additive levels of your engine coolant.

Compare the results to the supplemental coolant additive (SCA) chart to determine the amount of inhibiting additives in your coolant and whether more coolant conditioner should be added.

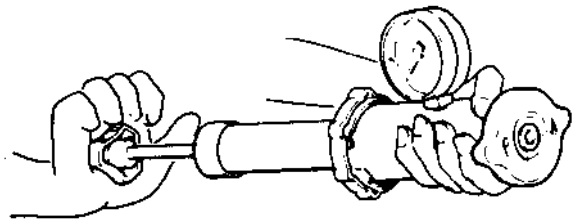
Pressure Testing Cooling System

⚠CAUTION

Explosive release of fluids from pressurized cooling system can cause serious burns. Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

Test Radiator Cap

1. Remove radiator cap and attach to the Tester as shown.



2. Pressurize cap to specification listed. Gauge should hold pressure for 10 seconds within the normal range if cap is acceptable. If gauge does not hold pressure, replace radiator cap.

Specification

Radiator Cap Holding Pressure (Not Opening For 10 Seconds)

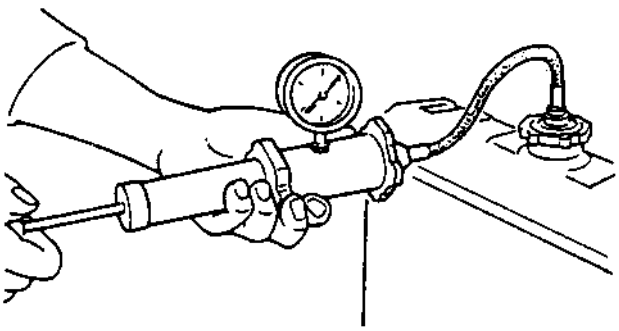
Pressure - 70 kPa (0.7 bar) (10 psi) Minimum

3. Remove the cap from gauge, turn it 180°, and retest cap. This will verify that the first measurement was accurate.

Test Cooling System

NOTE: Engine should be warmed up to test overall cooling system.

1. Allow engine to cool, then carefully remove radiator cap.



2. Fill radiator with coolant to the normal operating level.

NOTICE

DO NOT apply excessive pressure to cooling system; doing so may damage radiator and hoses.

3. Connect gauge and adapter to radiator filler neck. Pressurize cooling system to specification listed for radiator cap.

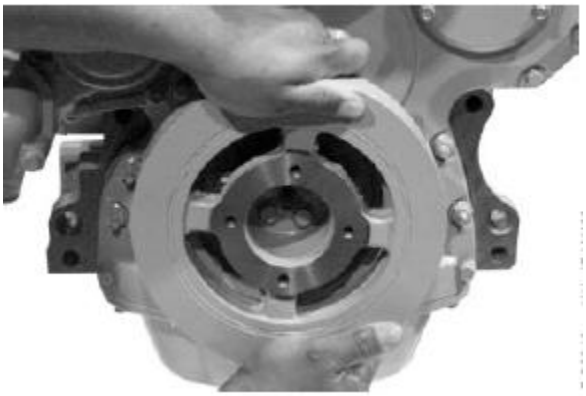
4. With pressure applied, check all cooling system hose connections, radiator, and overall engine for leaks. If leakage is detected, correct as necessary and pressure test system again. If no leakage is detected, but the gauge indicated a drop in pressure, coolant may be leaking internally within the system or at the block-to-head gasket. Have your engine distributor or servicing dealer correct this problem immediately.

Lubrication & Maintenance, 2000 Hour/ 24 Month

Checking Crankshaft Vibration Damper (6-Cylinder Engine Only)

1. Remove belts (shown removed).

2. Grasp vibration damper with both hands and attempt to turn it in both directions. If rotation is felt, damper is defective and should be replaced.



Grasp Vibration Damper

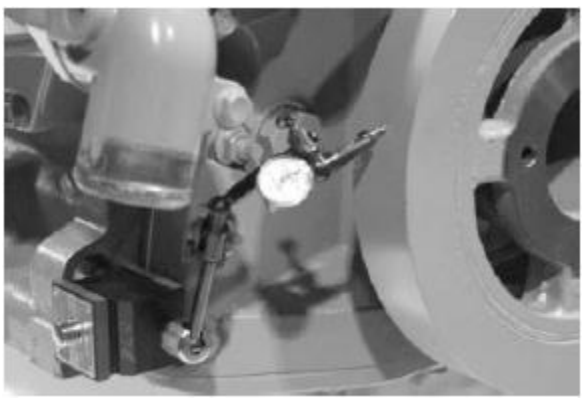
NOTICE

The vibration damper assembly is not repairable and should be replaced every 4500 hours or 60 months, whichever occurs first.

3. Check vibration damper radial runout by positioning a dial indicator (A) so that the probe contacts the damper outer diameter.

4. With the engine at operating temperature, rotate the crankshaft using a flywheel turning tool.

5. Note the dial indicator reading. If the runout exceeds the specifications given below, replace the vibration damper.



Check Radial Runout

Specification

Vibration Damper – Maximum Radial Runout – 1.50 mm (0.060 in.)

Flushing and Refilling Cooling System

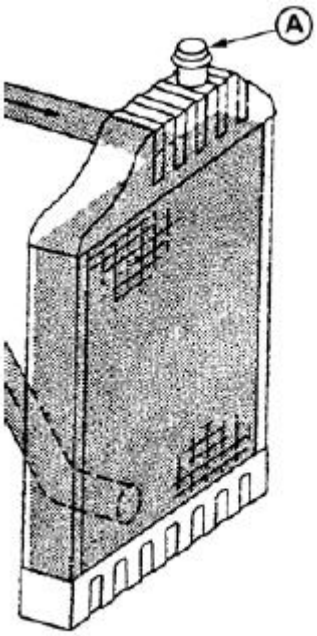
⚠CAUTION

Explosive release of fluids from pressurized cooling system can cause serious burns. Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

Drain old coolant, flush the entire cooling system, test thermostats, and fill with recommended clean coolant as follows:

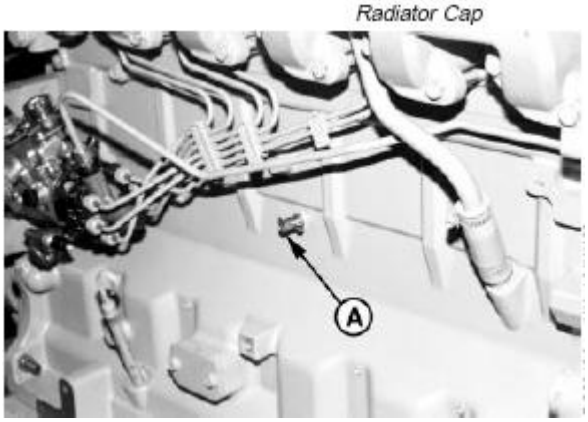
1. Pressure test entire cooling system and pressure cap if not previously done. (See PRESSURE TESTING COOLING SYSTEM, in the Lubrication and Maintenance/500 Hour/12 Month Section.)

2. Slowly open the engine cooling system filler cap or radiator cap to relieve pressure and allow coolant to drain faster.



Radiator Cap

3. Open engine block drain valve (A) on the left side of the engine. Drain All of the coolant from the engine block.



4. Open radiator drain valve. Drain all coolant from radiator.

5. Remove the thermostats at this time, if not previous done. Install the cover (without th ermostats) using the old gasket and tighten the cap screws to 47 N•m (35 lb -ft).

6. Test the thermostat opening temperature. (See TESTING THERMOSTATS OPENING TEMPERATURE later in this section.)

7. Close all drain valves after coolant has drained.

⚠CAUTION

Do not run engine longer than 10 minutes. Doing so may cause engine to overheat, which **may cause burns when radiator water is draining.**

8. Fill the cooling system with clean water. Run the engine about 10 minutes to stir up possible rust or sediment.

9. Stop engine, pull off lower radiator hose and remove radiator cap. Immediately drain the water from system before rust and sediment settles.

10. After draining the water, close the drain valves. Reinstall the radiator cap and radiator hose and clamp. Fill the cooling system with clean water and a heavy duty cooling system cleaner, follow the manufacture's directions on the label.

11. After cleaning the cooling system, drain the cleaner and fill with water to flush the system. Run the engine for about 10 minutes, remove the radiator cap and pull off the lower radiator hose to drain out the flushing water.

12. Close all of the drain valves on the engine and radiator. Reinstall the radiator hose and tighten the clamps securely. Install the thermostats using a new gasket (See TESTING THERMOSTATS OPENING TEMPERATURE later in this section.).

NOTICE

Air must be expelled from the cooling system when the system is refilled. Loosen the temperature-sending unit fitting at the rear of the cylinder head or plug in the thermostat housing to allow air to escape when filling system. Retighten the fitting or plug after filling the cooling system.

13. Add coolant to the radiator until coolant touches the bottom of the filler necks (See specification for capacity.) Install the radiator cap.

Specification
4.5 L Engine – Coolant Capacity – 8.5 L (9 qt)
6.8 L Engine – Coolant Capacity – 11.3 L (12 qt)

14. Run the engine until it reaches operating temperature. This mixes the solution uniformly and circulates it through the entire system. The normal engine coolant temperature range is 82º - 94ºC (180º - 202ºF).

15. After running the engine, check the coolant level and the entire cooling system for leaks.

16. Inspect the fan belt for wear and check the belt tension. (See Checking Belt Tensioner Spring Tension and Belt Wear in Lubrication and Maintenance 500 Hour/12 Month section).

Testing Thermostats Opening Temperature

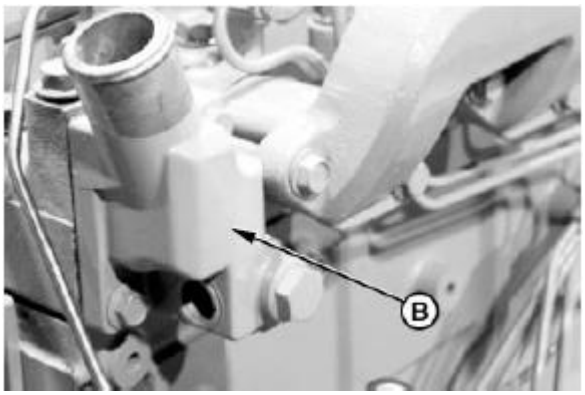
To Remove Thermostat

⚠CAUTION

Explosive release of fluids from pressurized cooling system can cause serious burns.
DO NOT drain coolant until it has cooled below operating temperature.
Always loosen radiator pressure cap or drain valve slowly to relieve pressure.

1. Visually inspect area around thermostat housing on top of engine timing gear cover for leaks.
2. Remove radiator pressure cap and partially drain cooling system.
3. Remove thermostat cover-to-coolant pump tube (A) and seal.
4. Remove thermostat (B) with gasket.
5. Remove thermostat(s).
6. Remove and discard all gasket material. Clean gasket surfaces.
7. Clean and check cover for cracks or damage.

A – Cover-to-Pump Coolant Tube

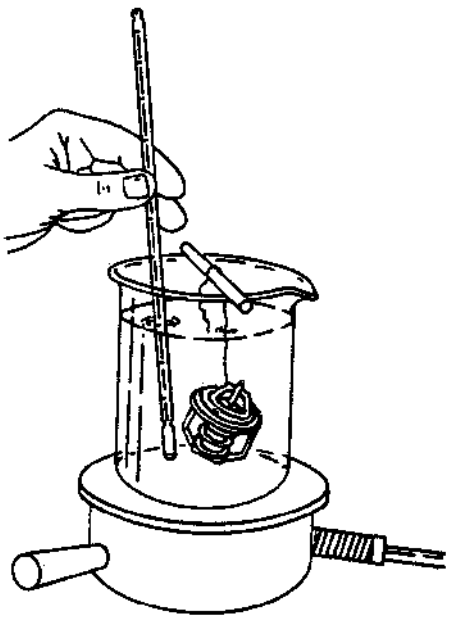


B – Thermostat Cover

Testing Thermostats Opening Temperature

Remove thermostat(s).

1. Visually inspect thermostat(s) for corrosion or damage. If dual thermostats, replace as a matched set as necessary.



⚠CAUTION

DO NOT allow thermostat or thermometer to rest against the side or bottom of container when heating water. Either may rupture if overheated.

2. Suspend thermostat and a thermometer in a container of water.

3. Stir the water as it heats. Observe opening action of thermostat and compare temperatures with the specification below.

NOTICE

NOTE: Due to varying tolerances of different suppliers, initial opening and full open temperatures may vary slightly from specified temperatures.

Testing Thermostat Opening Temperature

THERMOSTAT TEST SPECIFICATIONS		
Rating	Initial Opening (Range)	Full Open (Nominal
71ºC (160ºF)	69 - 72ºC (156 - 162ºF)	84ºC (182ºF)
77ºC (170ºF)	74 - 78ºC (166 - 172ºF)	89ºC (192ºF)
82ºC (180ºF)	80- -84ºC (175 – 182ºF)	94ºC (202ºF)
89ºC (192ºF)	86 – 90ºC (187 – 194ºF)	100ºC (213ºF)
90ºC (195ºF)	89 – 93ºC (192 – 199ºF)	101ºC (214ºF)
92ºC (197ºF)	89 – 93ºC (193 – 200ºF)	103ºC (218ºF)
96ºC (205ºF)	94 – 97ºC (201 – 207ºF)	105ºC (221ºF)
99ºC (210ºF)	96 – 100ºC (205 – 212ºF)	111ºC (232ºF)

4. Remove thermostat and observe its closing action as it cools. In ambient air the thermostat should close completely. Closing action should be smooth and slow.

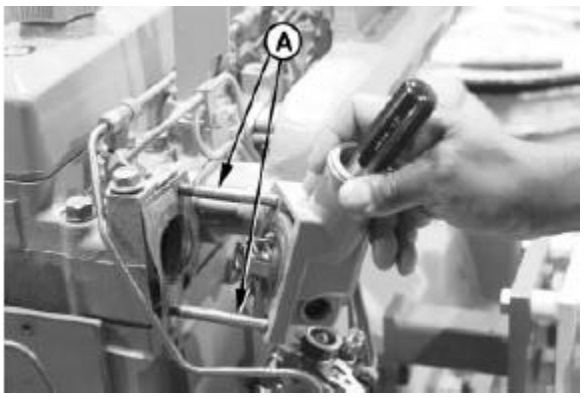
5. Replace any defective thermostat.

To Install Thermostats

NOTICE

Install manifold gasket so that the smaller (round) holes are at the lower left and the upper right corners of the manifold (matching studs A).

1. Clean all gasket material from the thermostat cover and housing mounting surfaces.
2. Using guide studs (A) to the gasket in place, install a new gasket on the cylinder head.
3. Install the themostat(s) with a jiggle wire facing upward in the 12 o'clock position.
4. Using a screwdriver to hold the thermostat(s) in place, install the thermostat(s) and the coolant manifold/thermostat cover.
5. Tighten the cover cap screws to 70 N•m (53 lb -ft).
6. Lubricate a new O-ring with PT507 Multi-Purpose Grease. Install seal (B) in the thermostat cover.
7. Install coolant manifold/thermostat cover-to-coolant pump tube (C). Tighten clamps.
8. If not already done, fill cooling system and check for leaks.



Installing Thermostat Cover

Thermostat Cover Seal

NOTICE

Air must be expelled from cooling system when filling. Loosen temperature-sending **unit fitting at rear of cylinder head or plug in thermostat housing to allow air to escape when filling system. Tighten fitting or plug when all air has been expelled.**

Cover-to-Coolant Pump Tube

Check and Adjust Valve Clearance

⚠CAUTION

To prevent accidental starting of engine while performing valve adjustments, always disconnect NEGATIVE (—) battery terminal.

NOTICE

Valve clearance MUST BE checked and adjusted with engine COLD.

1. Remove rocker arm cover and crankcase ventilator tube.

NOTICE

Visually inspect contact surfaces of valve tips and rocker arm wear pads. Check all parts for excessive wear, breakage, or cracks. Replace parts that show visible damage.
Rocker arms that exhibit excessive valve clearance should be inspected more thoroughly to identify damaged parts.

2. Remove plastic plugs or cover plate from engine timing/rotation hole (A) and timing pin hole (B).

   NOTE: Some engines are equipped with flywheel housings which do not allow use of an engine flywheel rotation tool. These engines may be rotated from front nose of engine, using JDG966 Crankshaft Front/Rear Rotation Adapter.

3. Using JDE83 or JDG281AFlywheel Turning Tool, rotate engine flywheel in running direction (clockwise viewed from front) until No. 1 cylinder is at TDC compression stroke. Insert JDG1571 Timing Pin in flywheel.

   If No.1 cylinder rocker arms are loose, the engine is at No. 1 TDC compression.

   If No. 1 cylinder rocker arms are not loose, rotate engine one full revolution (360°) to No. 1 TDC compression.

4. With engine lock-pinned at TDC of No. 1 piston's compression stroke, check valve clearance to following specifications. (Use sequence for 4-cylinder or 6-cylinder engines as outlined on next page.)

Specification

Intake Valve Clearance For Checking (Rocker Arm-to-Valve Tip) (Engine Cold)
Clearance - 0.31—0.38 mm (0.012—0.015 in.)

Exhaust Valve Clearance For Checking (Rocker Arm-to-Valve Tip) (Engine Cold)
Clearance - 0.41—0.48 mm (0.016—0.019 in.)

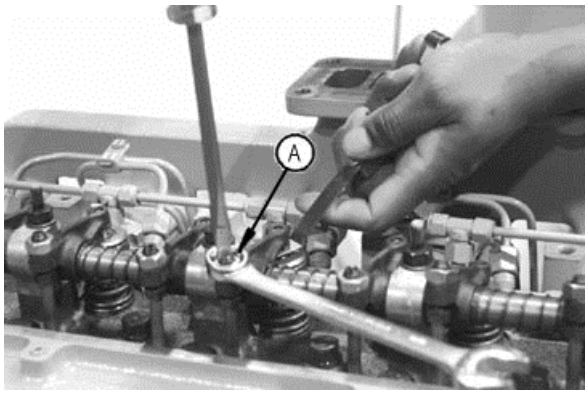
5. If valves need adjusting, use the appropriate valve clearance adjustment procedure on the next page and adjust to specifications below. Loosen the jam nut (A) on rocker arm adjusting screw. Turn adjusting screw until feeler gauge slips with a slight drag. Hold the adjusting screw from turning with screwdriver and tighten jam nut to specifications. Recheck clearance again after tightening jam nut. Readjust clearance as necessary.

Specification

Intake Valve Clearance For Adjusting (Rocker Arm-to-Valve Tip) (Engine Cold) - Clearance - 0.36 mm (0.014 in.)

Exhaust Valve Clearance For Adjusting (Rocker Arm-to-Valve Tip) (Engine Cold) - Clearance - 0.46 mm (0.018 in.)

Rocker Arm Adjusting Screw Jam Nut Torque - 27 N•m (20 lb-ft)



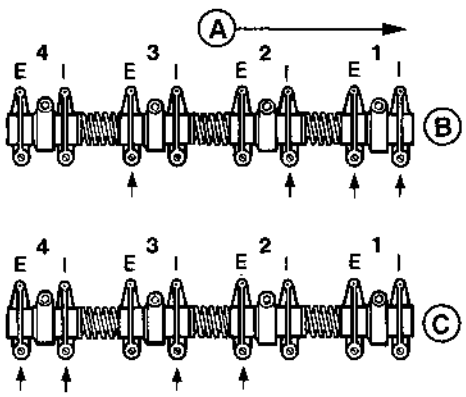
Adjusting Valves
A—Adjusting Screw Jam Nut

6. Replace rocker arm cover and crankcase ventilator tube.

4-Cylinder Engine:

NOTE: Firing order is 1-3-4-2

1. Using JDE81-4 Timing Pin, lock No. 1 piston at TDC compression stroke (B).
2. Adjust valve clearance on No. 1 and 3 exhaust valves and No. 1 and 2 intake valves.
3. Turn crankshaft 360°. Lock No. 4 piston at TDC compression stroke (C).
4. Adjust valve clearance on No. 2 and 4 exhaust valves and No. 3 and 4 intake valves.



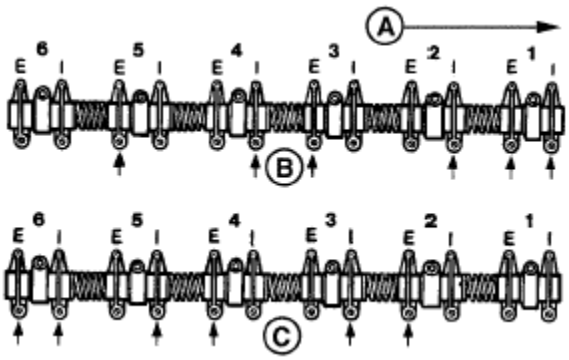
4-Cylinder Engine Valve Adjustment

A—Front of Engine
B—No. 1 Piston TDC Compression
C—No. 4 Piston TDC Compression
E—Exhaust Valve
I—Intake Valve

6-cylnder Engine:

NOTE: FIRING ORDER IS 1-5-3-6-2-4

1. Lock No. 1 piston at TDC compression stroke (B).
2. Adjust valve clearance on No. 1, 3, and 5 exhaust valves and no. 1, 2, and 4 intake valves.
3. Turn crankshaft 360º. Lock No. 6 piston at TDC compression stroke (C).
4. Adjust valve clearance on No. 2, 4, and 6 exhaust valves and No. 3, 5, and 6 intake valves.



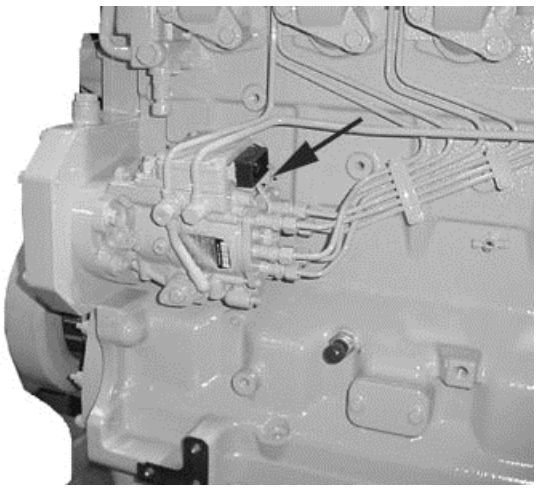
A—Front of Engine
B—No. 1 Piston TDC Compression
C—No. 6 Piston TDC Compression
E—Exhaust Valve
I—Intake Valve

6-Cylinder Engine Valve Adjustment

Service As Required

Do Not Modify Fuel System

NOTICE



Modification or alteration of the injection pump (arrow), the injection pump timing, or the fuel injectors in ways not recommended by the manufacturer will terminate the warranty obligation to the purchaser.

In addition, tampering with fuel system which alters emission-related equipment on engines may result in fines or other penalties, per EPA regulations or other local emission laws.

Do not attempt to service injection pump or fuel injectors yourself. Special training and special tools are required.
(See your authorized servicing dealer or engine distributor.)

Adding Coolant

⚠CAUTION

Explosive release of fluids from pressurized cooling system can cause serious burns.

Shut off engine. Only remove filler cap when cool enough to touch with bare hands. Slowly loosen cap to first stop to relieve pressure before removing completely.

NOTICE

Never pour cold liquid into a hot engine, as it may crack cylinder head or block.
DO NOT operate engine without coolant for even a few minutes.
Air must be expelled from cooling system when coolant is added.

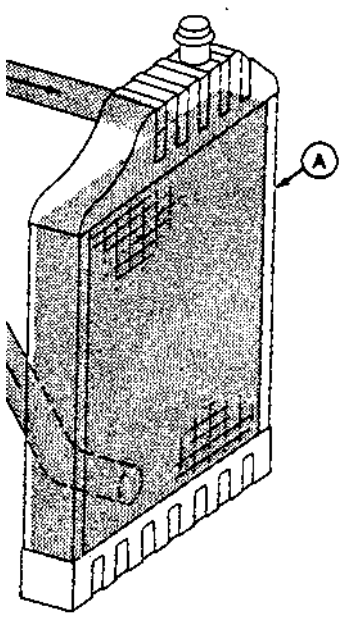
1. Loosen temperature-sending unit fitting at rear of cylinder head or plug in side of thermostat housing to allow air to escape when filling system.

NOTICE

When adding coolant to the system, use the appropriate coolant solution.
(See ENGINE COOLANT SPECIFICATIONS in Fuels, Lubricants, and Coolant Section for mixing of coolant ingredients before adding to cooling system.)

Do not overfill cooling system.
A pressurized system needs space for heat expansion without overflowing at top of radiator.

2. Fill radiator (A) until coolant level touches bottom of radiator filler neck.
3. Tighten plugs and fittings when air has been expelled from system.
4. Run engine until it reaches operating temperature.



Replacing Radial Seal Air Cleaner Filter Element

NOTICE

ALWAYS REPLACE primary air cleaner element when air restriction indicator shows a vacuum of 625 mm (25 in.) H_2O, is torn, or visibly dirty.

NOTE: Refer to manufacturers' instructions for servicing air cleaners not supplied by Ingersoll-Rand. If engine is NOT equipped with an air restriction indicator, replace air filter element every 500 hours of operation or every 12 months, whichever occurs first.

1. Unlatch and remove dust cup/cover (A) of air cleaner

2. Move end of filter (B) back and forth gently to break seal.

3. Pull filter (B) off outlet tube and out of housing.

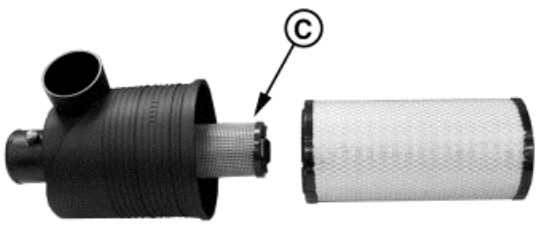
4. Thoroughly clean all dirt from inside housing and from outlet bore.

NOTICE

Remove secondary (safety) element (C) ONLY for replacement. DO NOT attempt to clean, wash, or reuse secondary element. Replacement of secondary element is usually necessary ONLY when primary element has a hole in it.

5. To replace secondary element (C), pull filter element out gently. Immediately replace secondary element with new element to prevent dust from entering air intake system.

6. Install new primary filter element. Apply pressure by hand at outer rim of filter.



NOTICE

Do NOT use latches on cover to force filter into air cleaner. Using cover to force filter will damage cleaner housing.

7. Close housing with dust unloader valve aimed down and latch latches.

NOTICE

Whenever the air cleaner has been serviced or cover has been removed, ALWAYS fully depress the air restriction indicator reset button (if equipped) to assure accurate readings.

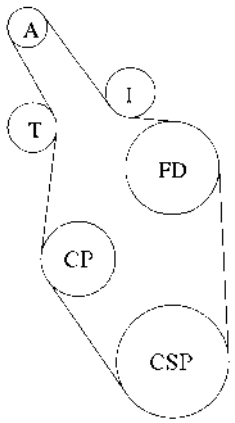
8. If equipped, fully depress air restriction indicator reset button and release to reset indicator.

Replacing Fan and Alternator Belts

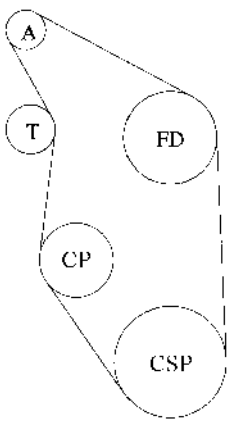
Refer to CHECKING BELT TENSIONER SPRING TENSION AND BELT WEAR in Lubrication and Maintenance/500 Hour/12 Month Section for additional information on the belt tensioner.

1. Inspect belts for cracks, fraying, or stretched out areas. Replace if necessary.
2. To replace belt with automatic tensioner, release tension on belt using a breaker bar and socket on tension arm.

   To replace belt with manual tensioner, release tension at belt tensioner (See MANUAL BELT TENSIONER ADJUSTMENT in Lubrication and Maintenance/500 Hour/12 Month Section.)
3. Remove poly-vee belt from pulleys and discard belt.
4. Install new belt, making sure belt is correctly seated in all pulley grooves. Refer to belt routing at right for your application.
5. Apply tension to belt with tensioner. Remove socket.
6. Start engine and check belt alignment.



290 mm (11.4 in.) Fan Height and Lower*



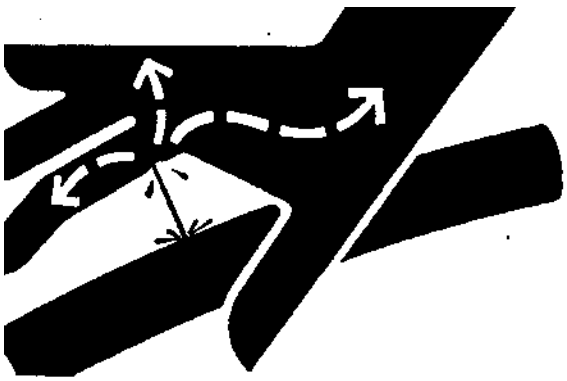
338 mm (13.3 in.) Fan Height and Higher*

*Measured from crank centerline to fan drive center.

A—Alternator
CSP— Crankshaft Pulley
FD—Fan Drive
I—Idler Pulley
T—Tensioner
CP—Coolant Pump

Bleed the Fuel System (Engines with Electronic Fuel Systems and Stanadyne DE10 Pump)

⚠CAUTION



Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid hazards by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high-pressure fluids.

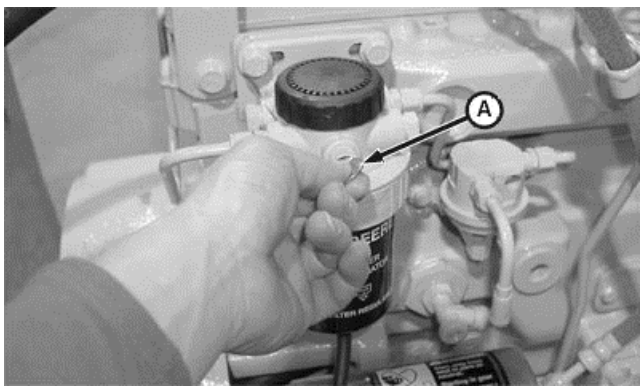
If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result.

Bleed the fuel system anytime the fuel system has been opened up. This includes:

1. After fuel filter changes.
2. After pump or nozzle replacement.
3. Anytime fuel lines have been disconnected.
4. After engine has run out of fuel.

The fuel system may be bled at one of several locations. Choose the best location for your engine/machine application.

1. Loosen the air bleed vent screw (A) two full turns by hand on fuel filter base.

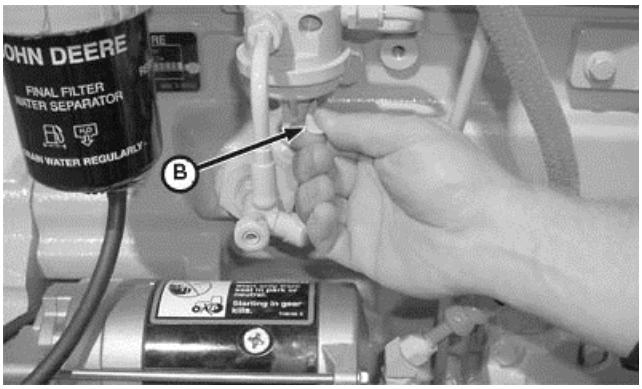


Final Fuel Filter Bleed Vent Screw
A—Bleed Vent Screw

2. Operate fuel supply pump primer lever (B) or primer button on fuel filter base (if equipped).

3. Tighten bleed plug securely, continue operating primer until pumping action is not felt

4. Start engine and check for leaks.



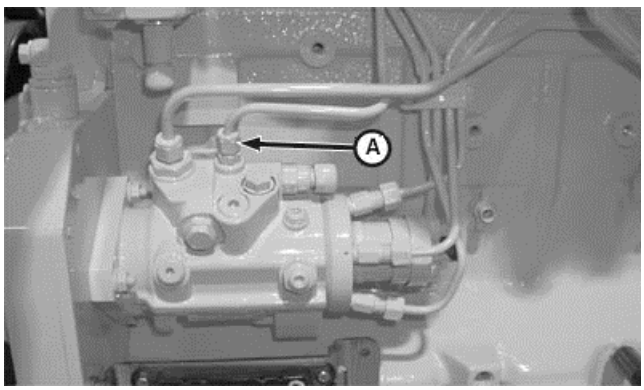
Fuel Supply Pump Primer Lever
B—Primer Lever

At Fuel Injection Pump

1. Loosen fuel return line (A) at fuel injection pump.

2. Operate fuel supply pump primer lever or primer button on fuel filter base (if equipped).

3. As soon as fuel flow is free from air bubbles, tighten fuel return line to specifications. Primer lever is spring-loaded and will return to normal position.



Fuel Injection Pump Return Line
A—Fuel Return Line

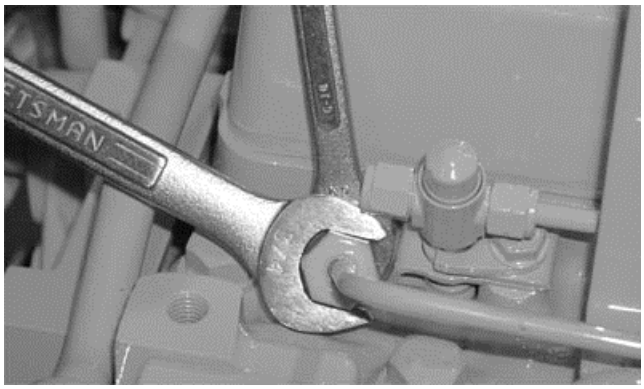
Specification

Fuel Injection Pump Return Line—Torque - 27 N•m (20 lb-ft)

At Fuel Injection Nozzles

NOTICE

Always use a backup wrench when loosening or tightening fuel lines at nozzles and/or injection pump to avoid damage.



Nozzle Fuel Pressure Line

1. Using **two** open-end wrenches, loosen two fuel line connections at injection nozzles.

2. Crank engine over with starter motor for 15 seconds (but do not start engine) until fuel free from bubbles flows out of loosened connection. Retighten connection to specifications.

Specification

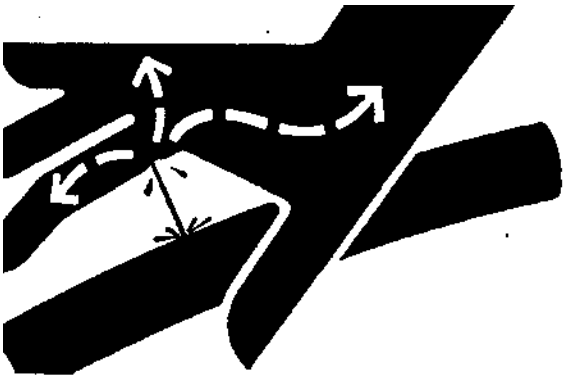
Fuel Injection Nozzle Delivery Lines—Torque - 27 N•m (20 lb-ft)

3. Repeat procedure for remaining injection nozzles (if necessary) until all air has been removed from fuel system.

If engine still will not start, see your authorized servicing dealer or engine distributor.

Bleeding the Fuel System (Engines with Electronic Fuel Systems and Bosch VP44 Pump)

⚠CAUTION



Escaping fluid under pressure can penetrate the skin causing serious injury. Avoid hazards by relieving pressure before disconnecting hydraulic or other lines. Tighten all connections before applying pressure. Search for leaks with a piece of cardboard. Protect hands and body from high-pressure fluids.

If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result.

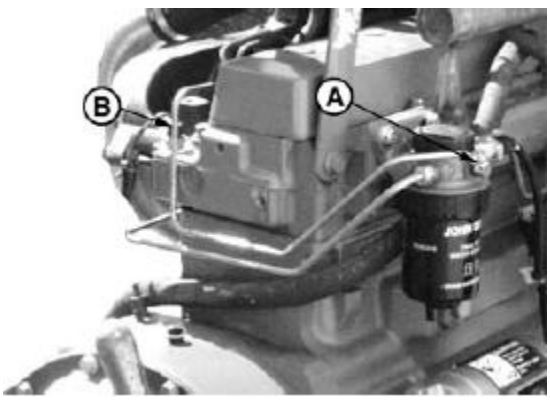
Bleed the fuel system anytime the fuel system has been opened up. This includes:

5. After fuel filter changes.
6. After pump or nozzle replacement.
7. Anytime fuel lines have been disconnected.
8. After engine has run out of fuel.

This fuel system can only be bled by the electronic transfer pump or at the injection nozzles. BLEEDING SHOULD NOT BE PERFORMED at any location on the Bosch VP44 injection pump.

Bleed Using the Electronic Transfer Pump

The bleed is automatically performed by a small orifice (A) inside the final fuel filter base connected to the overflow valve on the injection pump. The system allows air to escape continually through the fuel return line (B) when ignition is ON.



A – Orifice
B – Fuel Return Line

1. Ignition ON.

2. Allow 40 seconds for electronic transfer pump to complete priming.

3. If additional system bleeding is required, bleed the circuit by loosening fuel line connections at the injection nozzles. See the next procedure, BLEED FUEL SYSTEM AT FUEL INJECTION NOZZLES.

Bleed Fuel System at Fuel Injection Nozzles

NOTICE

Always use a backup wrench when loosening or tightening fuel lines at nozzles and/or injection pump to avoid damage.

1. Using **two** open-end wrenches, loosen two fuel line connections at injection nozzles.

2. Crank engine over with starter motor for 15 seconds (but do not start engine) until fuel free from bubbles flows out of loosened connection. Retighten connection to specifications.

Specification

Fuel Injection Nozzle Delivery Lines—Torque - 27 N•m (20 lb-ft)

Nozzle Fuel Pressure Line

3. Repeat procedure for remaining injection nozzles (if necessary) until all air has been removed from fuel system.

If engine still will not start, see your authorized servicing dealer or engine distributor.

Troubleshooting

General Troubleshooting Information

A reliable program for troubleshooting engine problems should include the following basic diagnostic thought process:

- Know the engine and all related systems.
- Study the problem thoroughly.
- Relate the symptoms to your knowledge of engine and systems.
- Diagnose the problem starting with the easiest things first.
- Double-check before beginning the disassembly.
- Determine cause and make a thorough repair.
- After making repairs, operate the engine under normal conditions to verify that the problem and cause was corrected.

NOTE: The engines covered in this manual have electronic control systems, which send diagnostic trouble codes to signal problems. That requires specialized diagnostic equipment to obtain the codes, contact your authorized servicing dealer or engine distributor for assistance.

Precautions For Welding On Engines Equipped With Electronic Engine Control Unit (ECU)

NOTICE

ALWAYS disconnect Electronic Control Unit (ECU) connectors and engine control system-to-machine ground before welding on engine or machine. High currents or electro-static discharge in electronic components from welding may cause permanent damage.

1. Remove the ground connection for the engine control system-to-machine frame.
2. Disconnect the connectors from the ECU.
3. Connect the welder ground close to the welding point and be sure ECU or other electronic components are not in the ground path.

Engine Troubleshooting

Symptom	Problem	Solution
Engine cranks but will not start	Incorrect starting procedure.	Verify correct starting procedure.
	No fuel.	Check fuel in tank.
	Exhaust restricted.	Check and correct exhaust restriction.
	Fuel filter plugged or full of water.	Replace fuel filter or drain water from filter.
	Injection pump not getting fuel or air	Check fuel flow at supply pump or in fuel system. Bleed supply pump or in fuel system.
	Faulty injection pump or nozzles.	Consult authorized diesel repair station for repair or replacement.
	ECU Fault*	See your authorized servicing dealer or engine distributor.
Engine hard to start or will not start	Engine starting under load.	Disengage load.
	Improper starting procedure.	Review starting procedure.
	No fuel.	Check fuel tank.
	Air in fuel line.	Bleed fuel line.
	Cold weather.	Use cold weather starting aids.
	Slow starter speed.	See “Starter Cranks Slowly”.
	Crankcase oil too heavy.	Use oil of proper viscosity.
	Improper type of fuel.	Consult fuel supplier; use proper type fuel for operating conditions.
	Water, dirt, or air in fuel system.	Drain, flush, fill, and bleed system.
	Clogged fuel filter.	Replace filter element.
	Dirty or faulty injection nozzles.	Have authorized servicing dealer or engine distributor check injectors.
	Electronic fuel system problem (if equipped)	See your Ingersoll-Rand distributor or servicing dealer.
Engine knocks	Low engine oil level.	Add oil to engine crankcase.
	Low coolant temperature.	Remove and check thermostat.
	Engine overheating.	See “Engine Overheats”.
	Engine cold	Wrong or defective thermostat. Remove and check thermostat.

*** See Listing of Diagnostic Trouble Codes (DTCs)**

Engine Troubleshooting

Symptom	Problem	Solution
Engine runs irregularly or stalls frequently	Low coolant temperature.	Remove and check thermostat.
	Clogged fuel filter.	Replace fuel filter element.
	Water, dirt, or air in fuel system.	Drain, flush, fill, and bleed system.
	Dirty or faulty injection nozzles.	Have authorized servicing dealer or engine distributor check injectors.
	Electronic fuel system problem	See your Ingersoll-Rand distributor or servicing dealer.
Below normal engine temperature	Defective thermostat.	Remove and check thermostat.
	Defective temperature gauge or sender.	Check gauge, sender, and connections.
Lack of power	Engine overloaded.	Reduce load.
	Intake air restriction.	Service air cleaner.
	Clogged fuel filter.	Replace filter elements.
	Improper type of fuel.	Use proper fuel.
	Overheated engine.	See “Engine Overheats”.
	Below normal engine temperature.	Remove and check thermostat.
	Improper valve clearance.	See your authorized servicing dealer or engine distributor.
	Dirty or faulty injection nozzles.	Have authorized servicing dealer or engine distributor check injectors.
	Injection pump out of time.	See your authorized servicing dealer or engine distributor.
	Electronic fuel system problem	See your Ingersoll-Rand distributor or servicing dealer.
	Turbocharger not functioning. (Turbocharger engines only.)	See your authorized servicing dealer or engine distributor.
	Leaking exhaust manifold gasket.	See your authorized servicing dealer or engine distributor.
	Defective aneroid control line.	See your authorized servicing dealer or engine distributor.
	Restricted fuel hose.	Clean or replace fuel hose.

Engine Troubleshooting

Symptom	Problem	Solution
Low oil pressure	Low oil level.	Add oil.
	Improper type of oil.	Drain; fill crankcase with oil of proper viscosity and quality.
High oil consumption	Crankcase oil too light.	Use proper viscosity oil.
	Oil leaks.	Check for leaks in lines, gaskets, and drain plug.
	Restricted crankcase vent tube.	Clean vent tube.
	Defective turbocharger.	See your authorized servicing dealer or engine distributor.
Engine emits white smoke	Improper type of fuel.	Use proper fuel.
	Low engine temperature.	Warm up engine to normal operating temperature.
	Defective thermostat.	Remove and check thermostat.
	Defective injection nozzles.	See your authorized servicing dealer or engine distributor.
Engine emits black or gray exhaust smoke	Improper type of fuel.	Use proper fuel.
	Clogged or dirty air cleaner.	Service air cleaner.
	Engine overloaded.	Reduce load.
	Injection nozzles dirty.	See your authorized servicing dealer or engine distributor.
	Electronic fuel system problem	See your authorized servicing dealer or engine distributor.
	Turbocharger not functioning.	See your authorized servicing dealer or engine distributor.
Engine overheats	Engine overloaded.	Reduce load.
	Low coolant level.	Fill radiator to proper level, check radiator and hoses for loose connections or leaks.
	Faulty radiator cap.	Have technician check.
	Stretched poly-vee belt or defective belt tensioner.	Check automatic belt tensioner and check belts for stretching. Replace as required.
	Low engine oil level.	Check oil level. Add oil as required.
	Cooling system needs flushing.	Flush cooling system.
	Defective thermostat.	Remove and check thermostat.
	Defective temperature gauge or sender.	Check coolant temperature with thermometer and replace, if necessary.

Engine Troubleshooting

Symptom	Problem	Solution
Engine overheats	Incorrect grade of fuel.	Use correct grade of fuel.
High fuel consumption	Improper type of fuel.	Use proper type of fuel.
	Clogged or dirty air cleaner.	Service air cleaner.
	Engine overloaded.	Reduce load.
	Improper valve clearance.	See your authorized servicing dealer or engine distributor.
	Injection nozzles dirty.	See your authorized servicing dealer or engine distributor.
	Electronic fuel system problem	See your authorized servicing dealer or engine distributor.
	Defective turbocharger.	See your authorized servicing dealer or engine distributor.
	Low engine temperature.	Check thermostat.
Undercharged electrical system	Excessive electrical load from added accessories.	Remove accessories or install higher output alternator.
	Excessive engine idling.	Increase engine rpm when heavy electrical load is used.
	Poor electrical connections on battery, ground strap, starter, or alternator.	Inspect and clean as necessary.
	Defective battery.	Test battery.
	Defective alternator.	Test charging system.
Battery uses too much water	Cracked battery case.	Check for moisture and replace as necessary.
	Defective battery.	Test battery.
	Battery charging rate too high.	Test charging system.
Batteries will not charge	Loose or corroded connections.	Clean and tighten connections.
	Sulfated or worn-out batteries.	See your authorized servicing dealer or engine distributor.
	Stretched poly-vee belt or defective belt tensioner.	Adjust belt tension or replace belts.

Engine Troubleshooting

Symptom	Problem	Solution
Starter will not crank	PTO engaged.	Disengage PTO.
	Loose or corroded connections.	Clean and tighten loose connections.
	Low battery output voltage.	See your authorized servicing dealer or engine distributor.
	Faulty start circuit relay.	See your authorized servicing dealer or engine distributor.
	Blown main system fuse (MDL-25)	Replace fuse.
Starter cranks slowly	Low battery output.	See your authorized servicing dealer or engine distributor.
	Crankcase oil too heavy.	Use proper viscosity oil.
	Loose or corroded connections.	Clean and tighten loose connections.
Entire electrical system does not function	Faulty battery connection.	Clean and tighten connections.
	Sulfated or worn-out batteries.	See your authorized servicing dealer or engine distributor.

Listing of Diagnostic Trouble Codes (DTCs) (Engines With Electronic Fuel Systems And Stanadyne DE10 Pump)

NOTE: Not all of these codes are used on all OEM engine applications.

Trouble Codes

DTC's Listing in Ascending SPN/FMI Codes

SPN	FMI	2-Digit Codes	Definition
000028	03	13	Throttle Voltage High
	04	14	Throttle Voltage Low
000029	03	15	Throttle Voltage High
	04	16	Throttle Voltage Low
	14	—	Throttle Voltage Out of Range
000084	31	—	Vehicle Speed Mismatch
000091	03	11	Throttle Voltage High
	04	12	Throttle Voltage Low
	07	—	Throttle Calibration Invalid
	10	—	Throttle Voltage Low
	13	—	Throttle Calibration Invalid
	14	—	Throttle Voltage Out of Range
000097	03	—	Water in Fuel Input Voltage High
	04	—	Water in Fuel Input Voltage Low
	16	—	Water in Fuel Detected
000100	01	65	Engine Oil Pressure Extremely Low
	03	23	Engine Oil Pressure Input Voltage High
	04	24	Engine Oil Pressure Input Voltage Low
	18	64	Engine Oil Pressure Moderately Low
000105	03	25	Manifold Air Temperature Input Voltage High
	04	26	Manifold Air Temperature Input Voltage Low
	16	66	Manifold Air Temperature Moderately High
000110	00	69	Engine Coolant Temperature High Most Severe
	03	18	Engine Coolant Temperature Input Voltage High
	04	19	Engine Coolant Temperature Input Voltage Low
	15	62	Engine Coolant Temperature High Least Severe
	16	63	Engine Coolant Temperature High Moderately Severe
000111	00	—	Loss of Coolant Temperature Extremely High
	03	—	Loss of Coolant Temperature Input Voltage High
	04	—	Loss of Coolant Temperature Input Voltage Low
000158	17	54	ECU Power Down Error
000160	02	—	Wheel Speed Input Noise
000174	03	37	Fuel Temperature Input Voltage High
	04	38	Fuel Temperature Input Voltage Low
	16	81	Fuel Temperature Moderately High
000189	00	—	Engine Speed Derate
000190	00	42	Engine Overspeed Extreme
	16	42	Engine Overspeed Moderate

Trouble Codes

DTC's Listing in Ascending SPN/FMI Codes

SPN	FMI	2-Digit Codes	Definition
000620	03	21	Sensor Supply Voltage High
	04	22	Sensor Supply Voltage Low
000627	04	—	ECU Unswitched Power Missing
000629	13	28	ECU Error
000637	02	39	Crank Position Input Noise
	10	39	Crank Position Input Pattern Error
000639	13	55	CAN Error
000729	03	—	Inlet Air Heater Signal High
	05	—	Inlet Air Heater Signal Low
000898	09	—	Vehicle Speed Invalid/Missing
000970	31	83	Auxiliary Engine Shutdown Switch Active
000971	31	84	External Engine Derate Switch Active
001069	09	—	Tire Speed Invalid
	31	—	Tire Speed Error
001076	00	71	Pump Control Valve Closure Too Long
	01	72	Pump Control Valve Closure Too Short
	03	77	Pump Solenoid Current High
	05	73	Pump Solenoid Circuit Open
	06	74	Pump Solenoid Circuit Severely Shorted
	07	75	Pump Control Valve Closure Not Detected
	10	76	Pump Solenoid Circuit Moderately Shorted
	13	—	Pump Current Decay Time Invalid
001079	03	—	Sensor Supply Voltage High
	04	—	Sensor Supply Voltage Low
001109	31	—	Engine Shutdown Warning
001110	31	82	Engine Shutdown
001568	04	—	Torque Curve Select Voltage Low
001569	31	68	Fuel Derate
002000	06	79	Internal ECU Failure
	13	78	Security Violation
N/A	N/A	32	When reading blink codes, signifies the start of active codes.
N/A	N/A	33	When reading blink codes, signifies the start of previously active codes.
N/A	N/A	88	When reading blink codes, signifies that no fault codes are in the buffer.

Listing of Diagnostic Trouble Codes (DTCs) (Engines With Electronic Fuel Systems And Bosch VP44 Pump)

NOTE: Not all of these codes are used on all OEM engine applications.

Trouble Codes

DTC's Listing in Ascending SPN/FMI Codes

SPN	FMI	2-Digit Codes	Definition
000028	03	13	Throttle Voltage High
	04	14	Throttle Voltage Low
000029	03	15	Throttle Voltage High
	04	16	Throttle Voltage Low
	14	—	Throttle Voltage Out of Range
000084	31	—	Vehicle Speed Mismatch
000091	03	11	Throttle Voltage High
	04	12	Throttle Voltage Low
	09	—	Throttle Invalid
000094	01	58	Fuel Supply Pressure Extremely Low
	03	27	Fuel Supply Pressure Input Voltage High
	04	28	Fuel Supply Pressure Input Voltage Low
	18	57	Fuel Supply Pressure Moderately Low
000097	00	—	Water in Fuel Continuously Detected
	16	—	Water in Fuel Detected
000100	01	75	Engine Oil Pressure Extremely Low
	03	23	Engine Oil Pressure Input Voltage High
	04	24	Engine Oil Pressure Input Voltage Low
	18	74	Engine Oil Pressure Moderately Low
000105	00	56	Manifold Air Temperature Input Voltage Extremely High
	03	25	Manifold Air Temperature Input Voltage High
	04	26	Manifold Air Temperature Input Voltage Low
	16	55	Manifold Air Temperature Moderately High
000107	00	-	Air Filter Differential Pressure
000110	00	63	Engine Coolant Temperature Extremely High
	03	18	Engine Coolant Temperature Input Voltage High
	04	19	Engine Coolant Temperature Input Voltage Low
	15	61	Engine Coolant Temperature High Least Severe
	16	62	Engine Coolant Temperature High Moderately Severe
000111	01	64	Engine Coolant Level Low
000158	17	54	ECU Power Down Error
000160	02	—	Wheel Speed Input Noise
000174	00	67	Fuel Temperature High Most Severe
	15	53	Fuel Temperature Least Severe
	16	71	Fuel Temperature Moderately Severe
	31	98	Fuel Temperature Sensor Faulty
000189	00	—	Engine Speed Derate
	31	48	Engine Speed Derate
000190	00	42	Engine Overspeed Extreme
	16	42	Engine Overspeed Moderate
000620	03	21	Sensor Supply Voltage High
	04	22	Sensor Supply Voltage Low

Trouble Codes

DTC's Listing in Ascending SPN/FMI Codes

SPN	FMI	2-Digit Codes	Definition
000627	04	76	ECU Unswitched Power Missing
000629	13	34	ECU Error
	19	34	ECU to Pump Communication Error
000636	02	44	Pump Position Input Noise
	08	43	Pump Position Input Missing
	10	44	Pump Position Input Pattern Error
000637	02	39	Crank Position Input Noise
	08	38	Crank Position Input Missing
	10	39	Crank Position Input Pattern Error
000729	03	—	Inlet Air Heater Signal High
	05	—	Inlet Air Heater Signal Low
000810	02	92	Calculate4d Vehicle Speed Input Noise
000898	09	77	Vehicle Speed Invalid/Missing
000970	02	-	Auxiliary Engine Shutdown Switch Signal Invalid
	31	83	Auxiliary Engine Shutdown Switch Active
000971	31	84	External Engine Derate Switch Active
001069	02	93	Tire Size Error
001077	07	35	Attempting to Fuel without Command
	11	68	Pump Supply Voltage Out of Range
	12	97	Pump Self Test Error
	19	96	Pump Detected Communication Error
	31	36	Pump Initiated Engine Protection
001078	07	95	ECU/Pump Timing Moderately Out of Sync
	11	87	ECU/Pump Speed Out of Sync
	31	94	ECU/Pump Timing Extremely Out of Sync
001079	03	21	Sensor Supply 1 Voltage High
	04	—22	Sensor Supply 1 Voltage Low
001080	03	51	Sensor Supply 2 Voltage High
	04	52	Sensor Supply 2 Voltage Low
001109	31	—	Engine Shutdown Warning
001110	31	82	Engine Shutdown
001485	02	89	Pump Power Relay Fault
001569	31	47	Fuel Derate
002000	13	-	Security Violation

General OEM Engine Specifications

ITEM	4IRD5TE		6IRF8TE	
Number of Cylinders	4		6	
Bore	106 mm (4.19 in.)		106 mm (4.19 in.)	
Stroke	127 mm (5.0in.)		127 mm (5.0in.)	
Displacement	4.5L (276 cu in.)		6.8L (414 cu in.)	
Compression Ratio	17.0:1		17.0:1	
Aspiration	Turbocharged		Turbocharged	
Engine Firing Order	1-3-4-2		1-5-3-6-2-4	
Valves Per Cylinder	1 Intake, 1 Exhaust		1 Intake, 1 Exhaust	
Valve Clearance (Cold) Intake (Checking)	0.31-0.38 mm (0.012-0.015 in)		0.31-0.38 mm (0.012-0.015 in)	
Exhaust (Checking)	0.41-0.48 mm (0.016-0.019 in)		0.41-0.48 mm (0.016-0.019 in)	
Intake (Adjusting)	0.36 mm (0.014 in.)		0.36 mm (0.014 in.)	
Exhaust (Adjusting)	0.46 mm (0.018/ in.)		0.46 mm (0.018/ in.)	
Max. Crank Pressure	0.5 kPa ($2H_20$)		0.5 kPa ($2H_20$)	
Vibration Damper Maximum Radial Runout	1.50 mm (0.060 in.)		1.50 mm (0.060 in.)	
Battery Capacities (CCA) 12-Volt System 24-Volt System	 640 570		 800 570	
Governor Regulation (Industrial)	7 - 10%		7 - 10%	
Governor Regulation (Generator)	5%		5%	
Thermostat Start To Open Temperature	82ºC (180ºF)		82ºC (180ºF)	
Thermostat Fully Open Temperature	94ºC (202ºF)		94ºC (202ºF)	
Coolant Capacity	8.5 L (9qt)		11.3 L (12 qt)	
Recommended Radiator Pressure Cap	70 kPa (10 psi)		70 kPa (10 psi)	
Oil Pressure At Rated Speed, Full Load (± 15 psi)	345 kPa (50 psi)		345 kPa (50 psi)	
Oil Pressure At Low Idle (Minimum)	105 kPa (15 psi)		105 kPa (15 psi)	
Engine Oil Capacity	**Oil Pan Option**	**Crankcase Oil Capacity L (qt)**	**Oil Pan Option**	**Crankcase Oil Capacity L (qt)**
	1903	12.5 (13.2)	1907	19.5 (20.6)
	1904	13.5 (14.3)	1908	19.0 (20.1)
	1923	15.0 (15.8)	1909	19.0 (20.1)
			1924	24.2 (25.6)
			1944	20.0 (21.1)
			1956	18.0 (19.0)
			1961	31.5 (33.3)
			19AC	27.0 (28.5)