PowerTech™ 9.0 L OEM Diesel Engines Base Engine Repair

COMPONENT TECHNICAL MANUAL

9.0 L OEM Diesel Engines — Base Engine Repair

CTM400 29AUG11 (ENGLISH)

For complete service information also see:

9.0 L Diesel Engines — Level 14 Electronic Fuel System with Denso HPCR	CTM385
OEM Engine Accessories	CTM67
Application List...	CTM106819

John Deere Power Systems

LITHO IN U.S.A.

Foreword

This repair manual is valid for the engines.

This manual is written for an experienced technician. Essential tools required in performing certain service work are identified in this manual.

Live with safety: Read the safety messages in the introduction of this manual and the cautions presented throughout the text of the manual.

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

Information in this manual is organized in sections and sub divided into groups.

Section 01 covers the safety measures to follow while repairing the engine; engine identification features, engine emission & application details, and information about the fuels, lubricants & coolants.

Section 02 covers the Repair and Adjustment procedures.

Section 03 explains Systems Theory of Operation.

Section 04 is the diagnostics section that provides troubleshooting procedures to find problems.

Section 05 lists all applicable service equipment and tools, other materials needed to do the job.

Section 06 details all specifications, wear tolerances, torque values and contains the wiring diagrams.

This manual contains SI Metric units of measure followed immediately by the U.S. customary units of measure. Most hardware on these engines is metric sized.

Read each block of material completely before performing service to check for differences in procedures or specifications. Follow only the procedures that apply to the component you are working on.

Component Technical Manuals are concise service guides for specific components. Component technical manuals are written as stand-alone manuals covering multiple machine applications.

Fundamental service information is available from other sources covering basic theory of operation, fundamentals of troubleshooting, general maintenance, and basic type of failures and their causes.

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.

RE38635,00000D9 -19-03SEP09-1/1

John Deere Dealers

Future changes to this manual will be documented below. For diagnostics and fuel system repair, and for electrical system repair, reference the following manuals.

- CTM400 (English) — Base Engine
- CTM385 (English) —Level 14 Electronic Fuel Systems
- CTM77 (English) —Electrical (Starter and Alternator) Systems

SECTION 01, GROUP 001 (Engine Identification)

SECTION 01, GROUP 002 (Fuels, Lubricants, and Coolants)

SECTION 02, GROUP 010 (Engine Rebuild)

SECTION 02, GROUP 020 (Cylinder Head and Valves Repair and Adjustment Serial Number

SECTION 02, GROUP 050 (Camshaft and Timing Gear Train Repair and Adjustment)

SECTION 02, GROUP 060 (Lubrication System Repair and Adjustment)

SECTION 02, GROUP 070 (Cooling System Repair and Adjustment)

SECTION 02, GROUP 080 (Air Intake and Exhaust System Repair and Adjustments)

SECTION 02, GROUP 081 (Air Intake and Exhaust System Repair and Adjustments — POWERTECH AND POWERTECH E)

SECTION 03, GROUP 120 (Base Engine Operation)

SECTION 03, GROUP 121 (Base Engine Operation — POWERTECH AND POWERTECH E)

- Base engine theory of operation is covered in this new group.

SECTION 04, GROUP 150 (Observable Diagnostics and Tests)

- Base engine observable diagnostics and tests are covered in this new section/group.

SECTION 05 (Tools and Other Materials)

- All essential tools, service tools, dealer fabricated tools, and other materials listed throughout this manual are consolidated in this section for ease of reference.

SECTION 06 (Specifications)

- All repair, test, and diagnostic specifications listed throughout this manual are consolidated in this section for ease of reference.
- Updated bolt and cap screw torque values.
- Updated General OEM specifications.
- Updated dynamometer specifications.

DPSG,OUO1004,898 -19-19MAY99-1/1

About this Manual

This component technical manual (CTM) covers the base engine for ***POWER**TECH*® 9.0 L diesel engines produced in Waterloo, Iowa. This manual's coverage includes repair and basic diagnostic information for 9.0 L engines

Direction of engine crankshaft rotation in this manual is referenced as clockwise, as viewed from the rear of the engine. Front of engine is fan drive end.

Read each procedure completely before performing any service.

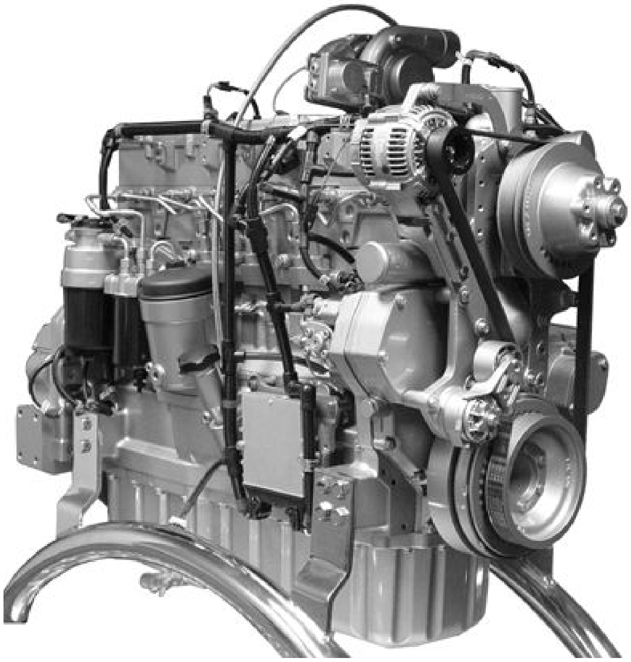
POWERTECH is a registered trademark of Deere & Company

IMPORTANT: For repair, diagnostics, and testing procedures on the fuel system, refer to the companion manuals:

- **CTM385 — 9.0 L Diesel Engines—Level 14 Electronic Fuel Systems with Denso High Pressure Common Rail**

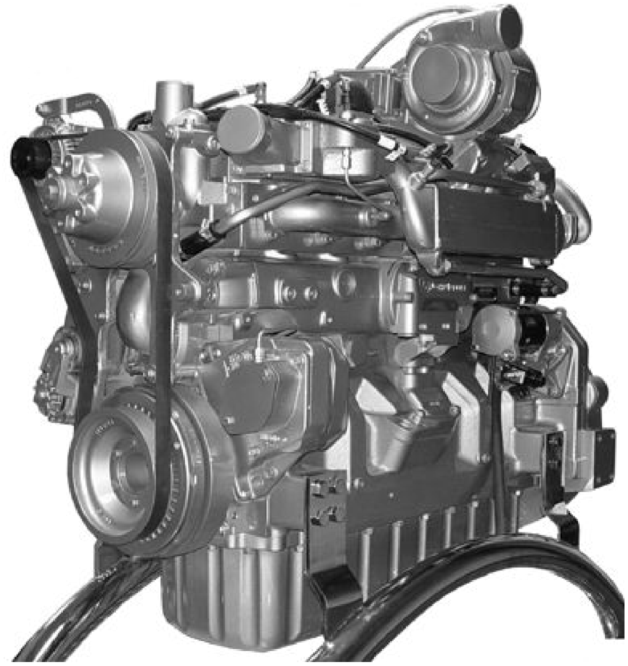
RE38635,0000076 -19-03SEP09-1/1

Identification Views - 6090 Tier 3 / Stage IIIA Emissions Certified Engines



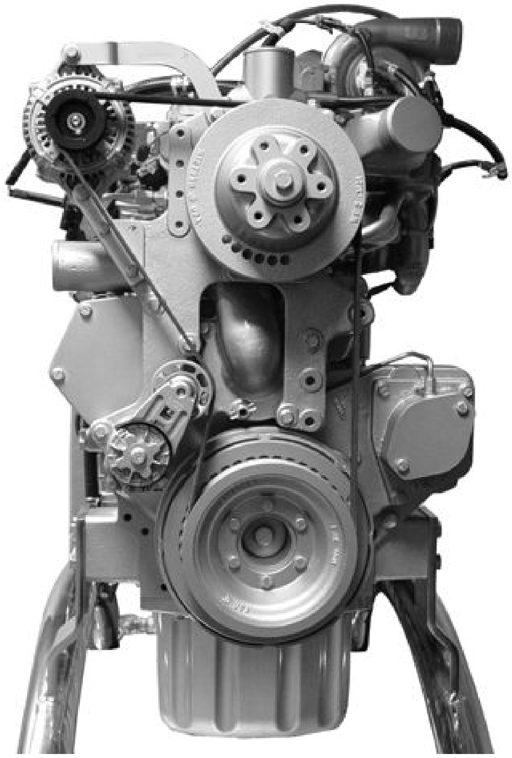
RG13848 —UN—24JAN05

9.0 L Diesel Engine Right Front View



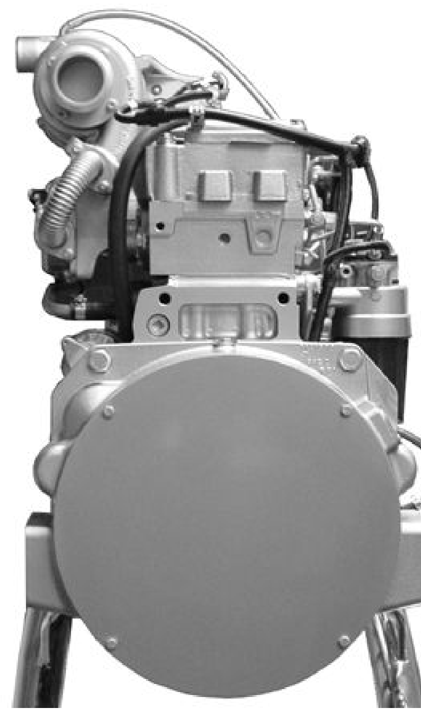
RG13847 —UN—24JAN05

9.0 L Diesel Engine Left Front View



RG13850 —UN—17JAN05

9.0 L Diesel Engine Front View



RG13849 —UN—24JAN05

9.0 L Diesel Engine Rear View

AS58880,0000007 -19-31JUL09-1/1

Contents

Original Instructions. All information, illustrations and specifications in this manual are based on the latest information available at the time of publication. The right is reserved to make changes at any time without notice.

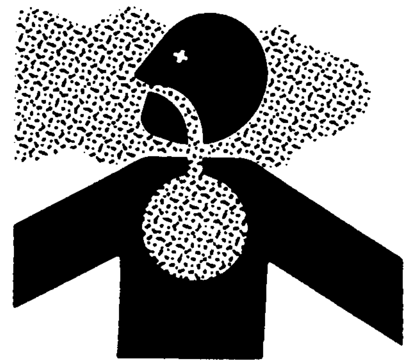
Section 01
General

Contents

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.



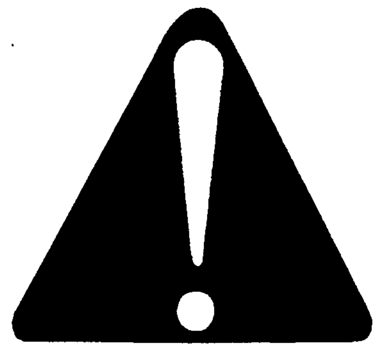
TS220 —UN—23AUG88

DX,AIR -19-17FEB99-1/1

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.



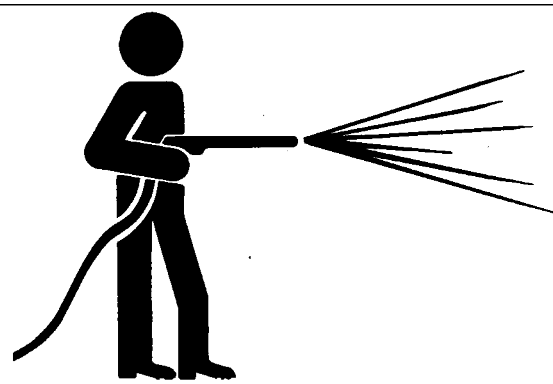
T81389 —UN—07DEC88

DX,ALERT -19-29SEP98-1/1

Work in Clean Area

Before starting a job:

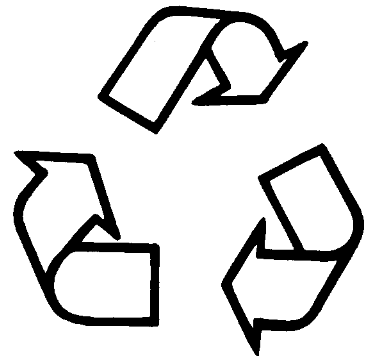
- Clean work area and machine.
- Make sure you have all necessary tools to do your job.
- Have the right parts on hand.
- Read all instructions thoroughly; do not attempt shortcuts.



T6642EJ —UN—18OCT88

DX,CLEAN -19-04JUN90-1/1

Dispose of Waste Properly



TS1133 —UN—26NOV90

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

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

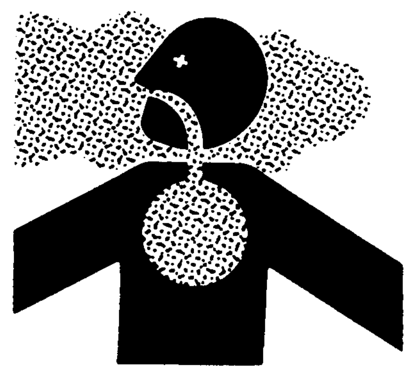
Do not pour waste onto the ground, down a drain, or into any water source.

Air conditioning refrigerants escaping into the air can damage the Earth's atmosphere. Government regulations may require a certified air conditioning service center to recover and recycle used air conditioning refrigerants.

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

DX,DRAIN -19-03MAR93-1/1

Avoid Harmful Asbestos Dust



TS220 —UN—23AUG88

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.

DX,DUST -19-15MAR91-1/1

Handle Fuel Safely—Avoid Fires

TS202 —UN—23AUG88

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.

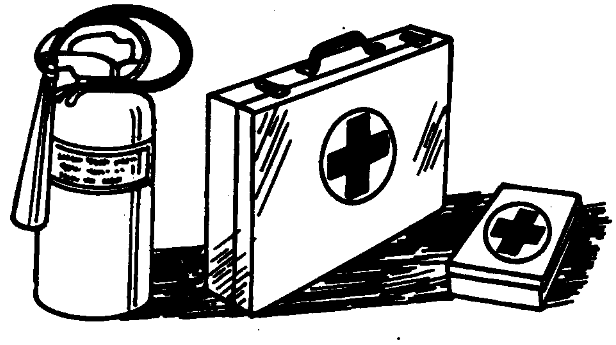
DX,FIRE1 -19-03MAR93-1/1

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.



TS291 —UN—23AUG88

DX,FIRE2 -19-03MAR93-1/1

Handle Starting Fluid Safely

Starting fluid is highly flammable.

Keep all sparks and flame away when using it. Keep starting fluid away from batteries and cables.

To prevent accidental discharge when storing the pressurized can, keep the cap on the container, and store in a cool, protected location.

Do not incinerate or puncture a starting fluid container.

TS1356 —UN—18MAR92

DX,FIRE3 -19-16APR92-1/1

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 machine is clean of trash, grease, and debris.

Do not store oily rags; they can ignite and burn spontaneously.

TS227 —UN—23AUG88

DX,FLAME -19-29SEP98-1/1

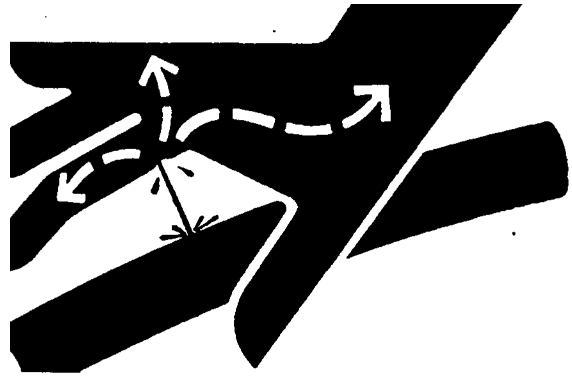
Avoid High-Pressure Fluids

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. Such information is available in English from Deere & Company Medical Department in Moline, Illinois, U.S.A., by calling 1-800-822-8262 or +1 309-748-5636.



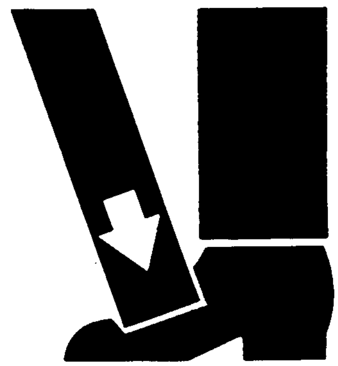
X9811 —UN—23AUG88

DX,FLUID -19-20AUG09-1/1

Use Proper Lifting Equipment

Lifting heavy components incorrectly can cause severe injury or machine damage.

Follow recommended procedure for removal and installation of components in the manual.

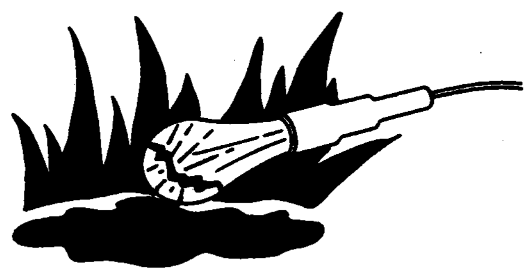


TS226 —UN—23AUG88

DX,LIFT -19-04JUN90-1/1

Illuminate Work Area Safely

Illuminate your work area adequately but safely. Use a portable safety light for working inside or under the machine. Make sure the bulb is enclosed by a wire cage. The hot filament of an accidentally broken bulb can ignite spilled fuel or oil.



TS223 —UN—23AUG88

DX,LIGHT -19-04JUN90-1/1

Live With Safety

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

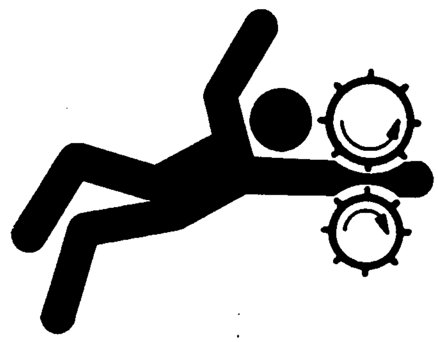
TS231 —19—07OCT88

DX,LIVE -19-25SEP92-1/1

Service Machines Safely

Tie long hair behind your head. Do not wear a necktie, scarf, loose clothing, or necklace when you work near machine 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.



TS228 —UN—23AUG88

DX,LOOSE -19-04JUN90-1/1

Handle Chemical Products Safely

Direct exposure to hazardous chemicals can cause serious injury. Potentially hazardous chemicals used with John Deere 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 John Deere dealer for MSDS's on chemical products used with John Deere equipment.)

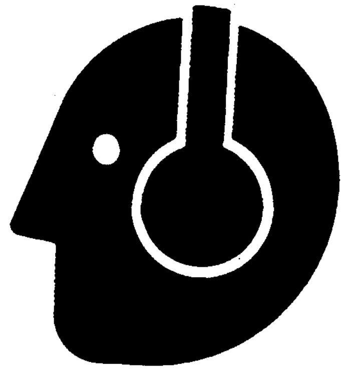
TS1132 —UN—26NOV90

DX,MSDS,NA -19-03MAR93-1/1

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.



TS207 —UN—23AUG88

DX,NOISE -19-03MAR93-1/1

Remove Paint Before Welding or Heating

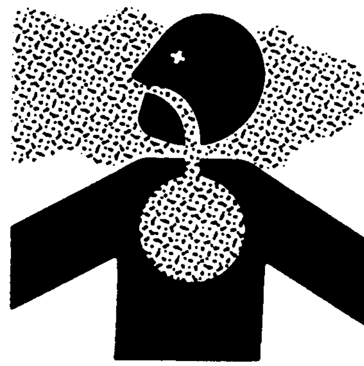
Avoid potentially toxic fumes and dust.

Hazardous fumes can be generated when paint is heated by welding, soldering, or using a torch.

Remove paint before heating:

- Remove paint a minimum of 100 mm (4 in.) from area to be affected by heating. If paint cannot be removed, wear an approved respirator before heating or welding.
- 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.



TS220 —UN—23AUG88

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

Dispose of paint and solvent properly.

DX,PAINT -19-24JUL02-1/1

Stay Clear of Rotating Drivelines

TS1644 —UN—22AUG95

Entanglement in rotating driveline can cause serious injury or death.

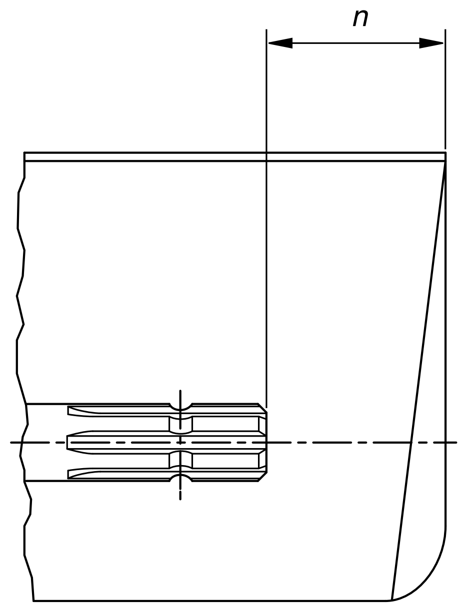
Keep tractor master shield and driveline shields in place at all times. Make sure rotating shields turn freely.

Wear close fitting clothing. Stop the engine and be sure that PTO driveline is stopped before making adjustments, connections, or cleaning out PTO driven equipment.

Do not install any adapter device between the tractor and the primary implement PTO drive shaft that will allow a 1000 rpm tractor shaft to power a 540 rpm implement at speeds higher than 540 rpm.

Do not install any adapter device that results in a portion of the rotating implement shaft, tractor shaft, or the adapter to be unguarded. The tractor master shield shall overlap the end of the splined shaft and the added adaptor device as outlined in the table.

PTO Type	Diameter	Splines	n ± 5 mm (0.20 in.)
1	35 mm (1.378 in.)	6	85 mm (3.35 in.)
2	35 mm (1.378 in.)	21	85 mm (3.35 in.)
3	45 mm (1.772 in.)	20	100 mm (4.00 in.)



H96219 —UN—29APR10

DX,PTO -19-30JUN10-1/1

Service Cooling System Safely

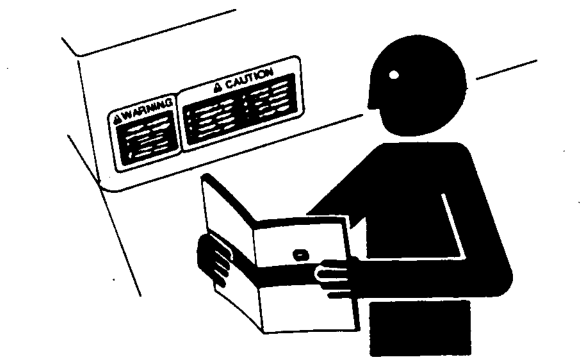
TS281 —UN—23AUG88

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.

DX,RCAP -19-04JUN90-1/1

Follow Safety Instructions



TS201 —UN—23AUG88

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 John Deere dealer.

There can be additional safety information contained on parts and components sourced from suppliers that is not reproduced in this operator's manual.

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 John Deere dealer.

DX,READ -19-16JUN09-1/1

Use Proper Tools

TS779 —UN—08NOV89

Use tools appropriate to the work. Makeshift tools and procedures can create safety hazards.

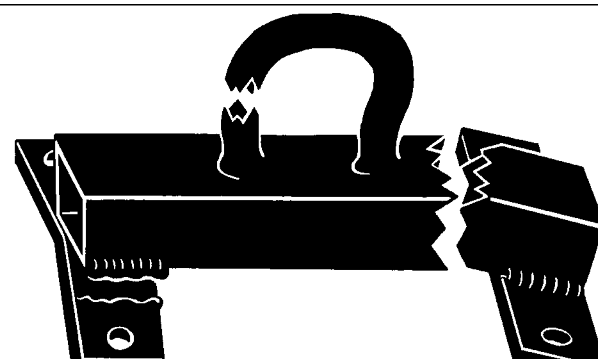
Use power tools only to loosen threaded parts and fasteners.

For loosening and tightening hardware, use the correct size tools. DO NOT use U.S. measurement tools on metric fasteners. Avoid bodily injury caused by slipping wrenches.

Use only service parts meeting John Deere specifications.

DX,REPAIR -19-17FEB99-1/1

Construct Dealer-Made Tools Safely



LX1016749

LX1016749 —UN—01JUL97

Faulty or broken tools can result in serious injury. When constructing tools, use proper, quality materials, and good workmanship.

Do not weld tools unless you have the proper equipment and experience to perform the job.

DX,SAFE,TOOLS -19-10OCT97-1/1

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.

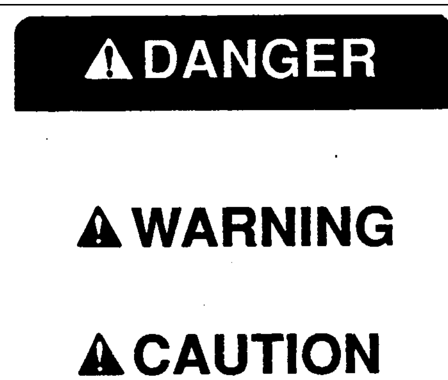
TS218 —UN—23AUG88

DX,SERV -19-17FEB99-1/1

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.

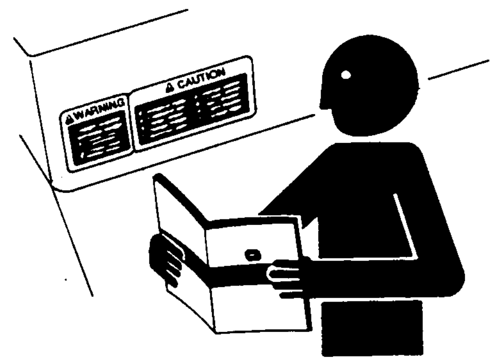


TS187 —19—30SEP88

DX,SIGNAL -19-03MAR93-1/1

Replace Safety Signs

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



TS201 —UN—23AUG88

DX,SIGNS1 -19-04JUN90-1/1

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 volt-meter or hydrometer.

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

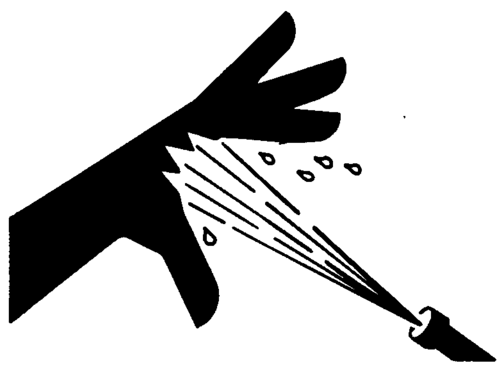
TS204 —UN—23AUG88

DX,SPARKS -19-03MAR93-1/1

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. Doctors unfamiliar with this type of injury should reference a knowledgeable medical source. Such information is available from Deere & Company Medical Department in Moline, Illinois, U.S.A.



TS1343 —UN—18MAR92

DX,SPRAY -19-16APR92-1/1

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 accidentally burst when heat goes beyond the immediate flame area.

TS953 —UN—15MAY90

DX,TORCH -19-10DEC04-1/1

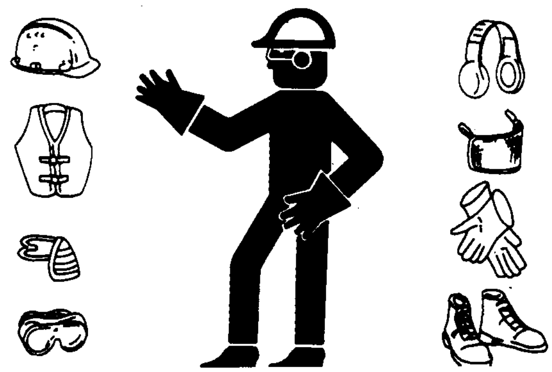
Wear Protective Clothing

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.

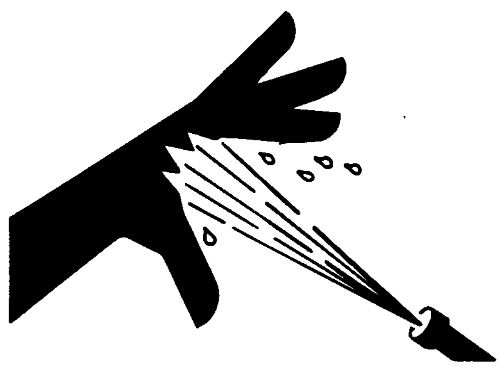


TS206 —UN—23AUG88

DX,WEAR -19-10SEP90-1/1

Wait Before Opening High-Pressure Fuel System

High-pressure fluid remaining in fuel lines can cause serious injury. Only technicians familiar with this type of system should perform repairs. Before disconnecting fuel lines, sensors, or any other components between the high-pressure fuel pump and nozzles on engines with High Pressure Common Rail (HPCR) fuel system, wait a minimum of 15 minutes after engine is stopped.



TS1343 —UN—18MAR92

DX,WW,HPCR2 -19-07JAN03-1/1

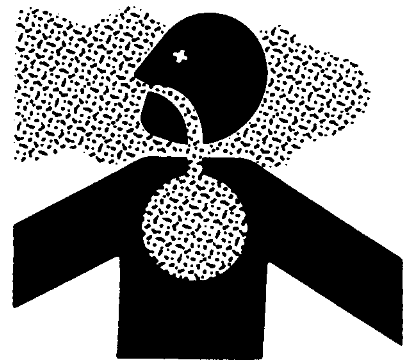
Handle Agricultural Chemicals Safely

Chemicals used in agricultural applications such as fungicides, herbicides, insecticides, pesticides, rodenticides, and fertilizers can be harmful to your health or the environment if not used carefully.

Always follow all label directions for effective, safe, and legal use of agricultural chemicals.

Reduce risk of exposure and injury:

- Wear appropriate personal protective equipment as recommended by the manufacturer. In the absence of manufacturer's instructions, follow these general guidelines:
  - Chemicals labeled **'Danger'**: Most toxic. Generally require use of goggles, respirator, gloves, and skin protection.
  - Chemicals labeled **'Warning'**: Less toxic. Generally require use of goggles, gloves, and skin protections.
  - Chemicals labeled **'Caution'**: Least toxic. Generally require use of gloves and skin protection.
- Avoid inhaling vapor, aerosol or dust.
- Always have soap, water, and towel available when working with chemicals. If chemical contacts skin, hands, or face, wash immediately with soap and water. If chemical gets into eyes, flush immediately with water.
- Wash hands and face after using chemicals and before eating, drinking, smoking, or urination.
- Do not smoke or eat while applying chemicals.
- After handling chemicals, always bathe or shower and change clothes. Wash clothing before wearing again.
- Seek medical attention immediately if illness occurs during or shortly after use of chemicals.
- Keep chemicals in original containers. Do not transfer chemicals to unmarked containers or to containers used for food or drink.



TS220 —UN—23AUG88

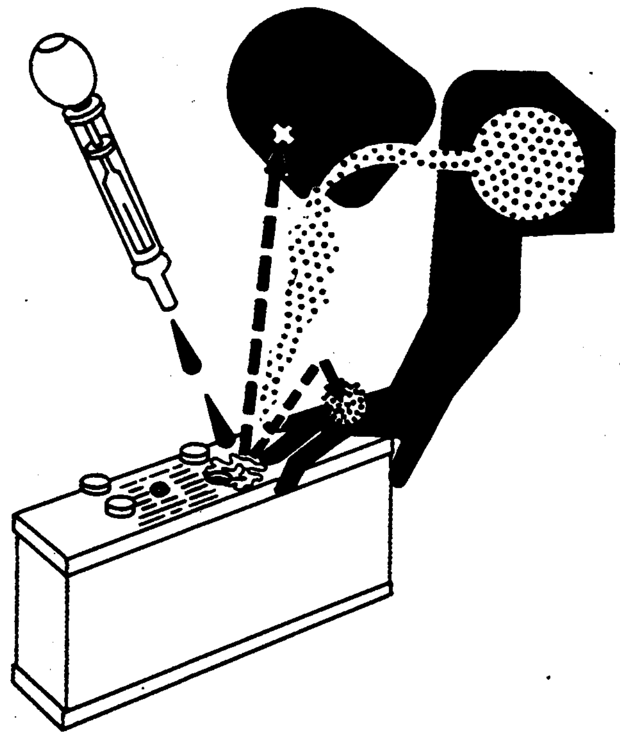
A34471 —UN—11OCT88

- Store chemicals in a secure, locked area away from human or livestock food. Keep children away.
- Always dispose of containers properly. Triple rinse empty containers and puncture or crush containers and dispose of properly.

DX,WW,CHEM01 -19-24AUG10-1/1

Handling Batteries Safely

TS204 —UN—23AUG88



TS203 —UN—23AUG88

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 (-) battery clamp first and replace grounded clamp last.

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

Avoid hazards by:

- Filling batteries in a well-ventilated area
- Wearing eye protection and rubber gloves
- Avoiding use of air pressure to clean batteries
- Avoiding breathing fumes when electrolyte is added
- Avoiding spilling or dripping electrolyte
- Using correct battery booster or charger procedure.

If acid is spilled on skin or in eyes:

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

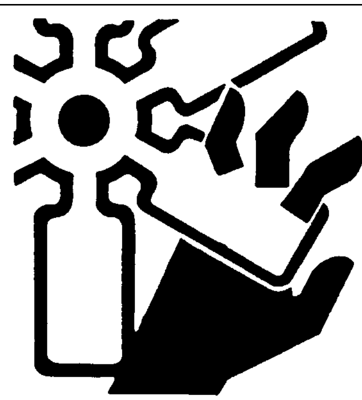
If acid is swallowed:

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

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.**

DX,WW,BATTERIES -19-02DEC10-1/1

Install All Guards



TS677 —UN—21SEP89

Rotating cooling system fans, belts, pulleys, and drives can cause serious injury.

Keep all guards in place at all times during engine operation.

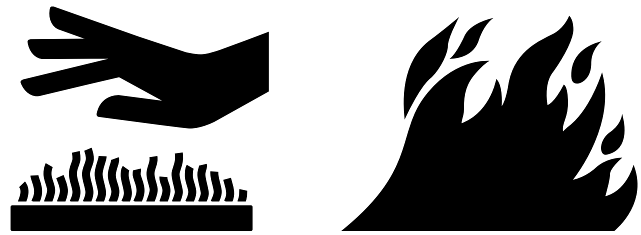
Wear close-fitting clothes. Stop the engine and be sure fans, belts, pulleys, and drives are stopped before making adjustments, connections, or cleaning near fans and their drive components.

DX,GUARDS -19-18AUG09-1/1

Avoid Hot Exhaust

Servicing machine or attachments with engine running can result in serious personal injury. Avoid exposure and skin contact with hot exhaust gases and components.

Exhaust parts and streams become very hot during operation. Exhaust gases and components reach temperatures hot enough to burn people, ignite, or melt common materials.



RG17488 —UN—21AUG09

DX,EXHAUST -19-20AUG09-1/1

Engine Model Designation

NOTE: On engine serial number (A), the 7th digit shows the emission level, as follows:

- *"B" for non-certified engines*
- *"C" for Tier I/Stage I engines*
- *"G" for Tier II/Stage II engines*
- *"L" for Tier III/Stage III A engines*

JOHN DEERE ENGINE MODEL—6090

John Deere engine model designation includes number of cylinders, displacement in liters, aspiration, user code, and application code. For example:

6090 HF485 Engine

6	Number of cylinders
9.0	Liter designation
H	Aspiration code
F	User code (OEM)
485	Application Code (OEM Model)

Aspiration Code

H	Turbocharged and air-to-air aftercooled

User Code

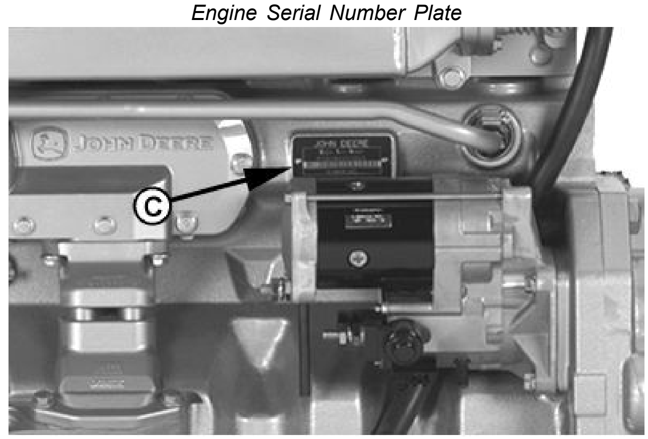
CQ	S.L.C. Horizontina (Brazil)
DW	Davenport
F	OEM (Original Equipment Manufacturer)
FF	Kernersvill Deere-Hitachi (North Carolina)
FM	OEM Marine
H	Harvester
N	Des Moines
RW	Waterloo (Tractors)
T	Dubuque, and Cameco (Thibodaux, Louisiana)
TJ	Ontario (Canada) - Timberjack
Z	Zweibrucken (Germany)

Application Code

001, etc.	See Application manual, CTM106819.

RG14799 —UN—23JUN06

Engine Serial Number Plate



RG13813 —UN—11JAN05

Location of Engine Serial Number Plate

A—Engine Serial Number
B—Engine Model Number
C—Serial Number Plate

RE38635,00000DE -19-10DEC09-1/1

Engine Serial Number Plate Information

IMPORTANT: The engine serial number plate can be easily destroyed. Remove the plate or record the information elsewhere, before "hot tank" cleaning the block.

RG13814 —UN—11JAN05

Engine Serial Number Plate

A—Engine Serial Number **B—Engine Model Number**

Engine Serial Number (A)

Each engine has a 13-digit John Deere engine serial number identifying the producing factory, engine model designation, and a 6-digit sequential number. The following is an example:

RG6090H000000

RG .... Factory code producing engine
6090H .... Engine model designation
000000 .... Sequential serial number

Factory Code

RG .... Waterloo Engine Works

Engine Model Designation

6090H .... (See <u>ENGINE MODEL DESIGNATION</u>.)

Sequential Number

000000 .... 6-digit sequential number

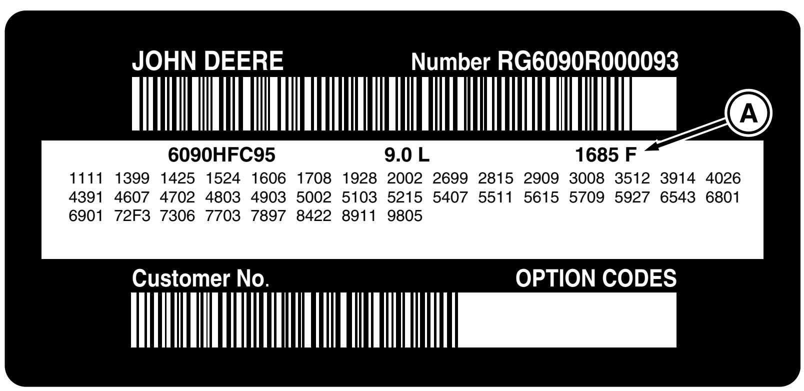
The engine serial number plate is located either on the right-hand side of engine between the oil filter base and fuel pump (viewed from flywheel end) or on the left-hand side of the engine directly above the starter motor.

Engine Application Data (B)

The second line of information on the engine serial number plate identifies the engine/Deere machine or OEM relationship. See<u>ENGINE APPLICATION CHART</u> later in this group.

RE38635,00000B6 -19-11APR05-1/1

OEM Engine Option Code Label



RG17416 —UN—07JAN10

Option Code Label

In addition to the serial number plate, 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.

RE38635,0000016 -19-28JUL09-1/1

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. Renewable diesel fuel produced by hydrotreating animal fats and vegetable oils is basically identical to petroleum diesel fuel. Renewable diesel that meets EN 590 or ASTM D975 is acceptable for use at all percentage mixture levels.

Required Fuel Properties

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

Cetane number of 43 minimum. Cetane number greater than 47 is preferred, especially for temperatures below –20°C (–4°F) or elevations above 1500 m (5000 ft.).

Cold Filter Plugging Point (CFPP) should be at least 5°C (9°F) below the expected lowest temperature or **Cloud Point** below the expected lowest ambient temperature.

Fuel lubricity should pass a maximum scar diameter of 0.45 mm as measured by ASTM D6079 or ISO 12156-1.

Diesel fuel quality and sulfur content must comply with all existing emissions regulations for the area in which the engine operates. DO NOT use diesel fuel with sulfur content greater than 10 000 mg/kg (10 000 ppm).

Sulfur content for Interim Tier 4 and Stage III B engines

- Use ONLY ultra low sulfur diesel (ULSD) fuel with a maximum of 15 mg/kg (15 ppm) sulfur content.

Sulfur Content for Tier 3 and Stage III A Engines

- Use of diesel fuel with sulfur content less than 1000 mg/kg (1000 ppm) is RECOMMENDED
- Use of diesel fuel with sulfur content 1000–5000 mg/kg (1000–5000 ppm) REDUCES oil and filter change intervals.
- BEFORE using diesel fuel with sulfur content greater than 5000 mg/kg (5000 ppm), contact your John Deere dealer

Sulfur Content for Tier 2 and Stage II Engines

- Use of diesel fuel with sulfur content less than 500 mg/kg (500 ppm) is RECOMMENDED.
- Use of diesel fuel with sulfur content 500–5000 mg/kg (500–5000 ppm) REDUCES the oil and filter change interval
- BEFORE using diesel fuel with sulfur content greater than 5000 mg/kg (5000 ppm), contact your John Deere dealer

Sulfur Content for Other Engines

- Use of diesel fuel with sulfur content less than 5000 mg/kg (5000 ppm) is recommended.
- Use of diesel fuel with sulfur content greater than 5000 mg/kg (5000 ppm) REDUCES the oil and filter change intervals.

IMPORTANT: Do not mix used diesel engine oil or any other type of lubricating oil with diesel fuel.

IMPORTANT: Improper fuel additive usage may cause damage on fuel injection equipment of diesel engines.

DX,FUEL1 -19-11APR11-1/1

Biodiesel Fuel

Biodiesel is a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats. Biodiesel blends are biodiesel mixed with petroleum diesel fuel on a volume basis.

Biodiesel users in the U.S. are strongly encouraged to purchase biodiesel blends from a BQ-9000 Certified Marketer and sourced from a BQ-9000 Accredited Producer (as certified by the National Biodiesel Board). Certified Marketers and Accredited Producers can be found at the following website: http://www.bq-9000.org.

While 5% blends are preferred (B5), biodiesel concentrations up to a 20% blend (B20) in petroleum diesel fuel can be used in all John Deere engines. Biodiesel blends up to B20 can be used ONLY if the biodiesel (100% biodiesel or B100) meets ASTM D6751 (US), EN 14214 (EU), or equivalent specification. Expect a 2% reduction in power and a 3% reduction in fuel economy when using B20.

John Deere approved fuel conditioners containing detergent/dispersant additives are recommended when using lower biodiesel blends, but are required when using blends of B20 or greater.

John Deere engines can also operate on biodiesel blends above B20 (up to 100% biodiesel) ONLY if the biodiesel meets the EN 14214 specification (primarily available in Europe). Engines operating on biodiesel blends above B20 may not fully comply with all applicable emissions regulations. Expect up to a 12% reduction in power and an 18% reduction in fuel economy when using 100% biodiesel. John Deere approved fuel conditioners containing detergent/dispersant additives are required.

The petroleum diesel portion of biodiesel blends must meet the requirements of ASTM D975 (US) or EN 590 (EU) commercial standards.

Biodiesel blends up to B20 must be used within 90 days of the date of biodiesel manufacture. Biodiesel blends from B21 to B100 must be used within 45 days of the date of biodiesel manufacture.

Request a certificate of analysis from your fuel distributor to ensure that the fuel is compliant with the above specifications.

When using biodiesel fuel, the engine oil level must be checked daily. If oil becomes diluted with fuel, shorten oil change intervals. Refer to Diesel Engine Oil and Filter Service Intervals for more details regarding biodiesel and engine oil change intervals.

The following must be considered when using biodiesel blends up to B20:

- Cold weather flow degradation
- Stability and storage issues (moisture absorption, oxidation, microbial growth)
- Possible filter restriction and plugging (usually a problem when first switching to biodiesel on used engines.)
- Possible fuel leakage through seals and hoses
- Possible reduction of service life of engine components

The following must also be considered when using biodiesel blends above B20.

- Possible coking and/or blocked injector nozzles, resulting in power loss and engine misfire if John Deere approved fuel conditioners containing detergent/dispersant additives are not used
- Possible crankcase oil dilution, requiring more frequent oil changes
- Possible corrosion of fuel injection equipment
- Possible lacquering and/or seizure of internal components
- Possible formation of sludge and sediments
- Possible thermal oxidation of fuel at elevated temperatures
- Possible elastomer seal and gasket material degradation (primarily an issue with older engines)
- Possible compatibility issues with other materials (including copper, lead, zinc, tin, brass, and bronze) used in fuel systems and fuel handling equipment
- Possible reduction in water separator efficiency
- Potential high acid levels within fuel system
- Possible damage to paint if exposed to biodiesel

IMPORTANT: Raw pressed vegetable oils are NOT acceptable for use as fuel in any concentration in John Deere engines. Their use could cause engine failure.

DX,FUEL7 -19-20APR11-1/1

Minimizing the Effect of Cold Weather on Diesel Engines

John Deere 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 John Deere dealer for additional information and local availability of cold weather aids.

Use Winter Grade Fuel

When temperatures fall below 0°C (32°F), winter grade fuel (No. 1-D in North America) is best suited for cold weather operation. Winter grade 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 lowest temperature at which movement of the fuel is observed.

NOTE: On average, winter grade diesel fuel has a lower Btu (heat content) rating. Using winter grade fuel may reduce power and fuel efficiency, but should not cause any other engine performance effects. Check the grade of fuel being used before troubleshooting for low power complaints in cold weather operation.

Air Intake Heater

An air intake heater is an available option for some engines to aid cold weather starting.

Ether

An ether port on the intake is available to aid cold weather starting.

CAUTION: Ether is highly flammable. Do not use ether when starting an engine equipped with glow plugs or an air intake heater.

Coolant Heater

An engine block heater (coolant heater) is an available option to aid cold weather starting.

Seasonal Viscosity Oil and Proper Coolant Concentration

Use seasonal grade viscosity engine oil based on the 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 in this section.)

Diesel Fuel Flow Additive

Use John Deere Fuel-Protect Diesel Fuel Conditioner (winter formula), which contains anti-gel chemistry, or equivalent fuel conditioner to treat non-winter grade fuel (No. 2-D in North America) during the cold weather season. This generally extends operability to about 10°C (18°F) below the fuel cloud point. For operability at even lower temperatures, use winter grade fuel.

IMPORTANT: Treat fuel when outside temperature drops below 0°C (32°F). For best results, use with untreated fuel. Follow all recommended instructions on label.

BioDiesel

When operating with biodiesel blends, wax formation can occur at warmer temperatures. Begin using John Deere Fuel-Protect Diesel Fuel Conditioner (winter formula) at 5°C (41°F) to treat biodiesel fuels during the cold weather season. Use B5 or lower blends at temperatures below 0°C (32°F). Use only winter grade petroleum diesel fuel at temperatures below -10°C (14°F).

Winterfronts

Use of fabric, cardboard, or solid winterfronts is not recommended with any John Deere 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. Winterfronts may also put abnormal stress on fan and fan drive components potentially causing premature failures.

If winterfronts 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 aftercooling 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 John Deere dealer.

DX,FUEL10 -19-20APR11-1/1

Handling and Storing Diesel Fuel

CAUTION: Reduce the risk of fire. 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.

When using biodiesel fuel, the 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.

IMPORTANT: 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.

DX,FUEL4 -19-14APR11-1/1

Lubricity of Diesel Fuel

Most diesel fuels manufactured in the United States, Canada, and the European Union have adequate lubricity to ensure proper operation and durability of fuel injection system components. However, diesel fuels manufactured in some areas of the world may lack the necessary lubricity.

IMPORTANT: Make sure the diesel fuel used in your machine demonstrates good lubricity characteristics.

Fuel lubricity should pass a maximum scar diameter of 0.45 mm as measured by ASTM D6079 or ISO 12156-1.

If fuel of low or unknown lubricity is used, add John Deere Fuel-Protect Diesel Fuel Conditioner (or equivalent) at the specified concentration.

Lubricity of Biodiesel Fuel

Fuel lubricity can improve significantly with biodiesel blends up to B20 (20% biodiesel). Further increase in lubricity is limited for biodiesel blends greater than B20.

DX,FUEL5 -19-14APR11-1/1

Testing Diesel Fuel

A fuel analysis program can help to monitor the quality of diesel fuel. The fuel analysis can provide critical data such as cetane number, fuel type, sulfur content, water content, appearance, suitability for cold weather operations, bacteria, cloud point, acid number, particulate contamination, and whether the fuel meets specification.

Contact your John Deere dealer for more information on diesel fuel analysis.

DX,FUEL6 -19-14APR11-1/1

Engine Oil and Filter Service Intervals

See applicable operator’s manual for service intervals.

DM80898,000025E -19-14OCT10-1/1

Diesel Engine Oil

Use oil viscosity based on the expected air temperature range during the period between oil changes.

John Deere Plus-50™ II oil is preferred.

John Deere Plus-50™ is also recommended.

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

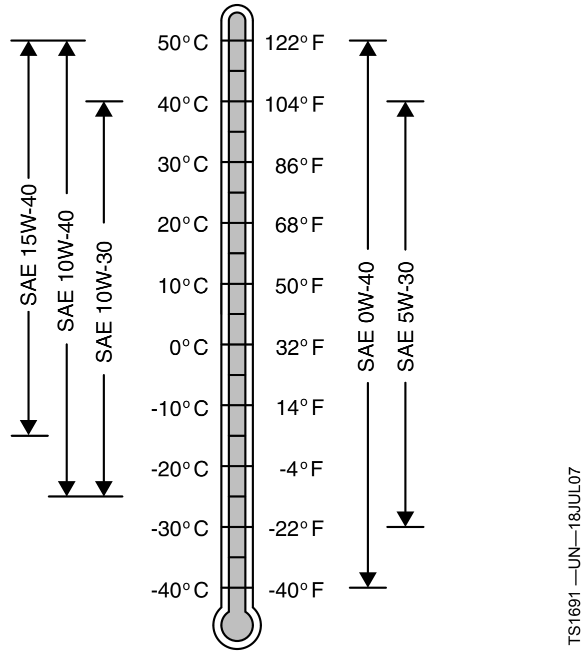
- John Deere Torq-Gard™
- API Service Category CJ-4
- API Service Category CI-4 PLUS
- API Service Category CI-4
- ACEA Oil Sequence E9
- ACEA Oil Sequence E7
- ACEA Oil Sequence E6
- ACEA Oil Sequence E5
- ACEA Oil Sequence E4

Multi-viscosity diesel engine oils are preferred.

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

DO NOT use diesel fuel with sulfur content greater than 10 000 mg/kg (10 000 ppm).

Plus-50 is a trademark of Deere & Company
Torq-Gard is a trademark of Deere & Company



Oil Viscosities for Air Temperature Ranges

DX,ENOIL11 -19-11APR11-1/1

Diesel Engine Break-In Oil

New engines are filled at the factory with either John Deere Break-In™ or John Deere Break-In Plus™ Engine Oil. During the break-in period, add John Deere Break-In™ or Break-In Plus ™ Engine Oil, respectively, as needed to maintain the specified oil level.

Operate the engine under various conditions, particularly heavy loads with minimal idling, to help seat engine components properly.

If John Deere Break-In Engine Oil is used during the initial operation of a new or rebuilt engine, change the oil and filter at a maximum of 250 hours.

If John Deere Break-In Plus Engine Oil is used, change the oil and filter at a minimum of 100 hours and a maximum equal to the interval specified for John Deere Plus-50™ II or Plus-50 oil.

After engine overhaul, fill the engine with either John Deere Break-In™ or Break-In Plus™ Engine Oil.

If John Deere Break-In or Break-In Plus Engine Oil is not available, use an SAE 10W-30 viscosity grade diesel engine oil meeting one of the following and change the oil and filter at a maximum of 100 hours of operation:

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

IMPORTANT: Do not use Plus-50™ II, Plus-50 or engine oils meeting any of the following for the initial break-in of a new or rebuilt engine:

API CJ-4	**ACEA E9**
API CI-4 PLUS	**ACEA E7**
API CI-4	**ACEA E6**
API CH-4	**ACEA E5**
API CG-4	**ACEA E4**
API CF-4	**ACEA E3**
API CF-2	
API CF	

These oils will not allow the engine to break in properly.

John Deere Break-In Plus™ Engine Oil can be used for all John Deere diesel engines at all emission certification levels.

After the break-in period, use John Deere Plus-50™ II, John Deere Plus-50, or other diesel engine oil as recommended in this manual.

Break-In is a trademark of Deere & Company.
Break-In Plus is a trademark of Deere & Company
Plus-50 is a trademark of Deere & Company.

DX,ENOIL4 -19-20APR11-1/1

Oil Filters

Filtration of oils is critical to proper operation and lubrication.

Always change filters regularly as specified in this manual.

Use filters meeting John Deere performance specifications.

DX,FILT -19-18MAR96-1/1

Grease

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

John Deere SD Polyurea Grease is preferred.

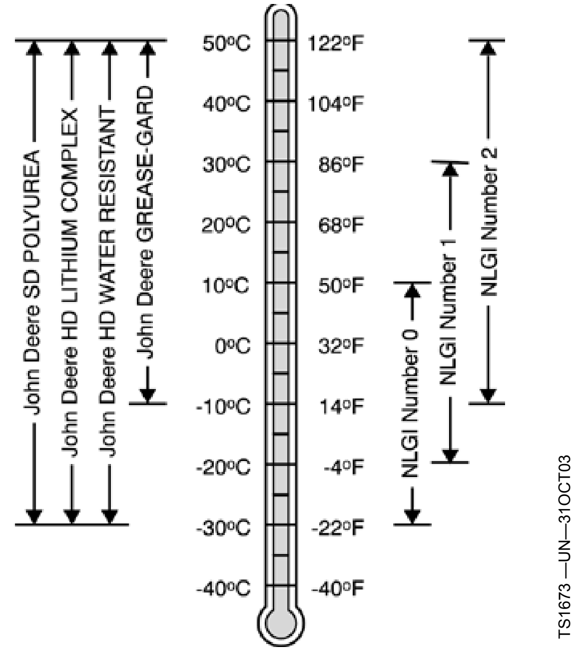
The following greases are also recommended:

- John Deere HD Lithium Complex Grease
- John Deere HD Water Resistant Grease
- John DeereGREASE-GARD™

Other greases may be used if they meet the following:

- NLGI Performance Classification GC-LB

IMPORTANT: Some types of grease thickeners are not compatible with others. Consult your grease supplier before mixing different types of grease.



Greases for Air Temperature Ranges

GREASE-GARD is a trademark of Deere & Company

DX,GREA1 -19-14APR11-1/1

Alternative and Synthetic Lubricants

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

Some John Deere brand coolants and lubricants may not be available in your location.

Consult your John Deere 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 lubricants.

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

DX,ALTER -19-11APR11-1/1

Lubricant Storage

Your equipment can operate at top efficiency only when clean lubricants are used.

Use clean containers to handle all lubricants.

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.

DX,LUBST -19-11APR11-1/1

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 John Deere dealer to obtain specific information and recommendations.

DX,LUBMIX -19-18MAR96-1/1

Heavy Duty 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). If protection at lower temperatures is required, consult your John Deere dealer for recommendations.

The following engine coolants are preferred:

- John Deere COOL-GARD™ II Premix
- John Deere COOL-GARD II PG Premix

Use John Deere COOL-GARD II PG Premix when a non-toxic coolant formulation is required.

Additional Recommended Coolants

The following engine coolant is also recommended:

- John Deere COOL-GARD II Concentrate in a 40–60% mixture of concentrate with quality water.

John Deere COOL-GARD II Premix, COOL-GARD II PG Premix, and COOL-GARD II Concentrate coolants do not require use of supplemental coolant additives.

Other Coolants

John Deere COOL-GARD II and COOL-GARD II PG coolants might not be available in the geographical area where service is performed.

If these coolants are unavailable, use a coolant concentrate or prediluted coolant intended for use with heavy duty diesel engines and with a minimum of the following chemical and physical properties:

- Is formulated with a quality nitrite-free additive package.
- Provides cylinder liner cavitation protection according to either the John Deere Cavitation Test Method or a fleet study run at or above 60% load capacity
- Protects the cooling system metals (cast iron, aluminum alloys, and copper alloys such as brass) from corrosion

The additive package must be part of one of the following coolant mixtures:

- ethylene glycol or propylene glycol base prediluted (40—60%) heavy duty coolant
- ethylene glycol or propylene glycol base heavy duty coolant concentrate in a 40—60% mixture of concentrate with quality water

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 and propylene glycol base engine coolant concentrate.

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

Do not mix ethylene glycol and propylene glycol base coolants.

Do not use coolants that contain nitrites.

COOL-GARD is a trademark of Deere & Company

DX,COOL3 -19-14APR11-1/1

Supplemental Coolant Additives

Some coolant additives will gradually deplete during engine operation. For nitrite-containing coolants, replenish coolant additives between drain intervals by adding a supplemental coolant additive as determined necessary by coolant testing.

John Deere Liquid Coolant Conditioner is recommended as a supplemental coolant additive for nitrite-containing coolants.

John Deere Liquid Coolant Conditioner is not designed for use with John Deere COOL-GARD™ II Premix, COOL-GARD II PG Premix, or COOL-GARD II Concentrate.

IMPORTANT: Do not add a supplemental coolant additive when the cooling system is drained and refilled with any of the following:

- **John Deere COOL-GARD II**
- **John Deere COOL-GARD II PG**

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 drop-out and gelation of the coolant.

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

COOL-GARD is a trademark of Deere & Company

DX,COOL4 -19-14APR11-1/1

Operating in Warm Temperature Climates

John Deere engines 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.

John Deere COOL-GARD™ II Premix is available in a concentration of 50% ethylene glycol. However, there are situations in warm temperature climates where a coolant with lower glycol concentration (approximately 20% ethylene glycol) has been approved. In these cases, the low glycol formulation has been modified to provide the same level of corrosion inhibitor as John Deere COOL-GARD II Premix (50/50).

IMPORTANT: 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.

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DX,COOL6 -19-03NOV08-1/1

Additional Information About Diesel Engine Coolants and John Deere LIQUID COOLANT CONDITIONER

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

Coolant Specifications

Some products, including John Deere COOL-GARD™ Premix coolant, are fully formulated coolants that contain all three components in their correct concentrations. Do not add an initial charge of supplemental coolant additives or water to John Deere COOL-GARD Premix.

John Deere COOL-GARD Concentrate contains both ethylene glycol and inhibiting coolant additives. Mix COOL-GARD Concentrate with quality water, but do not add an initial charge of supplemental coolant additives.

Replenish Coolant Additives

Some coolant additives will gradually deplete during engine operation. Periodic replenishment of inhibitors is required, even when John Deere COOL-GARD Premix, COOL-GARD Concentrate, or COOL-GARD PG Premix is used. Follow the recommendations in this manual for the use of supplemental coolant additives.

Why use John Deere LIQUID COOLANT CONDITIONER?

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

John Deere LIQUID COOLANT CONDITIONER is an additive system designed to reduce corrosion, erosion, and pitting when used with nitrite-containing diesel engine coolants such as John Deere COOL-GARD Premix, COOL-GARD Concentrate, and COOL-GARD PG Premix. Maintaining John Deere COOL-GARD coolants with John Deere LIQUID COOLANT CONDITIONER provides optimum protection for up to 5 years or 5000 hours of operation.

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Avoid Automotive-type Coolants

Never use automotive-type coolants (such as those meeting ASTM D3306). 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. Do not treat an automotive engine coolant with a supplemental coolant additive because the high concentration of additives can result in additive fallout.

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 and propylene 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 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)
Propylene Glycol	**Freeze Protection Limit**
40%	-21°C (-6°F)
50%	-33°C (-27°F)
60%	-49°C (-56°F)

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

DX,COOL7 -19-03NOV08-1/1

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).

John Deere COOL-GARD is preferred for service.

If John Deere COOL-GARD is not available, use a low silicate ethylene glycol or propylene glycol base coolant concentrate in a 50% mixture of concentrate with quality water.

The coolant concentrate shall be of a quality that provides cavitation protection to cast iron and aluminum parts in the cooling system. John Deere COOL-GARD meets this requirement.

Freeze protection

A 50% mixture of ethylene glycol engine coolant in water provides freeze protection to -37°C (-34°F).

A 50% mixture of propylene glycol engine coolant in water provides freeze protection to -33°C (-27°F).

If protection at lower temperatures is required, consult your John Deere dealer for recommendations.

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 and propylene glycol base engine coolant concentrate.

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

IMPORTANT: Do not mix ethylene glycol and propylene glycol base coolants.

DX,COOL8 -19-16NOV01-1/1

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 John Deere dealer. These test strips provide a simple, effective method to check the freeze point and additive levels of your engine coolant.

When Using John Deere COOL-GARD II

John Deere COOL-GARD II Premix™ , COOL-GARD II PG Premix and COOL-GARD II Concentrate are maintenance free coolants for up to six years or 6000 hours of operation, provided that the cooling system is topped off using only John Deere COOL-GARD II Premix or COOL-GARD II PG premix. Test the coolant condition annually with coolant test strips designed for use with John Deere COOL-GARD II coolants. If the test strip chart indicates that additive is required, add John Deere COOL-GARD II Coolant Extender as directed.

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Add only the recommended concentration of John Deere COOL-GARD II Coolant Extender. DO NOT add more than the recommended amount.

When Using Nitrite-Containing Coolants

Compare the test strip results to the supplemental coolant additive (SCA) chart to determine the amount of inhibiting additives in your coolant and whether more John Deere Liquid Coolant Conditioner should be added.

Add only the recommended concentration of John Deere Liquid Coolant Conditioner. DO NOT add more than the recommended amount.

Coolant Analysis

For a more thorough evaluation of your coolant, perform a coolant analysis. The coolant analysis can provide critical data such as freezing point, antifreeze level, pH, alkalinity, nitrite content (cavitation control additive), molybdate content (rust inhibitor additive), silicate content, corrosion metals, and visual assessment.

Contact your John Deere dealer for more information on coolant analysis.

DX,COOL9 -19-11APR11-1/1

Drain Intervals for Diesel Engine Coolant

Drain and flush the cooling system and refill with fresh coolant at the indicated interval, which varies with the coolant used.

John Deere COOL-GARD™ II Premix, COOL-GARD II PG Premix and COOL-GARD II Concentrate are maintenance free coolants for up to six years or 6000 hours of operation, provided that the cooling system is topped off using only John Deere COOL-GARD II Premix or COOL-GARD II PG Premix.

Test the coolant condition annually with Coolant Test Strips designed for use with John Deere COOL-GARD II coolants. If the test strip chart indicates that additive is required, add John Deere COOL-GARD II Coolant Extender as directed.

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If John Deere COOL-GARD™ II Premix, COOL-GARD II PG Premix, or COOL-GARD II Concentrate is used, but the coolant is not tested OR additives are not replenished by adding John Deere COOL-GARD II Coolant Extender, the drain interval is four years or 4000 hours of operation. This drain interval only applies to COOL-GARD II coolants that have been maintained within a 40—60% mixture of concentrate with quality water.

If a coolant other than COOL-GARD II, or COOL-GARD II PG is used, reduce the drain interval to two years or 2000 hours of operation.

DX,COOL11 -19-14APR11-1/1

Section 02
Repair and Adjustments

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Continued on next page

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Continued on next page

Engine Overhaul Guidelines

Engine life and performance will vary depending on operating conditions and the level of regular engine maintenance. Engines can be brought back to original performance standards through proper overhaul procedure and replacement of parts with genuine John Deere service parts. Overhauling the engine prior to failure can avoid costly repairs and downtime.

Consider installing a John Deere overhaul kit when:

- The engine begins to experience power loss and there are no known engine component failures.
- The engine is hard to start due to low cranking compression.
- The engine begins to smoke and there are no known engine component failures.
- The engine begins to use oil. Refer to Section 04 for acceptable oil consumption.
- The engine has high usage hours and the owner wants to take preventive measure to avoid high-cost repairs and costly downtime.

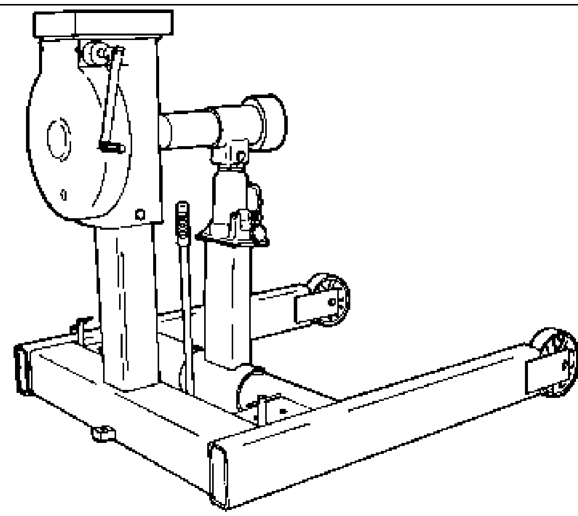
John Deere overhaul kits have a 1500-hour or 12-month warranty, whichever comes first. Installation labor is covered by warranty if an authorized John Deere dealer installed the overhaul kit and the replacement parts.

DPSG,OUO1032,3410 -19-15JUN00-1/1

Engine Repair Stand

NOTE: Only the 2722 kg (6000 lb) heavy-duty engine repair stand, number D05223ST manufactured by Owatonna Tool Co., Owatonna, Minnesota is referenced in this manual. When any other repair stand is used, consult the manufacturer's instructions for mounting the engine.

Refer to machine technical manual for steps to remove engine from machine before installing it on repair stand.



D05223ST Engine Repair Stand

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Safety Precautions

The engine repair stand should be used only by qualified service technicians familiar with this equipment.

To maintain shear strength specifications, alloy steel SAE Grade 8 or higher socket head cap screws must be used to mount adapters or engine. Use LOCTITE® 242 Thread Lock and Sealer on cap screws when installing lifting straps on engine. Tighten cap screws to 170 N·m (125 lb-ft).

For full thread engagement, be certain that tapped holes in adapters and engine blocks are clean and not damaged. A thread length engagement equal to 1-1/2 screw diameters minimum is required to maintain strength requirements.

To avoid structural or personal injury, do not exceed the maximum capacity rating of 2722 kg (6000 lb). Maximum capacity is determined with the center of the engine located not more than 330 mm (13 in.) from the mounting hub surface of the engine stand.

To avoid an unsafe off-balance load condition, the center of balance of an engine must be located within 51 mm (2 in.) of the engine stand rotating shaft. Engine center of balance is generally located a few millimeters above the crankshaft.

To prevent possible personal injury due to engine slippage, recheck to make sure engine is solidly mounted before releasing support from engine lifting device.

Never permit any part of the body to be positioned under a load being lifted or suspended. Accidental slippage may result in personal injury.

The lifting jack is to be used when it is necessary to lift the engine for rotation. When working on the engine, the jack should be at its lowest position to keep the center of gravity low and the possibility of tipping low.

To prevent possible personal injury due to sudden engine movement, lower engine by operating jack release valve slowly. Do not unscrew release valve knob more than two turns from its closed position.

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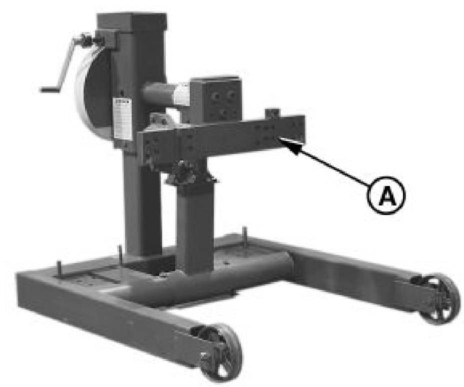
RG,RG34710,1044 -19-23OCT97-1/1

Install Adapters on Engine Repair Stand

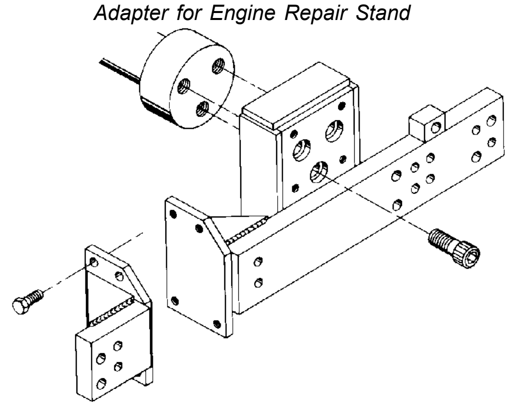
Attach the No. 205466 Engine Adapter (A) to mounting hub of the engine repair stand using SAE Grade 8 socket-head screws. Tighten screws to 135 N·m (100 lb-ft).

A—Engine Adapter



RG8183A —UN—08DEC00

Adapter for Engine Repair Stand



RG16509 —UN—02OCT08

#205466 Engine Adapter

RE38635,0000170 -19-03OCT08-1/1

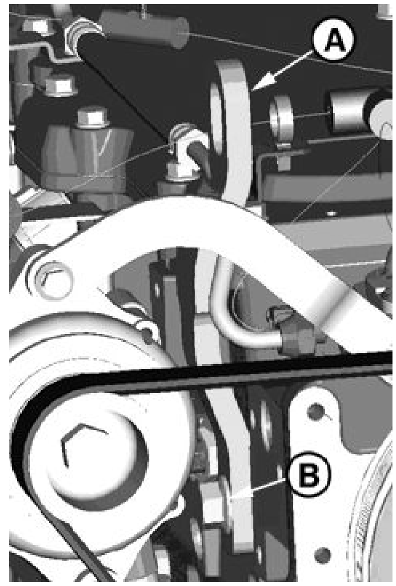
Install Engine Lift Straps

1. Using one cap screw, install lift strap to the right front side (A) of cylinder head.
2. Using one cap screw, install lift strap to the left rear (C) of cylinder head.
3. Torque both cap screws to specification.

Specification

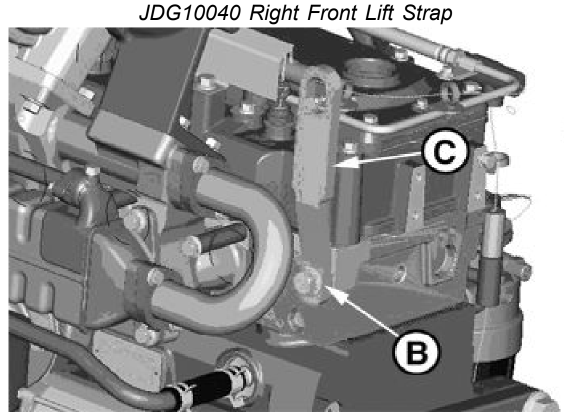
Engine Lift Straps to
Cylinder Head—Torque........................ 170 +/- 34 N•m (126 +/- 25 lb-ft)

A—Right Front Lift Strap
B—Cap Screws
C—Left Rear Lift Strap



RG14849 —UN—25APR06

JDG10040 Right Front Lift Strap



RG14850 —UN—25APR06

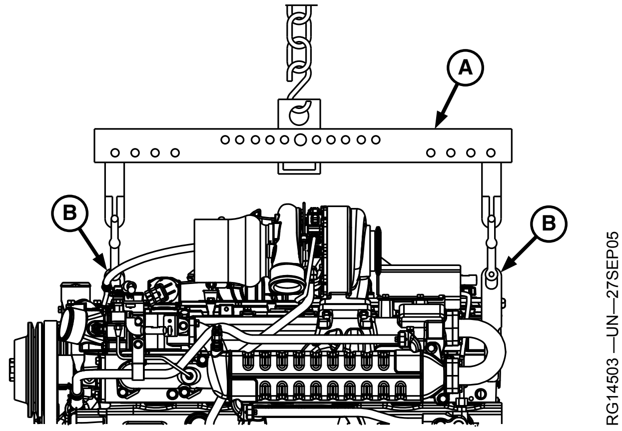
JDG10059 Left Rear Lift Strap

RE38635,000004A -19-28MAR07-1/1

Engine Lifting Procedure

CAUTION: The only recommended method for lifting the 6090 engine is with JDG23 Engine Lifting Sling and safety approved JDG10040 and JDG10059 lift straps. Lift Straps either come already installed on the engine or are available as service tools. Use extreme caution when lifting and NEVER permit any part of the body to be positioned under an engine being lifted or suspended.

Lift engine with longitudinal loading on lift sling and lifting brackets only. Angular loading greatly reduces lifting capacity of sling and brackets.



Engine Lift Sling and Straps

A—JDG23 Engine Lifting Sling
B—Engine Lift Straps - JDG10040 (Front) and JDG10059 (Rear)

1. Attach JDG23 Engine Lifting Sling (A) to engine JDG10040 (front) and JDG10059 (rear) lifting straps (B) and to overhead hoist or floor crane.

NOTE: If engine lifting straps are misplaced, they should be procured through service parts or SERVICEGARD™. Use of an engine lifting sling (as shown) is the ONLY APPROVED method for lifting engine.

IMPORTANT: Lifting straps are designed to lift the engine and small accessories such as hydraulic pumps and air compressors mounted to the engine auxiliary gear drive, or belt-driven components, such as air conditioning compressors and alternators. If larger components, such as PTO's, transmissions, generators or air compressors, are attached to other locations on the engine, the lift straps provided with the engine are not intended for this purpose. Technician is responsible for providing adequate lifting devices under these situations. See machine technical manual for additional information on removing engine from machine.

2. Carefully lift engine to desired location.

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RE38635,0000049 -19-28MAR07-1/1

Clean Engine

1. Cap or plug all openings on engine. If electrical components (starter, alternator, etc.) are not removed prior to cleaning, cover with plastic and tape securely to prevent moisture from entering.
2. Steam-clean engine thoroughly.

IMPORTANT: Never steam clean or pour cold water on the high pressure fuel pump while it is still warm. To do so may cause seizure of pump parts. Also, avoid electrical components, wiring, the ECU, and sensors.

RE38635,0000014 -19-21OCT04-1/1

Disconnect Turbocharger Oil Inlet Line

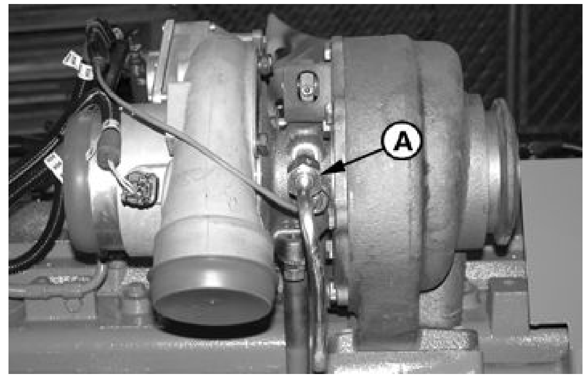
1. Drain all engine oil and coolant, if not previously done.

IMPORTANT: When servicing turbocharged engines on a rollover stand, disconnect turbocharger oil inlet line (A) from oil filter housing or turbocharger before rolling engine over. Failure to do so may cause a hydraulic lock upon starting engine. Hydraulic lock may cause possible engine failure.

Hydraulic lock occurs when trapped oil in the oil filter housing drains through the turbocharger, the exhaust and intake manifolds, and then into the cylinder head.

After starting the engine, the trapped oil in the manifold and head is released into the cylinder(s) filling them with oil causing hydraulic lock and possible engine failure.

2. Disconnect turbocharger oil inlet line at turbocharger or oil filter base.



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Turbocharger Oil Supply Line

A—Oil Supply Line

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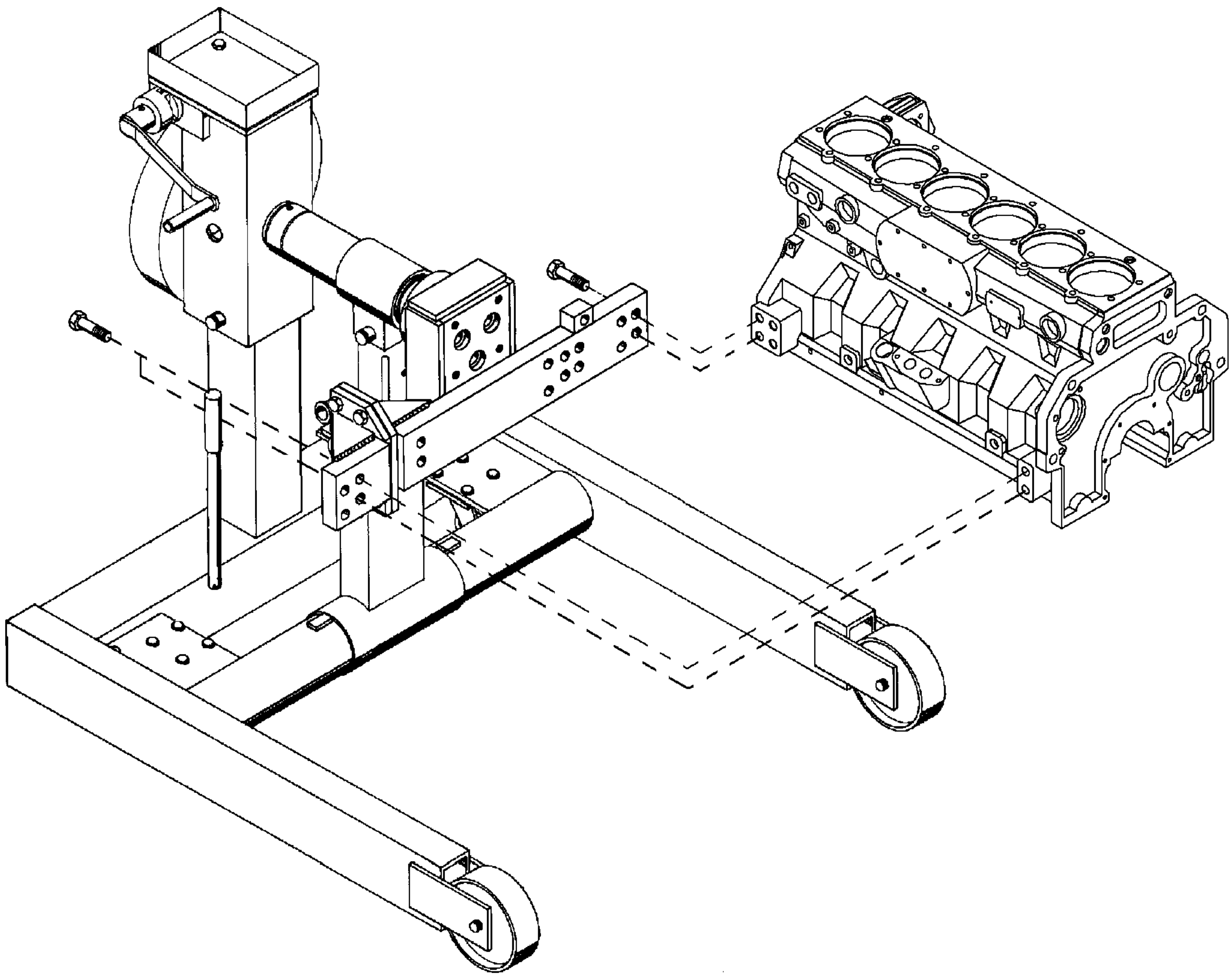
Mount Engine on Repair Stand



RG8770

RG8770 —UN—08DEC97

Mounting Engine on Repair Stand

CAUTION: NEVER remove the overhead lifting equipment until the engine is securely mounted onto the repair stand and all mounting hardware is tightened to specified torque. Always release the overhead lifting equipment slowly.

NOTE: If starter motor or crankshaft driven auxiliary drive accessory is to be removed from engine, remove before mounting engine onto repair stand.

Continued on next page

RE38635,0000025 -19-15DEC04-1/2

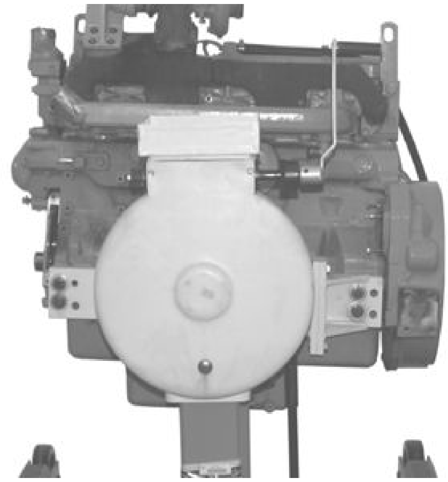
1. Mount the starter side of the engine to the engine adapter with four SAE Grade 8 (or higher grade) cap screws in the following sizes:

6090HRW01	M16-2 X 110mm.
6090HRW02	M16-2 X 110mm
6090HRW04	M16-2 X 110mm
6090HZ003	M16-2 X 110mm.
6090HT001R	M16-2 X 110mm.
6090HH001	M16-2 X 110mm
6090HDW01	M16-2 X 110mm
6090HF485	M16-2 X 110mm
All Other 6090 Engines	M16-2 X 110mm

Engine-to-Stand Cap Screws (use w/2 large diameter washers)

2. Tighten cap screws to 203 N·m (150 lb-ft).
3. Carefully remove lift sling from engine.

To remove engine from repair stand, reverse the installation procedure.



RG10054 —UN—23JUN99

Engine on Repair Stand

To install engine in vehicle, refer to machine technical manual.

RE38635,0000025 -19-15DEC04-2/2

Engine Disassembly Sequence for Overhaul

The following sequence is suggested when complete disassembly for overhaul is required. Refer to the appropriate repair group when removing individual engine components.

1. Drain all coolant and engine oil. Check engine oil for metal contaminates.
2. Remove turbocharger oil inlet line and oil return line. Remove turbocharger and air pipe to EGR cooler assembly.
3. Remove fan pulley and thermostat housing assembly.
4. Remove coolant pump assembly from timing gear cover.

NOTE: DO NOT damage option code label (if equipped), when removing rocker arm cover.

NOTE: The vent hose should be disconnected from the vent elbow. The vent elbow should not be removed from the rocker arm cover unless the intent is to replace the elbow assembly.

5. Remove breather hose from rocker arm cover. Remove rocker arm cover.
6. Remove electronic injector wiring harness.
7. Remove rocker arm assembly and push rods. Identify parts for reassembly.
8. Remove front crankshaft pulley and damper assembly.
9. Remove fuel injection lines, fuel connectors, and injection nozzles.
10. Remove engine oil filter, filter base, and valve housing.
11. Remove fuel filter and mounting base. Remove high pressure fuel pump gear cover and remove injection pump.
12. Remove high pressure common rail.
13. Remove engine oil cooler assembly.

PLASTIGAGE is a registered trademark of DANA Corp.

14. Remove front and rear exhaust manifolds and EGR cooler and valve assembly.
15. Remove air intake manifold.

NOTE: ALWAYS bolt down liners when rotating engine flywheel with cylinder head removed.

16. Remove cylinder head with assembly. Remove head gasket.
17. Revolve engine on repair stand and remove engine oil pump assembly.
18. Remove front timing gear cover.
19. Revolve engine to vertical position. Remove pistons and connecting rods. Identify for reassembly. Perform bearing-to-journal wear checks with PLASTIGAGE®.
20. On SAE No. 3 flywheel housings, remove flywheel housing and then remove flywheel.
21. On SAE No. 1 and 2 flywheel housings, remove flywheel and then remove flywheel housing.
22. Remove main bearing caps and remove crankshaft. Perform bearing-to-journal wear checks with PLASTIGAGE®.
23. Remove camshaft and cam followers. Identify for reassembly.
24. Revolve engine to horizontal position, remove liners, O-rings, and packings. Mark liners for reassembly in same bore from which removed.
25. Remove piston cooling orifices from cylinder block.
26. Remove any sensors/gauges, cylinder block plugs and engine serial number plate, if block is to be put in a “hot tank”.
27. Refer to appropriate group for inspection and repair of engine components.

RE38635,0000026 -19-13JAN06-1/1

Sealant Application Guidelines

Listed below are sealants which have been tested and are used by the John Deere factory to control leakage and assure hardware retention. ALWAYS use the following recommended sealants when assembling your John Deere Diesel Engine to assure quality performance.

LOCTITE® thread sealants are designed to perform to sealing standards with machine oil residue present. If excessive machine oil or poor cleanliness quality exists, clean with solvent. Refer to John Deere Merchandise and Parts Sales Manual for ordering information.

AR31790 SCOTCH-GRIP® EC1099 Plastic Adhesive:

- AR31790 118 ml (4 oz)

LOCTITE® 242—Thread Lock & Sealer (Medium Strength) (Blue):

- TY9370 6 ml (0.2 oz) tube
- T43512 50 ml (1.7 oz) bottle

Plugs and fittings: fuel filter base, intake manifold, cylinder block (oil galley).

Injection pump timing hole plug.

Cap screws: injection pump access cover, electronic tachometer cover, oil filler inlet, oil filter adapter, flywheel, thermostat housing.

Oil pressure sending unit.

LOCTITE® 592 Pipe Sealant with TEFLON® (White):

- TY9374 6 ml. (0.2 oz) tube
- TY9375 50 ml. (1.7 oz) bottle

Pipe plugs: cylinder block (coolant manifold), thermostat housing, air intake manifold, and coolant pump.

Coolant pump and block coolant drain valves

Fuel filter drain and bleed plugs

Temperature sending unit and switch

Oil pan (drain hose, drain valve and elbow)

Connectors: turbo line and turbo drain

Adapter fitting for turbo oil inlet line

LOCTITE® 680 Retaining Compound (Green):

- TY15969 50 ml. (1.7 oz) bottle

Expansion (frost) plugs in cylinder block

PERMATEX Aviation (Form-A-Gasket No. 3):

- TY6299 227 g (8oz) container

Rear camshaft bore steel cap plug

Oil pan gasket surfaces

PT569 NEVER-SEEZ® Compound:

- PT569 227 g (8 oz) Brush
- PT506 453 g (16 oz) Spray

Cap Screws: turbocharger mounting and aftercooler cover.

Cap Screws: reinstallation of special 12-point flange head cap screws on exhaust manifold of tractors.[1]

LOCTITE® 51048 Moly Paste

Camshaft nose (gear installation)

[1]Special 12-point flange head cap screws have pre-applied anti-sieze compound. Apply additional compound for reuse only.

RG,RG34710,1051 -19-23OCT97-1/1

Engine Assembly Sequence After Overhaul

The following assembly sequence is suggested when engine has been completely disassembled. Be sure to check run-out specifications, clearance tolerances, torques, etc. as engine is assembled. Refer to the appropriate repair group when assembling engine components.

6090 Engine Assembly Sequence After Overhaul

1. Install all plugs in cylinder block that were removed to service block. Install engine serial number plate.
2. Install piston cooling orifices.
3. Install cylinder liners without O-rings and measure liner stand-out. Install liner O-rings in block and packings on liners. Install liners.

NOTE: If new piston and liner kit assemblies are being installed, install the crankshaft first.

4. Install main bearings and crankshaft. Rotate crankshaft to assure correct assembly. Check crankshaft end play.

NOTE: ALWAYS bolt liners down before rotating engine with cylinder head removed.

If installing new piston/liner kits, assemble kits onto the respective connecting rods using NEW snap rings. Bolt liners down as each kit is installed.

5. Install engine flywheel and housing, if applicable:
   - SAE 3: Flywheel goes on before housing.
   - SAE 1 and SAE 2: Housing goes on before flywheel.
6. Install piston and rod assemblies. Bolt liners down after each piston assembly is installed.
7. Install crankshaft rear oil seal housing and check runout. Install rear oil seal and wear sleeve.
8. Install cam followers in hole from which originally removed.
9. Install camshaft. Align timing marks (camshaft-to-crankshaft gears) with No. 1 piston at “TDC” compression stroke.
10. Install engine oil pump assembly.
11. Install high pressure common rail.
12. Install fuel pump and drive gear.
13. Install engine oil cooler assembly.
14. Install fuel filter base, supply lines, and filter.
15. Install oil filter base, valve housing, and new oil filter.
16. Install cylinder head and intake manifold.
17. Install push rods, rocker arm assemblies, electronic injectors, and fuel connectors.
18. Install electronic injector wiring harness.
19. Install rocker arm cover, and breather hose.
20. Install front and rear exhaust manifolds, EGR cooler and valve assembly.
21. Install timing gear cover. Install front crankshaft wear sleeve and oil seal.
22. Install coolant pump assembly and coolant manifold.
23. Install turbocharger. Install turbocharger oil inlet line and oil return line.
24. Install fuel leak-off lines and high pressure fuel delivery lines.
25. Install front pulley and new damper as an assembly.
26. Install fan pulley assembly. Install starter motor.
27. Fill engine with clean oil. Install dipstick.
28. Flush cooling system and refill with proper coolant.
29. Perform engine break-in and normal standard performance checks. See ENGINE BREAK-IN GUIDELINES later in this group.

RE38635,0000027 -19-15DEC04-1/1

Engine Break-In Guidelines

Engine break-in should be performed after overhaul or when the following repairs have been made:

Main bearings, rod bearings, crankshaft, or any combination of these parts have been replaced.

Pistons, rings, or liners have been replaced.

Rear crankshaft oil seal and wear sleeve have been replaced. (Primary objective is to see if oil seal still leaks).

Cylinder head has been removed. (Check and reset valve clearance.)

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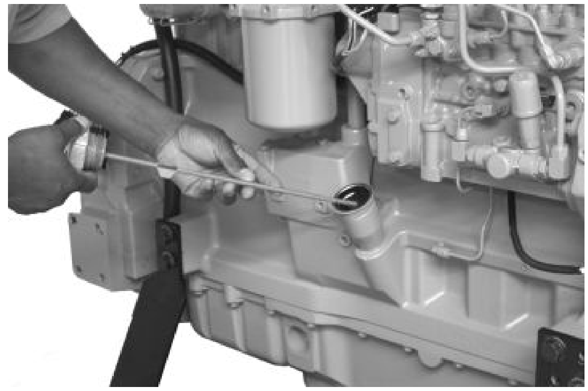
Perform Engine Break-In



RG7359 —UN—20JUN00

Check Engine Oil Level

RG5895 —UN—13AUG91

Engine Oil Level Dipstick

Use a dynamometer to perform the following preliminary break-in procedure. If necessary, preliminary engine break-in can be performed without a dynamometer if under controlled operating conditions.

IMPORTANT: DO NOT use John Deere PLUS-50 oil or engine oils meeting API CG4, API CF4, ACEA E3 or ACEA E2, performance levels during break-in period of an engine that has had a major overhaul. These oils will not allow an overhauled engine to properly wear during the break-in period.

Do not add makeup oil until the oil level is BELOW the add mark. John Deere Break-In Oil should be used to make up any oil consumed during break-in period.

DO NOT fill above the crosshatch pattern or FULL mark. Oil levels anywhere within the crosshatch are acceptable.

1. Fill engine crankcase to proper level with John Deere ENGINE BREAK-IN OIL during break-in operation. Use break-in oil regardless of ambient temperature. This oil is specifically formulated to enhance break-in of John Deere diesel engines. Under normal conditions, do not exceed 250hours with break-in oil.

   If John Deere Engine Break-In Oil is not available, use diesel engine oil meeting API Service Classification CE or ACEA Specification E1.

IMPORTANT: During preliminary break-in, periodically check engine oil pressure and coolant temperature. Also check for signs of fuel, oil, or coolant leaks.

2. Start engine, run at loads and speeds shown in following chart for time limits given.

PRELIMINARY ENGINE BREAK-IN AFTER MAJOR OVERHAUL

Time	Load	Engine Speed
1 minute	No load	850 rpm
2 minutes	No load	Fast Idle
15 minutes	1/2—3/4 load	2000 rpm to rated speed
10 Minutes	Full load	Rated speed

3. After preliminary break-in, run engine 1—2 minutes at 1500 rpm, with no load before shut-down.
4. Check and readjust valve clearance as necessary. Cylinder head retorque is not required.

NOTE: 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. Operate the engine at heavy loads with minimal idling during the break-in period.

If the engine has significant operating time at idle, constant speeds, and/or light load usage, an additional 250hour break-in period is recommended using a new change of John Deere ENGINE BREAK-IN OIL and new John Deere oil filter.

Check engine oil level more frequently during engine break-in period. As a general rule, makeup oil should not need to be added during 250-hour break-in period. However, if makeup oil is required in the first 250-hour break-in, an additional 250-hour break-in period is required. Use a new change of John Deere ENGINE BREAK-IN OIL and a new John Deere oil filter.

After 250 hours maximum, drain break-in oil and change oil filter. Fill crankcase with John Deere TORQ-GARD SUPREME® OR PLUS-50® or other heavy-duty diesel engine oil within the same service classification as recommended in this manual. See DIESEL ENGINE OIL in Group 002, Fuels, Lubricants, and Coolant.

Continued on next page

RE38635,0000028 -19-15DEC04-1/2

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

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

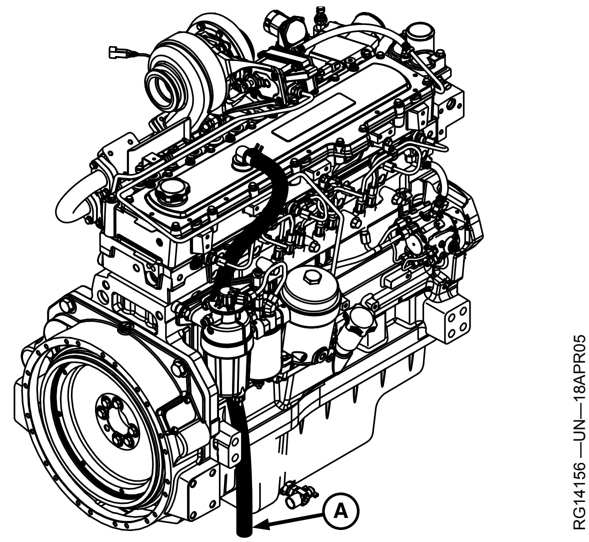
TORQ-GARD SUPREME is a registered trademark of Deere & Company. PLUS-50 is a registered trademark of Deere & Company.

RE38635,0000028 -19-15DEC04-2/2

Check Crankcase Ventilation System

1. Inspect crankcase ventilation system for restrictions. Lack of ventilation causes sludge to form in crankcase. This can lead to clogging of oil passages, filters, and screens, resulting in serious engine damage.
2. Clean crankcase vent tube (A) with solvent and compressed air if restricted. Install and tighten hose clamps securely.

A—Crankcase Breather Tube



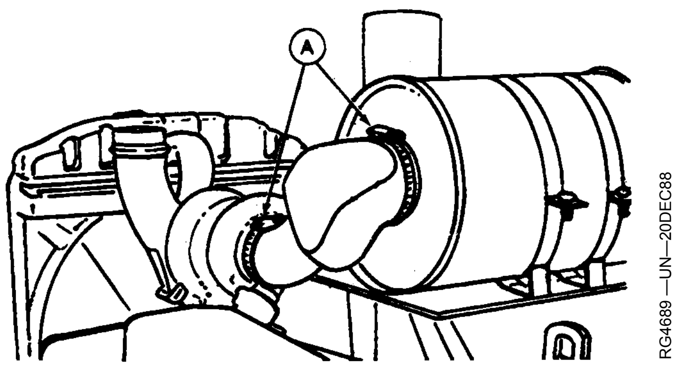
Crankcase Breather Tube

RG,RG34710,1055 -19-23OCT97-1/1

Check Air Intake System

1. Replace air cleaner primary filter element. (See operator's manual.) Replace secondary element if primary element has holes in it.
2. Check condition of air intake hose(s). Replace hoses that are cracked, split, or otherwise in poor condition.
3. Check hose clamps (A) for tightness. Replace clamps that cannot be properly tightened. This will help prevent dust from entering the air intake system which could cause serious engine damage.

A—Hose Clamps



Air Intake Hose Clamps

RG,RG34710,1056 -19-23OCT97-1/1

Check Exhaust System

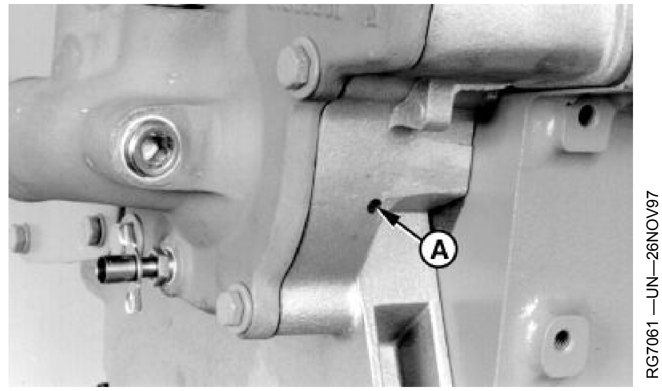
1. Inspect exhaust system for leaks or restrictions. Check manifold for cracks. Repair or replace as necessary.
2. Check that turbocharger-to-exhaust gas recirculator (EGR), cooler, etc, clamps are securely tightened and do not leak.
3. Check exhaust stack for evidence of oil leakage past valve stem seals.

   Oil in exhaust stack may be caused by excessive valve stem-to-guide clearance or excessive light load engine idling.

RE38635,0000016 -19-21OCT04-1/1

Check and Service Cooling System

1. Remove trash that has accumulated on or near radiator.
2. Visually inspect entire cooling system and all components for leaks or damage. Repair or replace as necessary.
3. Remove the foam filter from weep hole (A, shown removed) located on the side of timing gear cover and discard filter. Inspect the weep hole for any restrictions.
4. Insert a heavy gauge wire deep into weep hole to make sure hole is open.



Cooling System Weep Hole with Foam Filter

A—Weep Hole

Continued on next page

RG,RG34710,1058 -19-23OCT97-1/2

5. Install new foam filter flush with timing gear cover.

CAUTION: Do not drain coolant until the coolant temperature is below operating temperature. Always loosen coolant pump drain valve (A) and block drain valve (B) slowly to relieve any excess pressure.

IMPORTANT: Both coolant pump drain valve and block drain valve must be opened to completely drain the engine.

6. Remove and check thermostat(s). See REMOVE AND TEST THERMOSTATS in Group 070.
7. Drain and flush cooling system. See FLUSH AND SERVICE COOLING SYSTEM in Group 002.

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen temperature sending unit fitting at rear of cylinder head, bleed plug at top front 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.

8. Fill cooling system with coolant. See DIESEL ENGINE COOLANT in Group 002.
9. Run engine until it reaches operating temperature. Check entire cooling system for leaks.
10. After engine cools, check coolant level.

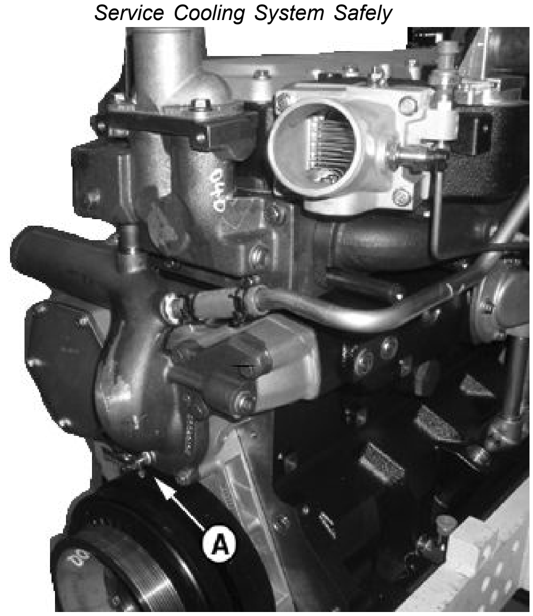
NOTE: Coolant level should be even with bottom of radiator filler neck.

11. Check system for holding pressure. See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP in Group 150.

A—Coolant Pump Drain Valve B—Block Drain Valve

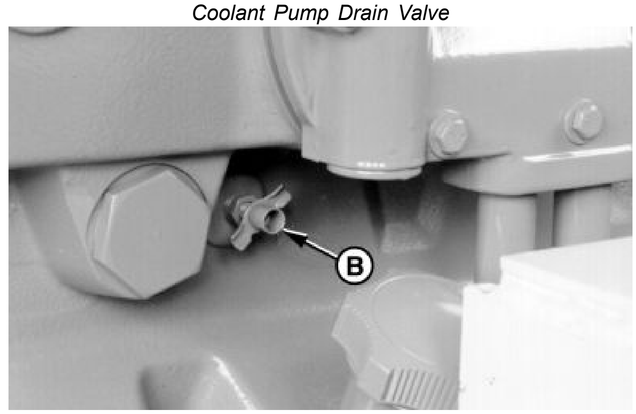
TS281 —UN—23AUG88

Service Cooling System Safely



RG14158 —UN—12APR05

Coolant Pump Drain Valve



RG7143 —UN—26NOV97

Cylinder Block Coolant Drain Valve

RG,RG34710,1058 -19-23OCT97-2/2

Check Electrical System

TS204 —UN—23AUG88

Prevent Battery Explosions

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 (-) 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. Clean batteries and cables with damp cloth. If corrosion is present, remove it and wash terminals with a solution of ammonia or baking soda in water. Then flush area with clean water.
2. Coat battery terminals and connectors with petroleum jelly mixed with baking soda to retard corrosion.
3. Test batteries. If batteries are not near full charge, try to find out why.
4. On low-maintenance batteries, check level of electrolyte in each cell of each battery. Level should be to bottom of filler neck. If water is needed, use clean, mineral-free water.

   If water must be added to batteries more often than every 250 hours, alternator may be overcharging.

NOTE: Water cannot be added to maintenance-free batteries.

5. If batteries appear to be either undercharged or overcharged, check alternator and charging circuit.
6. Check tension of drive belts. See CHECKING BELT TENSIONER SPRING TENSION AND BELT WEAR in Group 070.
7. Check operation of starter motor and instruments.

NOTE: For test and repair of alternators and starter motors, see CTM77, Alternators and Starting Motors.

RG,RG34710,1059 -19-23OCT97-1/1

General Tune-Up Recommendations

As a general rule, an engine tune-up is not necessary if ALL recommended operator's manual hourly service procedures are performed on schedule. If your engine performance is not within the rated application guidelines, the following service procedures are recommended to help restore engine to normal operating efficiency.

IMPORTANT: 6090 engines are equipped with electronically-controlled fuel systems that have a diagnostic feature that will display detailed codes to alert operator of specific performance problems. Refer to CTM385 for diagnostic code troubleshooting procedures on electronically controlled fuel systems.

Operation	Detailed Reference
Change engine oil and filters.	Operator's Manual
Lubricate PTO clutch internal levers and linkage, if equipped.	Operator's Manual
Replace fuel filter.	This Group/Operator's Manual
Clean crankcase vent tube.	This Group/Operator's Manual
Check air intake system. Replace air cleaner elements.	This Group/Operator's Manual
Check exhaust system.	This Group
Check and service engine cooling system.	This Group/Operator's Manual
Check and adjust fan and alternator belts.	Operator's Manual
Check electrical system.	This Group
Check crankshaft vibration damper.	Group 040/Operator's Manual
Inspect turbocharger and check turbocharger boost pressure.	Group 150
Check fuel injection system	This group
Check engine oil pressure. Correct as necessary.	Group 150
Check engine valve clearance. Adjust if necessary.	Group 020/Group 021
Check engine speeds. Correct as necessary.	Authorized Servicing Dealer
Check engine performance on dynamometer.	This Group

RE38635,0000017 -19-21OCT04-1/1

Valve — Clearance Adjustment

Too little valve clearance throws valves out of time. Valves open too early and close too late. This causes the valves to overheat due to hot combustion gases rushing past valves when out of time. Overheating lengthens valve stems which prevents proper seating of valves. The valves seat so briefly or poorly that normal heat transfer into the cooling system does not have time to take place, causing burned valves and low power.

Too much valve clearance causes a lag in valve timing, causing engine valve train imbalance. The fuel-air mixture enters the cylinders late during intake stroke. The exhaust valve closes early and prevents waste gases from being completely removed from cylinders. Also, the valves close with a great deal of impact, which may crack or break the valves and scuff the camshaft and followers.

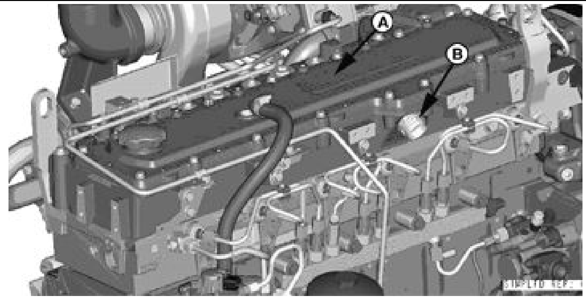
CAUTION: To prevent accidental starting of engine while performing valve adjustments, always disconnect NEGATIVE (—) battery terminal.

IMPORTANT: Valve clearance MUST BE checked and adjusted with engine COLD.

1. Disconnect main wiring harness (B) from right side of intake manifold.
2. Remove rocker arm cover with vent tube (A).

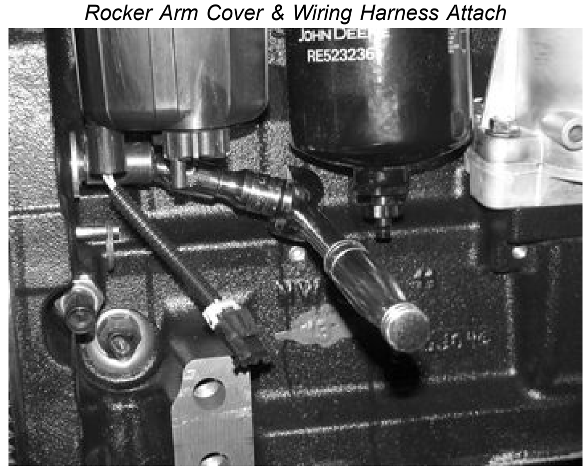
IMPORTANT: Visually inspect contact surfaces of valve tips and rocker arm wear pads. Check all parts for excessive wear, breakage, or cracks. Replace parts that show visible damage.

Rocker arms that exhibit excessive valve clearance should be inspected more thoroughly to identify damaged parts.



RG13925 —UN—29JAN05

Rocker Arm Cover & Wiring Harness Attach



RG13945 —UN—04FEB05

JDG820 Flywheel Turning Tool

A—Rocker Arm Cover **B—Wiring Harness Attachment**

NOTE: Use a flexible socket extension when rotating engine to avoid interference with fuel filter assembly, as shown.

3. Remove plastic plug from cylinder block bores and install JDG820 Flywheel Turning Tool and Timing Pin.

Continued on next page

AS58880,00000B4 -19-13APR09-1/4

4. Rotate engine with the flywheel turning tool until timing pin engages timing hole in flywheel.
5. If the rocker arms for No. 1 (front) cylinder are loose, the engine is at No. 1 TDC-Compression.
6. If the rocker arms for No. 6 (rear) cylinder are loose, the engine is at No. 6 TDC-Compression. Rotate the engine one full revolution (360 degrees) to No. 1 TDC-Compression.

NOTE: To assist in adjusting valve clearance, push the rocker arm foot forward (A) for easier feeler gauge access (B)

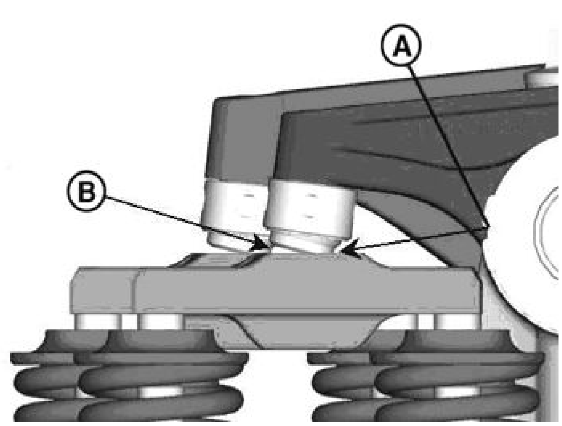
IMPORTANT: If engine has been overhauled where the roller camshaft followers have been removed and/or replaced, BE CERTAIN to apply a firm downward pressure over the rocker arm adjusting screw, using push rod to seat roller follower on camshaft. Loose valve clearance settings can result if this step is not completed. If the valve clearance is being checked or reset, this step is not necessary.

7. With engine lock-pinned at "TDC" of No. 1 piston's compression stroke, use a bent feeler gauge to check valve clearance on Nos. 1, 3, and 5 exhaust valves and Nos. 1, 2, and 4 intake valves. If out of specification, loosen lock nut 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 lock nut to specifications.

Specification

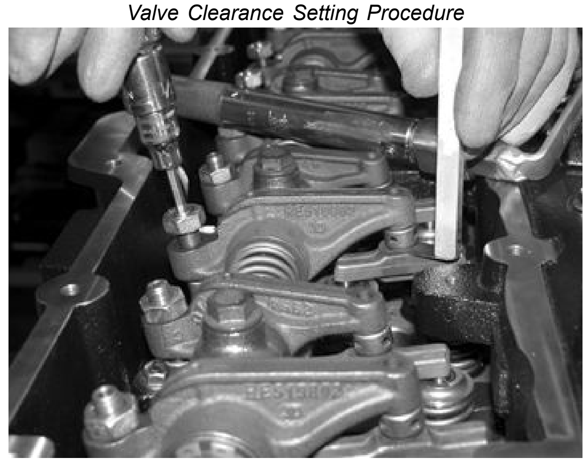
Intake Valve Clearance Checking (Rocker Arm-to-Valve Bridge With Engine Cold)—Clearance	0.13—0.23 mm (0.005—0.009 in.)
Exhaust Valve Clearance Checking (Rocker Arm-to-Valve Bridge With Engine Cold)—Clearance	0.58—0.69 mm (0.023—0.027 in.)
Valve Adjusting Screw Lock Nut—Torque	27 N•m (20 lb-ft)

Recheck clearance again after tightening lock nut. Readjust clearance as necessary.

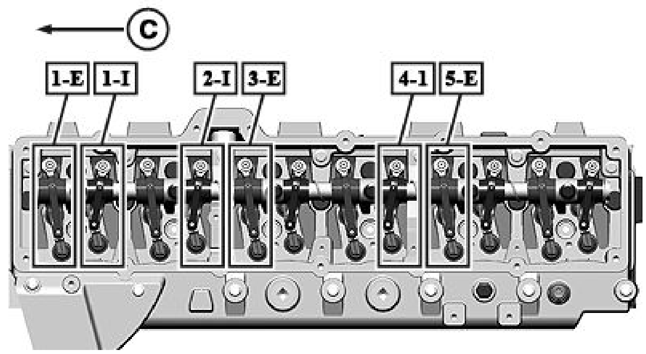


RG13842 —UN—07JAN05

Valve Clearance Setting Procedure


RG13946 —UN—04FEB05

Checking Valve Clearance with Feeler Gauge



RG13840 —UN—04APR08

Valve Checking Sequence - #1 TDC

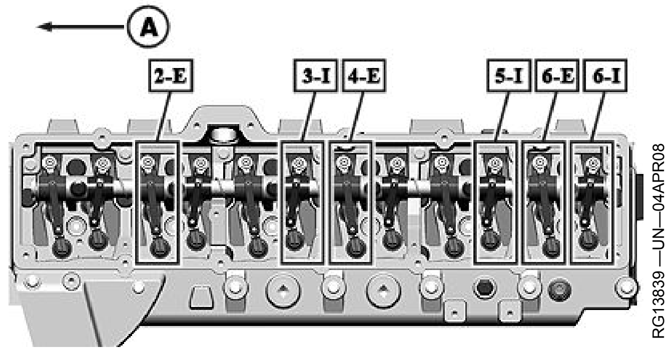
A—Rocker Arm Foot Position
B—Clearance for Feeler Gauge
C—Front of Engine

Continued on next page AS58880,00000B4 -19-13APR09-2/4

8. Rotate flywheel 360° until No. 6 piston is at “TDC” of its compression stroke. Rocker arms for No. 6 piston should be loose.
9. Check and adjust valve clearance to the same specifications on Nos. 2, 4, and 6 exhaust and Nos. 3, 5, and 6 intake valves.

IMPORTANT: When reinstalling rocker arm cover, DO NOT reuse gasket. Install cover using a new gasket.

10. Install rocker arm cover gasket.



Valve Checking Sequence - #6 TDC

A—Front of Engine

AS58880,00000B4 -19-13APR09-3/4

11. Install rocker arm cover with vent tube and tighten cap screws in sequence shown to specification.

Specification

Rocker Arm Cover Cap Screws—Torque..35 N•m (26 lb-ft)

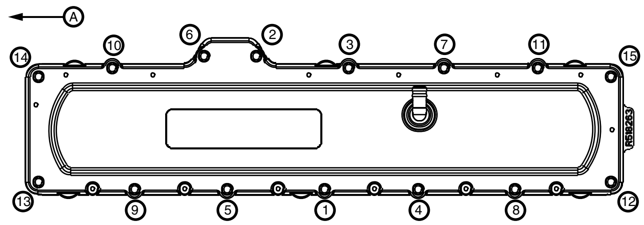
After 10 minutes re-torque the cap screws in sequence shown to specification.

Specification

Rocker Arm Cover Cap Screws—Torque..35 N•m (26 lb-ft)

12. Connect main engine wiring harness.

RG13907 —UN—14JAN05



Rocker Arm Cover Torque Sequence

A—Front of Engine

AS58880,00000B4 -19-13APR09-4/4

Valve — Lift Check

IMPORTANT: For a more accurate measurement, it is recommended that valve lift be measured at 0.00 mm (in.) valve clearance and with engine COLD.

NOTE: Measuring valve lift can give an indication of wear on camshaft lobes and cam followers or bent push rods.

1. Remove turbocharger oil inlet clamp and rocker arm cover. Loosen lock nut on rocker arm. Set valve clearance at 0.00 mm (in.) on valve being checked. Tighten lock nut.
2. Put dial indicator tip on valve stem tip. Be sure that valve is fully closed.
3. Check preset on dial indicator. Set dial indicator pointer at zero.
4. Manually turn engine in running direction, using the engine rotation tools previously mentioned for checking valve clearance.
5. Observe dial indicator reading as valve is moved to fully open position. Record reading and valve number.

Specification

Intake Valve—Lift... 12.1 mm (0.476 in.) at 0.00 mm (in.) clearance
Wear—Tolerance... N\A
Exhaust Valve—Lift.. 12.1 mm (0.476 in.) at 0.00 mm (in.) clearance

6. Repeat procedure on all remaining valves.
7. Reset valve clearance to specification after measuring lift. (See ADJUST VALVE CLEARANCE earlier in this group.)

RE38635,0000018 -19-31MAY05-1/1

Cylinder Head—Removal

It is not necessary to remove engine from machine to service cylinder head on all applications. Refer to your Machine Technical Manual for engine removal procedure, if required.

CAUTION: After operating engine, allow exhaust system to cool before working on engine.

DO NOT drain coolant until the coolant temperature is below operating temperature. Always loosen drain valve slowly to relieve any excess pressure.

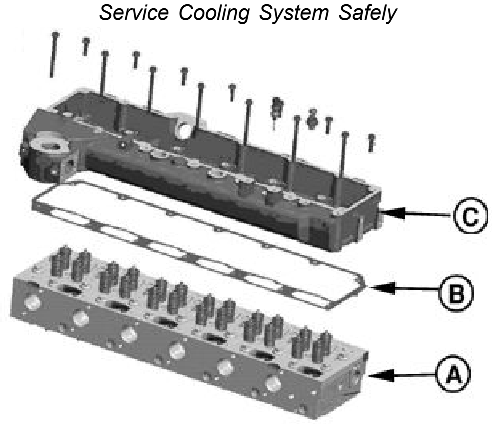
TS218 —UN—23AUG88

Service Cooling System Safely

1. Drain engine oil and coolant. Disconnect turbo inlet line at turbocharger or at oil filter base. (See DISCONNECT TURBOCHARGER OIL INLET LINE in Group 010.)

NOTE: If cylinder head is being removed for piston and liner repairs or any other service that does not require disassembly of head, cylinder head can be removed with thermostat housing, turbocharger, exhaust gas recirculator (EGR) assembly, and exhaust manifold installed. The intake manifold MUST BE REMOVED, BEFORE REMOVING CYLINDER HEAD, to access all cylinder head bolts. Coolant supply and return lines for the turbocharger actuator and EGR must me disconnected.

2. Remove thermostat housing and all coolant piping. See REMOVE THERMOSTAT HOUSING in Group 070.
3. Remove turbocharger. See REMOVE TURBOCHARGER in Group 080.
4. Remove EGR assembly. See REMOVE EGR ASSEMBLY in Group 080.
5. Remove front and rear exhaust manifold. See REMOVE, INSPECT AND INSTALL EXHAUST MANIFOLD in Group 080.
6. Remove rocker arm cover.
7. Remove air intake manifold. See REMOVE, INSPECT AND INSTALL INTAKE MANIFOLD in Group 080.
8. Remove fuel injection delivery lines, and fuel leak-off lines.



RG14121 —UN—29MAR05

Removing Cylinder Head

A—Cylinder Head
B—Intake Manifold Gasket
C—Intake Manifold

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RE38635,0000031 -19-27MAR09-1/2

NOTE: The wiring harness can be removed with the intake manifold if no repair to the harness is required. Disconnect leads from injectors and lift harness off engine with intake manifold.

9. Disconnect fuel injector wiring harness nuts and harness hold down cap screws (A).
10. Loosen all rocker arm adjusting screws before loosening rocker arm pedestals. Remove rocker arm assembly.

IMPORTANT: Before removing injectors, identify and mark the QR tabs (B) as they are removed. These tabs WILL BREAK if not removed. They need to be reinstalled on the injector they were removed from. The tabs contain injector programming information, and they keep the injector wiring harness eyelets separated so they do not arc.

11. Remove fuel inlet connectors, fuel leak-off connectors, and electronic injectors. See REMOVE ELECTRONIC INJECTORS in Group 090 of CTM 385.
12. Remove push rods and identify for reassembly.

NOTE: Clean and inspect push rods. See CLEAN AND INSPECT PUSH RODS SERIAL NUMBER later in this group.

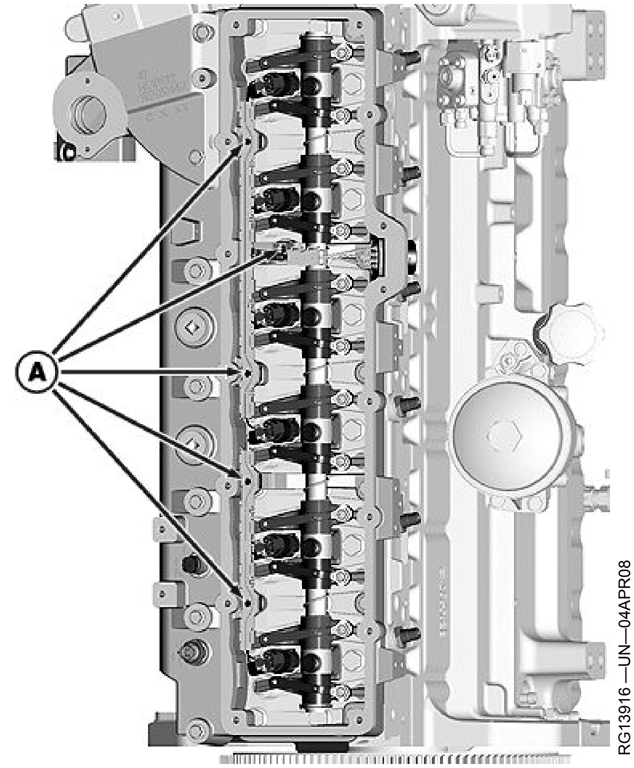
13. Remove all cylinder head cap screws. Discard cap screws, they are not reusable.

IMPORTANT: DO NOT use screwdrivers or pry bars between cylinder block and cylinder head to loosen head-to-block gasket seal.

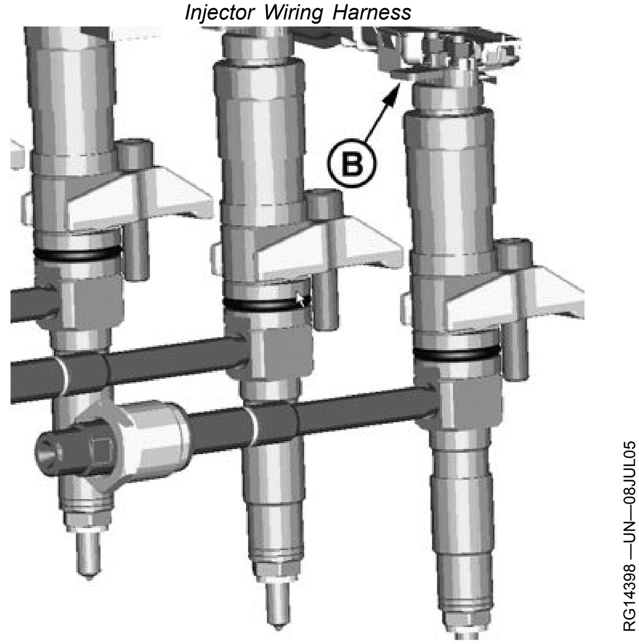
14. Lift cylinder head from block. If cylinder head sticks, use a soft hammer to tap the cylinder head.
15. Remove cylinder head gasket. Inspect for possible oil, coolant, or combustion chamber leaks. Also, check for evidence of incorrect or defective head gasket being used.

NOTE: Do not rotate crankshaft with cylinder head removed unless all cylinder liners are secured with cap screws and large flat washers as described in Group 10. See REMOVE PISTONS AND CONNECTING ROD ASSEMBLIES in Group 030.

A—Wiring Harness Clamp Points **B—Injector Tabs**



Injector Wiring Harness



Injector QR Tab

RE38635,0000031 -19-27MAR09-2/2

Diagnosing Head Gasket Joint Failures

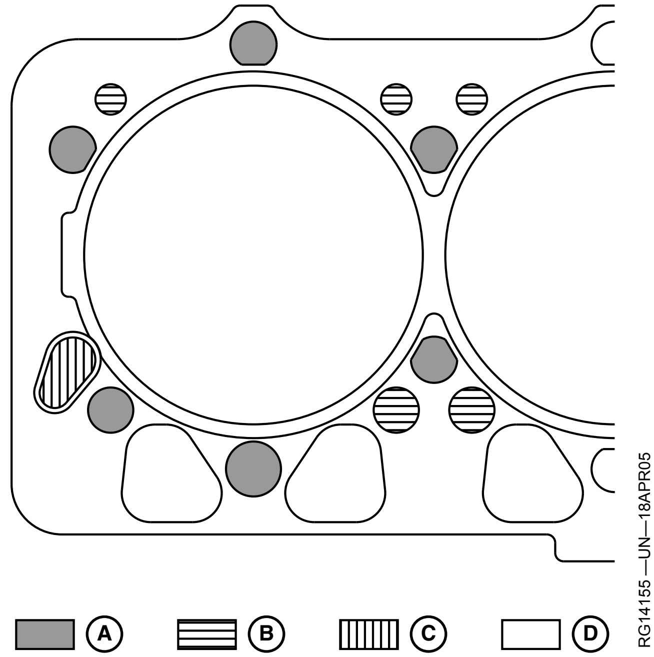
Head gasket failures generally fall into three categories:

- Combustion seal failures.
- Coolant seal failures.
- Oil seal failures.

Combustion seal failures occur when combustion gases escape between cylinder head and head gasket combustion flange, or between combustion flange and cylinder liner. Leaking combustion gases may vent to an adjacent cylinder, to a coolant or oil passage, or externally.

Coolant or oil seal failures occur when oil or coolant escapes between cylinder head and gasket body, or between cylinder block and gasket body. The oil or coolant may leak to an adjacent coolant or oil passage, or externally. Since oil and coolant passages are primarily on right hand (camshaft) side of engine, fluid leaks are most likely to occur in that area.

Follow these diagnostic procedures when a head gasket joint failure occurs, or is suspected.



6090 Cylinder Head Gasket

A—Cylinder Head Bolts
B—Coolant Passages
C—Oil Passage (supply)
D—Push Rod and Oil Drain

1. Before starting or disassembling engine, conduct a visual inspection of machine, and note any of the following:
   - Oil or coolant in head gasket seam, or on adjacent surfaces. Especially right rear corner of gasket joint.
   - Displacement of gasket from normal position.
   - Discoloration or soot from combustion gas leakage.
   - Leaking radiator, overflow tank, or hoses.
   - Leaking coolant from coolant pump weep hole.
   - Damaged or incorrect radiator, fan, or shroud.
   - Obstructed air flow or coolant flow.
   - Worn or slipping belts.
   - Damaged or incorrect radiator pressure cap.
   - Presence of oil in coolant.
   - Low coolant levels.
   - Improper coolant.
   - Unusually high or low oil levels.
   - Unburned fuel or coolant in exhaust system.
   - Oil degradation, dilution, or contamination.
   - Incorrectly specified injection pump.
   - Indications of fuel or timing adjustments.
2. Obtain coolant and oil samples for further analysis.
3. Start and warm up engine if it can be safely operated. Examine all potential leakage areas again as outlined previously. Using appropriate test and measuring equipment, check for the following:
   - White smoke, excessive raw fuel, or moisture in exhaust system.
   - Rough, irregular exhaust sound, or misfiring.
   - Air bubbles, gas trapped in radiator or overflow tank.
   - Loss of coolant from overflow.
   - Excessive cooling system pressure.
   - Coolant overheating.
   - Low coolant flow.
   - Loss of cab heating due to air lock (vehicle engines).
4. Shut engine down. Recheck crankcase, radiator, and overflow tank for any significant differences in fluid levels, viscosity, or appearance.
5. Compare your observations from above steps with the following diagnostic charts.

   If diagnostic evaluations and observations provide conclusive evidence of combustion gas, coolant, or oil leakage from head gasket joint, the cylinder head must be removed for inspection and repair of gasket joint components.

RE38635,0000032 -19-07JAN05-1/1

Head Gasket Diagnostic Charts

COMBUSTION SEAL LEAKAGE

Symptoms	Possible Causes
Exhaust from head gasket crevice	Insufficient liner standout
Air bubbles in radiator/overflow tank	Excessive liner standout differential between cylinders
Coolant discharge from overflow tube	Low head bolt clamping loads
Engine overheating	Rough/damaged liner flange surface
Power loss	Cracked/deformed gasket combustion flange
Engine runs rough	Out-of-flat/damaged/rough cylinder head surface
White exhaust smoke	Missing/mislocated gasket fire ring
Loss of cab heat (vehicle engines)	Block cracked in liner support area
Gasket section dislodged, missing (blown)	Excessive fuel delivery
Coolant in cylinder	Advanced injection pump timing
Coolant in crankcase oil	Hydraulic or mechanical disturbance of combustion seal
Low coolant level	Leaks in cooling system or engine overheating
	Cracked cylinder head or liners may also allow combustion gas leakage into coolant.

COOLANT SEAL LEAKAGE

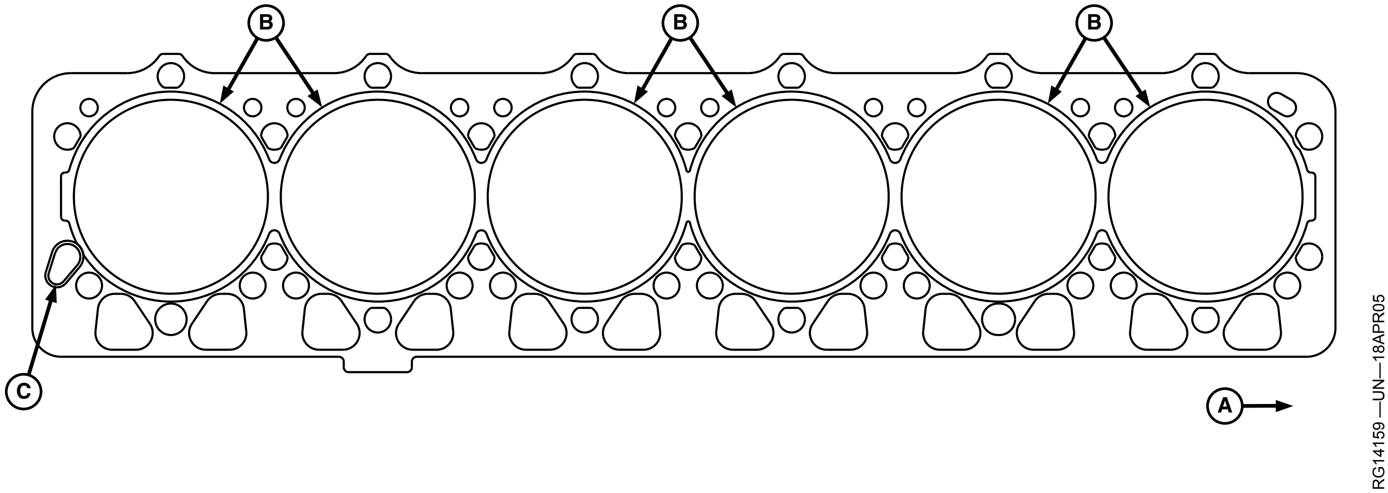
Symptoms	Possible Causes
Coolant discharge from head gasket crevice	Excessive liner standout
Coolant in crankcase oil	Excessive liner standout differential between cylinders
Low coolant level	Low head bolt clamping loads
High oil level	Out-of-flat/damaged/rough block surface
Coolant discharge from crankcase vent	Out-of-flat/damaged/rough cylinder head surface
	Oil or coolant overheating
	Cracks/creases in gasket body surfaces
	Damage/voids in elastomer beading of gasket
	Cracked cylinder head, liners, liner packings, defective oil cooler or aftercooler may also allow coolant leakage into crankcase.

OIL SEAL LEAKAGE

Symptoms	Possible Causes
Oil discharge from head gasket crevice	Excessive liner standout
Oil in coolant	Excessive liner standout differential between cylinders
Low crankcase oil level	Low head bolt clamping loads
Reduced oil to rocker arms (noisy)	Out-of-flat/damaged/rough block surface
	Out-of-flat/damaged/rough cylinder head surface
	Oil or coolant overheating
	Cracks/creases in gasket body surfaces
	Damage/voids in elastomer beading of gasket
	Damaged/missing O-ring seal at oil port to rocker arms
	Defective oil cooler may also allow oil leakage into coolant.

RE38635,0000033 -19-07JAN05-1/1

Head Gasket Inspection and Repair Sequence



Inspecting Cylinder Head Gasket

A—Front of Engine **B—Cylinder Combustion Flange** **C—Oil Supply Passage**

The following inspection procedures are recommended whenever a head gasket joint failure occurs, or when joint disassembly takes place.

1. Review historical data relating to machine operation, maintenance and repair, along with diagnostic observations. Note all areas requiring further inspection and analysis.
2. Remove rocker arm cover and check for presence of coolant in the oil.
3. Record head cap screw torques prior to removal.
4. Remove cylinder head using appropriate lifting devices to prevent handling damage to head gasket. See REMOVE CYLINDER HEAD earlier in this group.
5. Observe surfaces of removed head gasket.

   Examine cylinder head combustion flange (B) for the following:

   - Flange severed/expanded/cracked/deformed.
   - Adjacent body area burned/eroded.
   - Fire ring severed/displaced/missing.
   - Flange sealing pattern eccentric/contains voids.
   - Discoloration of flange and adjacent body areas.
   - Flange surfaces rough/abraded/channelled.

   Examine gasket body for the following:

   - Combustion gas erosion paths or soot deposits originating at combustion seals.
   - Extreme discoloration/hardening/embrittlement in localized areas.
   - Oil or coolant paths from port areas.
   - Localized areas of low compression.

6. Before cleaning components, inspect head, block, and liners for evidence of combustion gas and fluid leakage. Inspect cylinders and valve ports for unusual deposits.
7. Clean block, head, liners, and cap screws. (This group and Group 030.)
8. Proceed with the following dimensional checks and visual inspections:

   Cylinder Head (This group.)

   - Check surface flatness/finish.
   - Inspect for surface damage.
   - Check cylinder head thickness.

   Cylinder Block and Liners (assembled and clamped) (This group, Group 030.)

   - Check liner standout at four places on each liner.
   - Check liner standout difference between cylinders.

   Cylinder Block (Group 030.)

   - Check surface flatness/finish.
   - Inspect for surface damage.
   - Check liner counterbore depth (if liner is removed).
   - Check top deck to crankshaft centerline dimension.
   - Inspect cap screw bosses, must be clean/intact.

   Cylinder Liner (Group 030.)

   - Check liner flange flatness/finish.
   - Check liner flange thickness (if liner is removed).
   - Inspect flange for damage.

   Cylinder Head Cap Screws (This group.)

   - Inspect for corrosion damage.
   - Inspect condition of threads.
   - Inspect for straightness.

Continued on next page RE38635,00000BB -19-18APR05-1/2

9. When inspections and measurements have been completed, determine most probable causes of joint failure. Make all necessary repairs to joint components, cooling system, and fuel injection system.

10. Reassemble the engine according to procedures and specifications in the repair groups of this manual.

RE38635,00000BB -19-18APR05-2/2

Rocker Arm Assembly — Inspection

1. Inspect rocker arms, snap rings, pedestal, and shaft for damage. Look for:

   —Loose, bent, twisted, or worn snap rings.

   —Rotation of rocker arm on shaft. Rocker arms should rotate freely on shaft, but there should not be noticeable space between rocker bore and shaft.

NOTE: Wear could indicate weak valve springs, bent push rods, or loose rocker pedestal cap screws.

2. Check rocker arm adjusting nut and screw for damage. Visually inspect rocker arm for hairline cracks. Replace if necessary.
3. Clean rocker arm assembly with clean solvent. Dry with compressed air.

NOTE: If the rocker arm has been damaged by a valve failure, replace it and the push rods when replacing valves.

RG13906 —UN—04APR08

Rocker Arm Assembly

4. Roll push rods on a flat surface to check for bends or distortion. Replace parts as necessary.

RE38635,000016C -19-16SEP08-1/1

Rocker Arm Shaft — Tear Down

Rocker arm assembly cannot be disassembled and assembled.

Rocker arm assembly is NOT serviceable, and MUST BE replaced as a unit.

Rocker arm mountng screws **cannot** be re-used. Replace rocker arm mounting screws removed from engine with new screws.

RG13906 —UN—04APR08

Rocker Arm Shaft Assembly

RE38635,0000098 -19-29MAR05-1/1

Valve — Recess Measurement

Measure and record valve recess dimensions for all valves using JDG451 Gauge with D17526CI (English, in.) or D17527CI (Metric, mm) Dial Indicator or KJD10123 Gauge. Compare measurements to specifications given below.

Specification

Exhaust Valve—Recess..1.20—1.80 mm
(0.047—0.071 in.) below cylinder head
Intake Valve—Recess..1.20—1.80 mm
(0.047—0.071 in.) below cylinder head

NOTE: Thoroughly clean all gasket material from cylinder head combustion face before measuring.

If measurement does not meet specifications, check valve face angle and valve seat angle. If valve is recessed beyond the maximum specification, install either new valves, valve seat inserts, or both to obtain proper valve recess. See REMOVE VALVE SEAT INSERTS AND MEASURE BORES IN CYLINDER HEAD later in this group.


RG14170 —UN—28AUG09

Measuring Valve Recess

RE38635,0000001 -19-26APR05-1/1

Preliminary Cylinder Head and Valve Checks

Make preliminary inspection of cylinder head and valve assembly during disassembly.

Look for the following conditions:

Sticking Valves:

- Carbon deposits on valve stem.
- Worn valve guides.
- Scored valve stems.
- Warped valve stems.
- Misaligned or broken valve springs.
- Worn or distorted valve seats.
- Insufficient lubrication.

Warped, Worn, or Distorted Valve Guides:

- Lack of lubrication.
- Cylinder head distortion.
- Excessive heat.
- Unevenly tightened cylinder head cap screws.

Distorted Cylinder Head and Gasket Leakage:

- Loss of cylinder head cap screw torque.
- Broken cylinder head cap screw.
- Overheating from low coolant level operation.
- Insufficient liner standout.
- Coolant leakage into cylinder causing hydraulic failure of gasket.
- Leaking aftercooler.
- Cracked cylinder head.
- Cracked cylinder liner.
- Damaged or incorrect gasket.
- Overpowering or overfueling.
- Damaged cylinder head or block surfaces.
- Improper surface finish on cylinder head.
- Improperly tightened cylinder head cap screws.
- Faulty gasket installation (misaligned)

Worn or Broken Valve Seats:

- Misaligned valves.
- Distorted cylinder head.
- Carbon deposits on seats due to incomplete combustion.
- Valve spring tension too weak.
- Excessive heat.
- Improper valve clearance.
- Improper valve timing.
- Incorrect valve or seat installed.

Burned, Pitted, Worn, or Broken Valves:

- Worn or distorted valve seats.
- Loose valve seats.
- Worn valve guides.
- Insufficient cooling.
- Cocked or broken valve springs.
- Improper engine operation.
- Improper valve train timing.
- Faulty valve rotators.
- Warped or distorted valve stems.
- “Stretched” valves due to excessive spring tension.
- Warped cylinder head.
- Bent push rods.
- Carbon build-up on valve seats.
- Rocker arm failure.
- Incorrect valve or seat installed.
- Incorrect piston-to-valve clearance.

Improper Valve Clearance:

- Inefficient use of fuel.
- Engine starts harder.
- Maximum engine power will not be achieved.
- Shorter service life of valve train.
- Greater chance for engine to overheat.

Excessive Valve Recession:

- Worn valve guides.
- Bent valves.
- Debris passed through valve train.

RE38635,0000035 -19-07JAN05-1/1

Valve — Assembly Removal

Refer to PRELIMINARY CYLINDER HEAD AND VALVE CHECKS, earlier in this group as valves are removed from head.

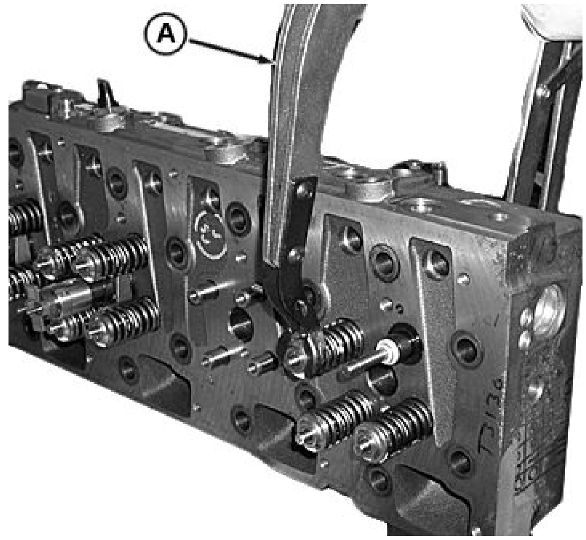
IMPORTANT: Identify all usable parts for correct reassembly in same location as removed.

1. Compress valve spring using JDE138 Valve Spring Compressor (A) as shown.
2. Remove retaining locks (B) using a small magnet.
3. Remove valve spring compressor from head.
4. Remove valve spring retainer (C) and valve spring (D).
5. Repeat procedure on remaining valves.
6. Remove oil seal (F) from valves. Remove valve (E) from cylinder head. Identify valve for reassembly, if valve is to be reused.

NOTE: On 9 L engines, all valves have oil seals.

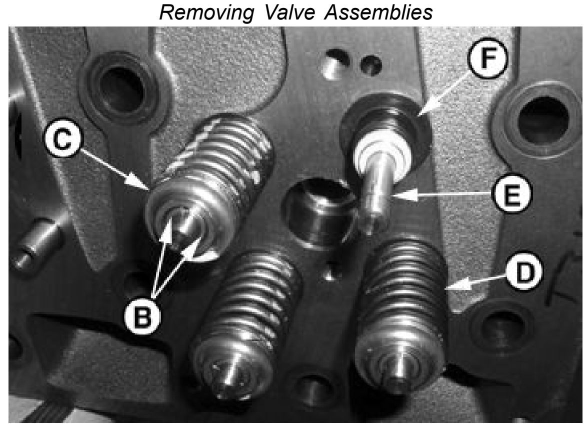
7. Repeat procedure on remaining valves.

A—JDE138 Valve Spring Compressor
B—Retainer Locks
C—Valve Retainer
D—Valve Spring
E—Valve Stem
F—Valve Stem Oil Seal



RG14171 —UN—28AUG09

Removing Valve Assemblies



RG14172 —UN—28MAY05

Valve Assemblies

RE38635,0000099 -19-29MAR05-1/1

Valve Springs — Inspection

1. Inspect valve springs for alignment, wear, and damage.
2. Put springs on a flat surface to see that they are square and parallel.

NOTE: Free spring length of 54.5 mm (2.15 in.) springs differ slightly, but compressed height must be the same.

3. Check valve spring tension using D01168A Spring Compression Tester.

Specification

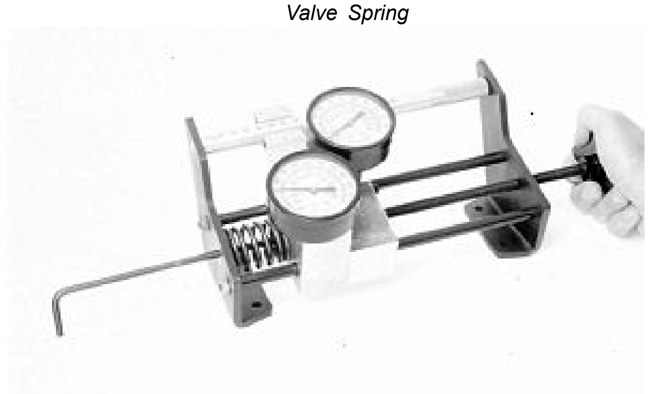
Intake Valve	
Spring—Height	32.91 mm (1.30 in.) @728—804 N (160—177 lb-force) with valve open
Height	45.00 mm (1.77 in.) @320—353 N (70—78 lb-force) with valve closed

Specification

Exhaust Valve	
Spring—Height	32.91 mm (1.30 in.) @728—804 N (160—177 lb-force) with valve open
Height	45.00 mm (1.77 in.) @320—353 N (70—78 lb-force) with valve closed


RG2732 —UN—28AUG09

Valve Spring


T82054 —UN—08NOV88

Checking Valve Spring Tension

RE38635,000009A -19-29MAR05-1/1

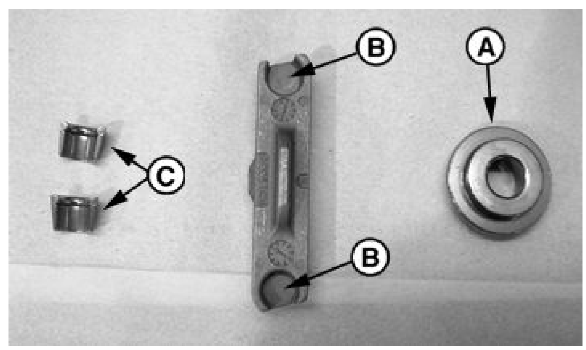
Valve Retainer, Valve Bridges, and Valve Retainer Locks — Inspection

1. Inspect valve retainers (A) for wear and cracks. Replace as needed.

NOTE: Index of valve bridges on valve stems is immaterial.

2. Inspect valve bridges for excessive wear at contact point with valve stem (B). Replace as needed.
3. Inspect retainer locks (C) for excessive wear. Replace if worn or pitted.

A—Valve Retainer
B—Valve Bridge
C—Valve Retainer Locks



RG14685 —UN—13JAN06

Inspecting Valve Components

RE38635,00000D7 -19-31MAY07-1/1

Valve — Cleaning and Inspection

1. Hold each valve firmly against a soft wire wheel on a bench grinder.
2. Make sure all carbon is removed from valve head, face and stem. Polish valve stem with steel wool or crocus cloth to remove scratch marks left by wire brush.

IMPORTANT: Any carbon left on valve stem will affect alignment in refacer if valves need to be refaced.

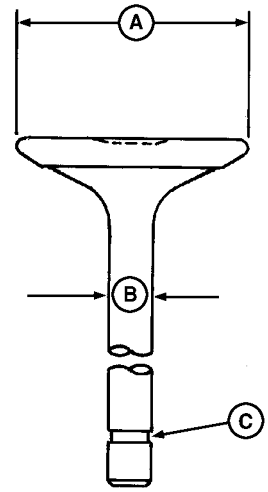
RE38635,0000037 -19-07JAN05-1/1

Valve — Measurement

1. Thoroughly clean and inspect valves to help determine if they can be restored to a serviceable condition. Replace valves that are burned, cracked, eroded, or chipped.
2. Inspect valve retainer lock groove (C) on valve stem for damage. Also inspect stems for signs of scuffing, which may indicate insufficient valve guide-to-valve stem clearance. Replace if defects are evident.
3. Measure valve head O.D. (A). Compare valve stem O.D. (B) with guide I.D. to determine clearance, as outlined later in this group.

Specification

Intake Valve Stem—OD....7.967—7.993 mm (0.3137—0.3147 in.)
Exhaust Valve Stem—OD....7.967—7.993 mm (0.3137—0.3147 in.)
Intake Valve Head—OD....39.87—40.13 mm (1.5697—1.5799 in.)
Exhaust Valve Head—OD....39.87—40.13 mm (1.5697—1.5799 in.)



RG5795 RG5795 —UN—05DEC97

Measuring Valves

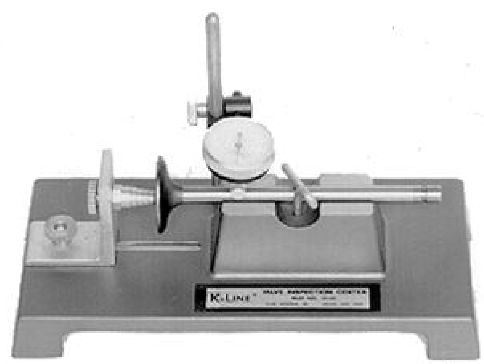
A—Valve Head OD
B—Valve Stem OD
C—Valve Retainer Lock Groove

RE38635,000009B -19-29MAR05-1/2

4. Use D05058ST Valve Inspection Center to determine if valves are out of round, bent or warped.

Specification

Valve Stem—Roundness.... 0.008 mm / 85 mm (0.0003 in.) maximum permissible



RG4234 —UN—05DEC97

Valve Stem Roundness Check

RE38635,000009B -19-29MAR05-2/2

Valve — Grinding

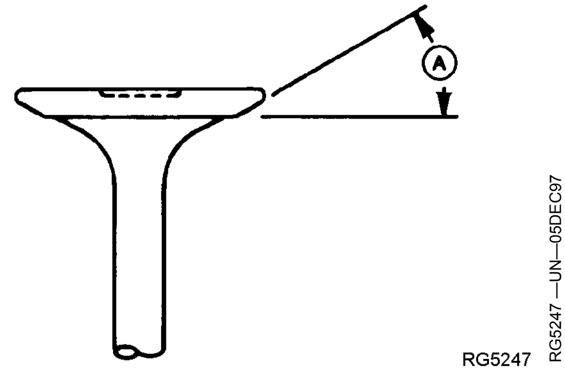
IMPORTANT: Valve grinding should only be done by experienced personnel familiar with equipment and capable of maintaining required specifications.

If necessary to reface valve, grind valve face angle (A) to following specification.

Specification

Valve Face (Intake and Exhaust)—Angle	29.25° ± 0.25°

IMPORTANT: When valve faces are ground, it is important not to nick valve head-to-stem radius with facing stone. A nick could cause the valve to break. Radius all sharp edges after grinding.



Valve Face Angle

A—Valve Face Angle

RE38635,000009C -19-29MAR05-1/1

Cylinder Head — Cleaning and Inspection

1. Inspect combustion face for evidence of physical damage, oil or coolant leakage, or gasket failure prior to cleaning the cylinder head. Repair or replace cylinder head if there is evidence of physical damage; such as cracking, abrasion, distortion, or valve seat “torching”. Inspect all cylinder head passages for restrictions.
2. Scrape gasket material, oil, carbon, and rust from head. Use a powered brass or copper wire brush to clean sealing surfaces.

IMPORTANT: Be sure to remove all plugs before cleaning head, as parts can be damaged or destroyed by hot tank solutions.

3. Clean cylinder head in a chemical hot tank, or with solvent and a brush.
4. Dry with compressed air and blow out all passages.
5. Reinstall plugs removed from cylinder head and tighten to the following specifications.

Specification

Cylinder Head Plugs—Torque	60 N·m (44 lb-ft)

RE38635,0000038 -19-29AUG08-1/1

Cylinder Head — Flatness Check

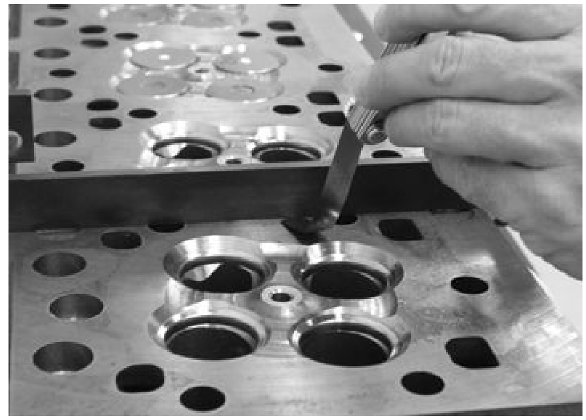
Check cylinder head flatness using D05012ST Precision Straightedge and feeler gauge. Check lengthwise, crosswise, and diagonally in several places.

NOTE: At this time, cylinder head resurfacing specifications have not been released.

If any measurement exceeds specification, the cylinder head must be replaced. See MEASURE CYLINDER HEAD THICKNESS later in this group.

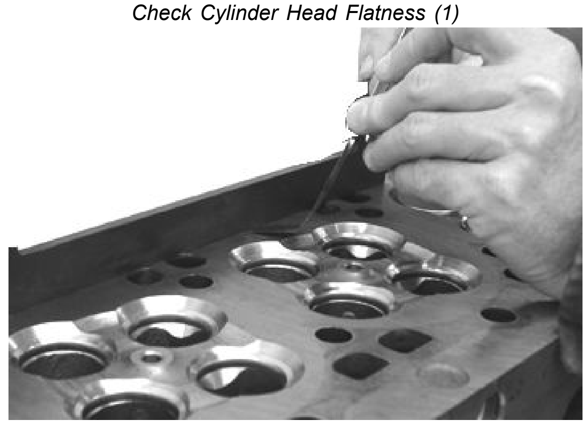
Specification

Cylinder Head—Maximum Acceptable Out-of-Flat Over Entire Length or Width	0.1 mm (0.004 in.)
Straightness Per Any 305 mm (12 in.) Length	Within 0.025 mm (0.001 in.)



RG14173 —UN—28MAY05

Check Cylinder Head Flatness (1)



RG14174 —UN—28MAY05

Check Cylinder Head Flatness (2)

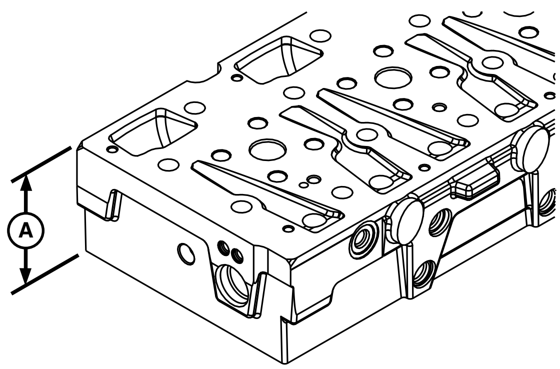
RE38635,0000002 -19-26APR05-1/1

Cylinder Head — Thickness Measurement

Measure head thickness (A) from intake manifold face to combustion face.

Specification

Cylinder Head—Thickness	104.80—105.20 mm (4.126—4.4.142 in.)
Flatness	0.1 mm (0.040 in.)
Combustion Face Surface Finish	0.8—3.2 micrometers (32—125 micro-in.)
Waviness	0.02 (.0008 in.) Height 3.0 (.120 in.) Width



RG14180 —UN—05MAY05

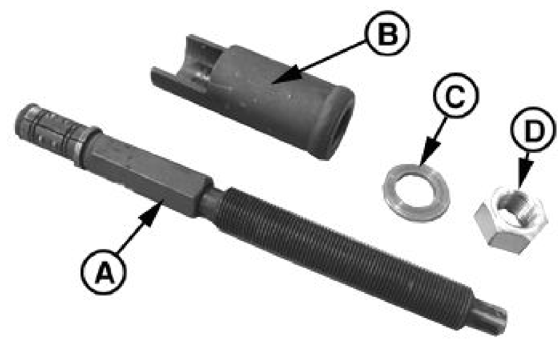
Cylinder Head Thickness

A—Head Thickness

RE38635,0000008 -19-01JUL08-1/1

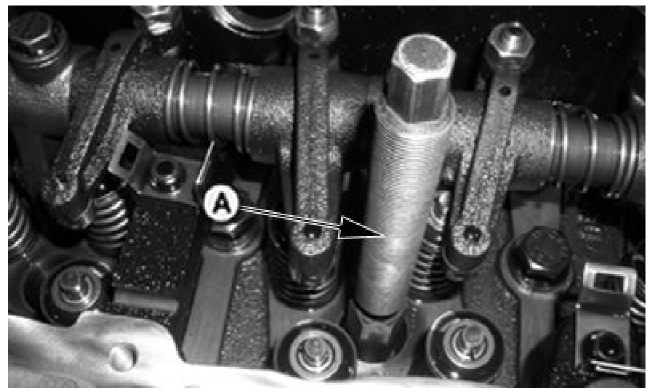
Fuel Injector Sleeves — Remove

1. Place forcing screw (A) into the injection nozzle sleeve. Insure the expander portion of the tool is installed so that the expander will locate securely on the sleeve inner diameter. Using a backup wrench, tighten the forcing screw.
2. Install spacer (B) on the forcing screw. Position the spacer with the cut-out facing into the cylinder head.
3. Install flat washer (C) and hex nut (D). Turn hex nut until sleeve is loose.
4. Remove tool with sleeve.

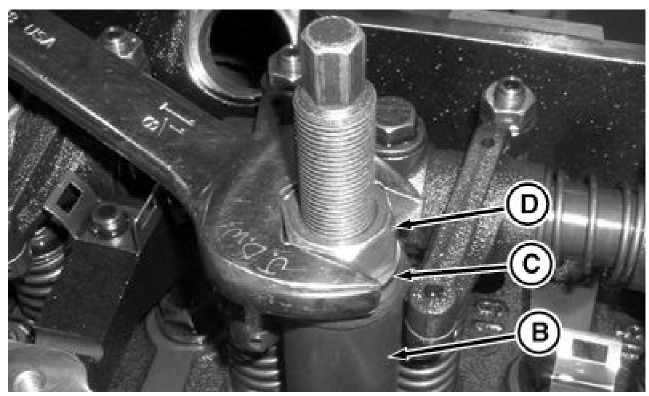


RG15754 —UN—09MAY08

A—Forcing Screw
B—Spacer
C—Flat Washer
D—Hex Nut



RG16368 —UN—16JUL08



RG16360 —UN—19AUG09

RG16361 —UN—01JUL08

AS58880,000003E -19-21JUL09-1/1

Fuel Injector Sleeves — Install

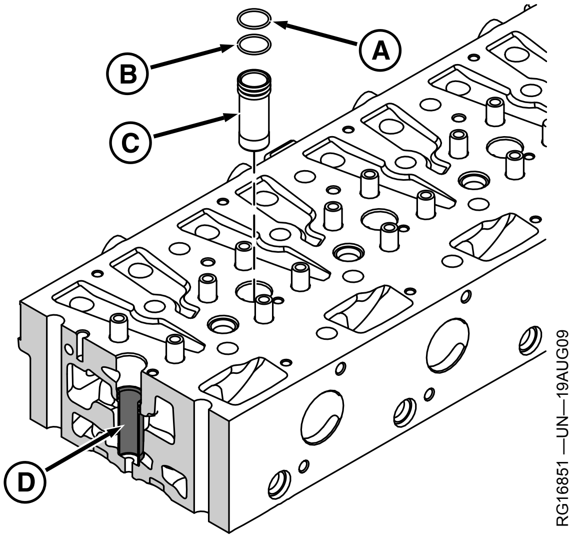
IMPORTANT: If installing a new fuel injector nozzle sleeve, make sure piston is NOT at or near top dead center (TDC). Rotate engine until piston is at bottom dead center (BDC) or piston damage will result.

1. Support cylinder head so that the lower surface of the head is approximately 50 mm (2.0 in.) above work bench.
2. Apply LOCTITE® 620 (TY15941) completely around the lower, outer edge of the fuel injection nozzle sleeve (C).

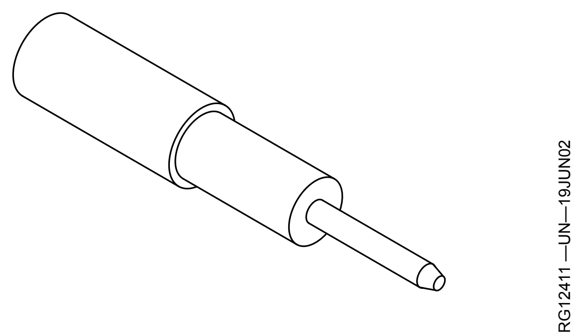
IMPORTANT: Do not remove or mix sleeve O-rings. Service sleeve is provided with O-rings installed on it. The upper O-ring is diesel fuel compatible while the lower one is coolant compatible. Both O-rings are identified by a different color and are not available as spare parts.

Do not use any petroleum based products to lubricate fuel injector sleeve O-rings or O-rings will swell.

3. Lubricate O-rings with liquid soap.
4. Set fuel injection nozzle sleeve (C) over bore and place JDG1649A Injector Sleeve Installer (E) into the sleeve.
5. Using a hammer, strike the nozzle installation tool carefully to drive the sleeve fully into the bore.



Fuel Injector Nozzle Sleeve



JDG1649A Injector Sleeve Installation Tool

A—Upper Green O-Ring
B—Lower Yellow O-Ring
C—Sleeve
D—Installed sleeve

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AS58880,0000217 -19-21JUL09-1/1

Valve Guide — Cleaning

Use an End Brush to clean valve guides before inspection or repair.

NOTE: A few drops of light oil or kerosene will help to fully clean the guide.

Clean Valve Guides

RE38635,0000003 -19-27APR05-1/1

Valve Guide — Measurement


RG14177 —UN—28MAY05

Measure Valve Guide ID

Measure valve guides for wear using a telescope gauge and micrometer.

Specification

Valve Guide—ID..8.017—8.043 mm
(0.3156—0.3167 in.) in new head

New Guide to Valve Stem—Clearance..0.024—0.076 mm
(0.001—0.003 in.)

NOTE: Worn guides can allow a clearance of 0.15 mm (0.006 in.) and still be acceptable. Worn guides may be knurled to return them to specified clearance if valve-to-guide clearance is 0.25 mm (0.010 in.) or less.

IMPORTANT: ALWAYS knurl exhaust valve guides before reaming to assure proper valve guide-to-stem clearance.

RE38635,0000004 -19-27APR05-1/1

Valve Seat — Cleaning and Inspection


RG14178 —UN—28MAY05

Cleaning Valve Seats

1. Use an electric hand drill with D17024BR Wire Cleaning Brush or equivalent brush to remove all carbon on valve seats.
2. Check seats for cracks, pits, or excessive wear.
3. Check entire combustion face for rust, scoring, pitting, or cracks.

RE38635,0000005 -19-27APR05-1/1

Valve Seat — Recess Measurement

1. Measure valve seats for proper specifications listed below.
2. Using D11010KW Eccentrimeter, measure valve seat runout (D).
3. If valve seat is not within specification, recondition valve seat by grinding or replace valve seat inserts (A) if reconditioning is not possible. See GRIND VALVE SEATS, or see INSTALL VALVE SEAT INSERTS, later in this group.

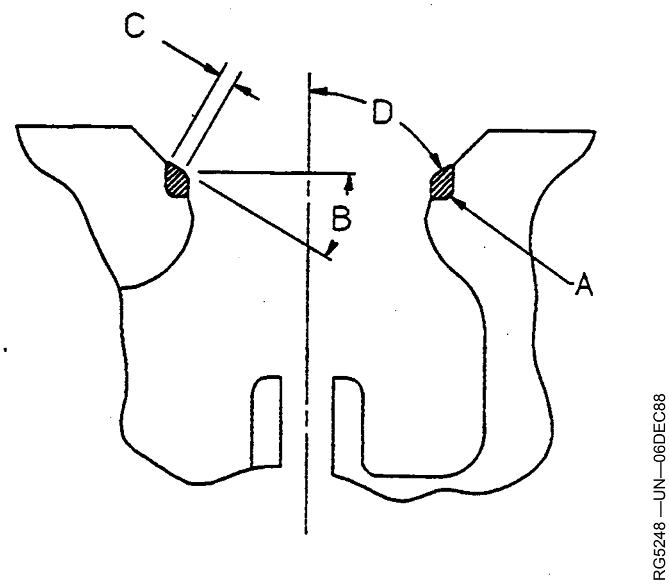
Specification

Valve Seat—Angle... 30° ± 0.25°
Maximum Runout .... 0.065 mm (0.0025 in.)

Specification

Valve Seat—Width............................. 1.98—2.61 mm (0.078—0.102 in.)

A—Valve Seat Insert
B—Valve Seat Angle
C—Valve Seat Width
D—Valve Seat Runout



Measuring Valve Seats

RE38635,0000007 -19-01SEP08-1/1

Valve Seat — Grinding

IMPORTANT: Valve seat grinding should only be done by experienced personnel familiar with equipment and capable of maintaining required specifications. ALWAYS keep work area clean when grinding valve seats. A 120-grit stone MUST BE used for grinding both intake and exhaust valve seat inserts (A).

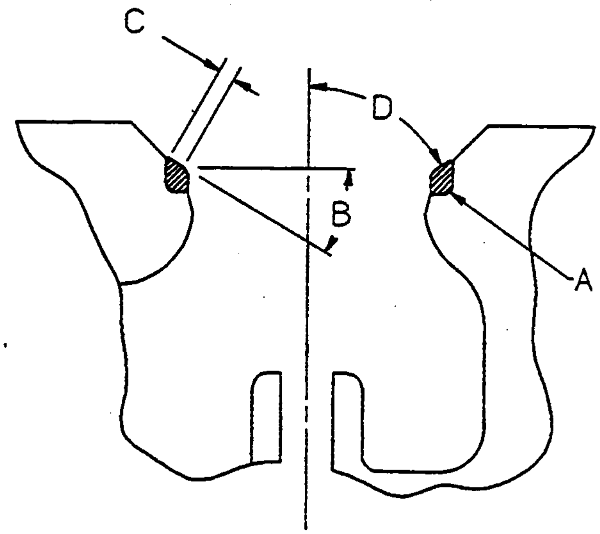
Using JT05893 Heavy-Duty Seat Grinder Set, grind valve seats to obtain correct valve recess in cylinder head. See<u>MEASURE VALVE RECESS SERIAL</u> earlier in this group. Be sure valve guide bores are clean before grinding valve seats. See <u>CLEAN VALVE GUIDES</u> earlier in this group.)

If valve seats need grinding, only a few seconds are required to recondition the average valve seat. Avoid the tendency to grind off too much. Do not use excessive pressure on the grinding stone.

1. Check the seat width (C) and contact pattern between the seat and valve with bluing. Seat width MUST BE maintained within specification. Use a vernier caliper or scale to measure seat width. Thoroughly clean seat area after grinding and replace valves and valve seat inserts as necessary.

NOTE: Valve seat width can be reduced with a narrowing stone. This will change the angle (B) at the top of the seat and increase the diameter. If valve seat width is too narrow, valve may burn or erode. Varying the width changes the fine contact between valve face and seat.

2. ALWAYS measure valve seat runout after grinding using D11010KW Eccentrimeter and check recess in cylinder head after grinding as described later.



RG5248 —UN—06DEC88

Measuring Valve Seats

A—Valve Seat Insert
B—Valve Seat Angle
C—Valve Seat Width
D—Valve Seat Runout

Specification

Valve Seat	
Grinding—Angle	30° ± 0.25° from horizontal
Valve Seat Width	1.98—2.61 mm (0.078—0.102 in.)
Maximum Seat Runout	0.050 mm (0.002 in.)

RE38635,0000009 -19-29APR05-1/1

Valve Seat Inserts — Removal

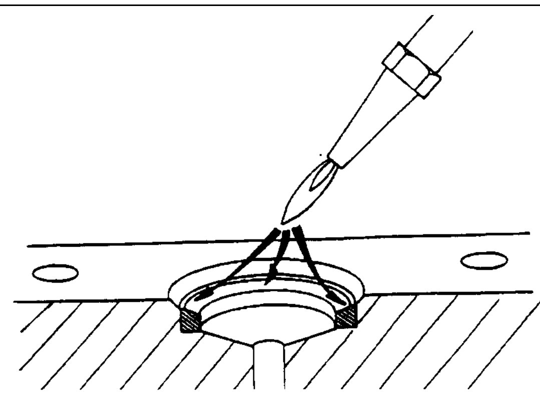
In some cases the valve seat bore in the cylinder head may become damaged or oversized. At this time, oversize valve seat inserts ARE NOT available. Replace the cylinder head.

IMPORTANT: Be careful not to damage cylinder head when removing seats.

1. Remove valve seat insert (if necessary) with JDE41296 Valve Seat Puller. Adjusting screw on puller may need to be retightened during removal of inserts.

   Valve seat inserts may be also removed using the following method:

   - Carefully heat insert at four points around face until insert becomes red hot. Allow seat to cool and carefully pry out the insert(s) with a screwdriver.



RG5605 —UN—17JAN90

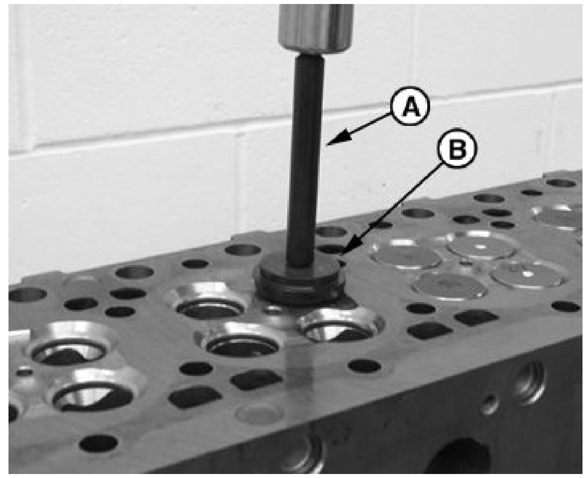
Heating Valve Seat Inserts

2. After removal of inserts, thoroughly clean area around valve seat bore and inspect for damage or cracks.

RE38635,000000A -19-29APR05-1/1

Valve Seat Inserts — Installation

1. Use the JDG10254 Driver (A) along with JDG10057 Valve Seat Installer (B) to drive inserts into place. Both intake and exhaust valve seats on the 9 L engine are the same size.
2. Install new or refaced valves and check valve recess. See MEASURE VALVE RECESS earlier in this group.
3. Grind valve seats as required to maintain correct valve recess and valve-to-seat seal. See GRIND VALVE SEATS earlier in this group.



RG14181 —UN—28MAY05

Install Valve Seat Inserts

RE38635,0000047 -19-28MAR07-1/1

Cylinder Head Nozzle Bore — Cleaning and Inspection

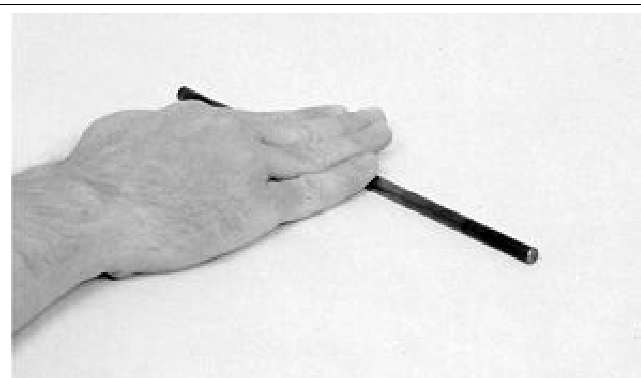
1. Inspect condition of nozzle seating surface and bore in cylinder head.

   Cylinder head nozzle seating surface and bore must be free of debris and carbon deposits.
2. Clean bore of light foreign deposits using a drill and the D17030BR Thread Cleaning Brush. Work brush up and down several times to clean threads.
3. Blow out debris with compressed air and thoroughly clean all nozzle bores.

RE38635,000000C -19-29APR05-1/1

Push Rod — Cleaning and Inspection

1. Clean push rods with solvent and compressed air.
2. Check push rods for straightness by rolling on a flat surface.
3. Inspect contact ends for wear and damage.
4. Replace defective push rods.



T81233 —UN—01NOV88

Checking Valve Push Rods for Straightness

RE38635,0000039 -19-07JAN05-1/1

Cylinder Block Top Deck — Cleaning and Inspection

1. Remove gasket material, rust, carbon, and other foreign material from top deck. Gasket surface must be clean.
2. Use compressed air to remove all loose foreign material from cylinders and top deck.
3. Clean all cylinder head mounting cap screw holes using JDG681 or an equivalent 9/16-12 UNC-2A tap about 88.9 mm (3.5 in.) long. Use compressed air to remove debris and any fluids which may be present in the cap screw holes.
4. Measure top deck flatness. See MEASURE CYLINDER BLOCK in Group 030.

RE38635,000009D -19-29MAR05-1/1

Cylinder Liner — Standout Measurement

IMPORTANT: Remove all old gasket material, rust, carbon, and other foreign material from top deck of block. Gasket surface MUST BE CLEAN. Use compressed air to remove all loose foreign material from cylinder and top deck.

1. Bolt down liners using cap screws and flat washers as shown. Flat washers should be at least 3.18 mm (1/8 in.) thick. Tighten cap screws to 68 N·m (50 lb-ft) to achieve an accurate standout reading.

NOTE: Liners having obvious defects must be replaced.

2. Using JDG451 Gauge (B) along with D17526CI (English) or D17527CI (Metric scale) Dial Indicator or KJD10123 Gauge, measure the height of bolted down liners that are not obviously defective before removal from block.

NOTE: Variations in measurement readings may occur within one cylinder and/or between adjacent cylinders.

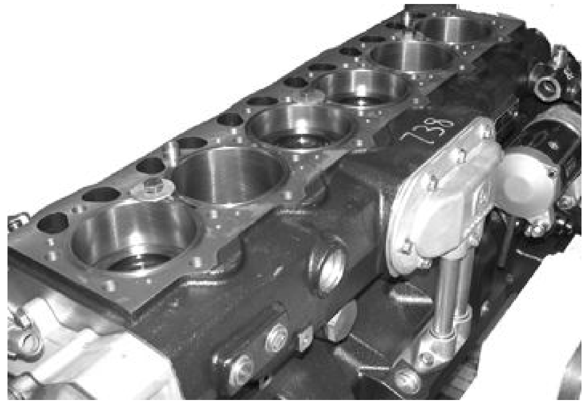
3. Measure each liner in four places, approximately at 1, 5, 7 and 11 O'clock positions as viewed from the rear of the engine (flywheel end). Record all measurements by cylinder number and compare to the following specifications.

Specification

Liner—Height Above
Block..0.051—0.127 mm
(0.002—0.005 in.) above block

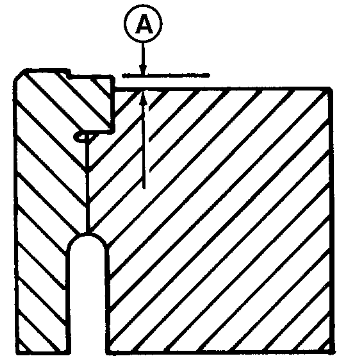
4. Remove any liner that does not meet standout specification at any location and install new piston/liner kit.

B—JDG451 Gauge



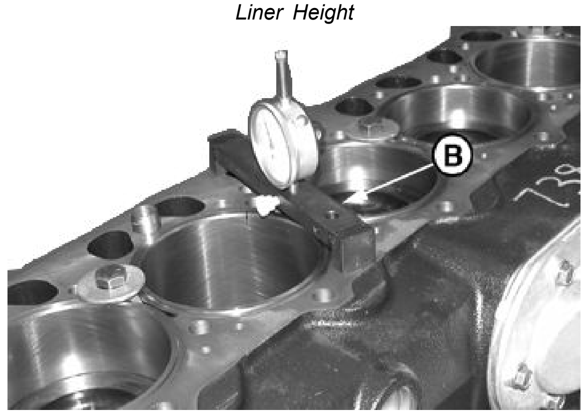
RG13983 —UN—19FEB05

Bolting Down Cylinder Liners



RG6439 —UN—03NOV97

Liner Height



RG13984 —UN—19FEB05

Checking Cylinder Liner Height Above Block

RE38635,000009E -19-29MAR05-1/1

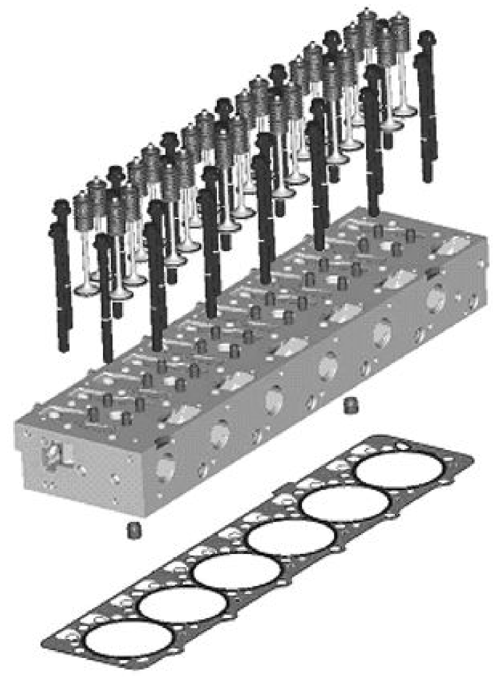
Valve Assembly — Reassemble

1. Apply AR44402 Valve Stem Lubricant or clean engine oil to valve stems and guides.
2. Lubricate valve stem seal bore prior to installation over valve guide.

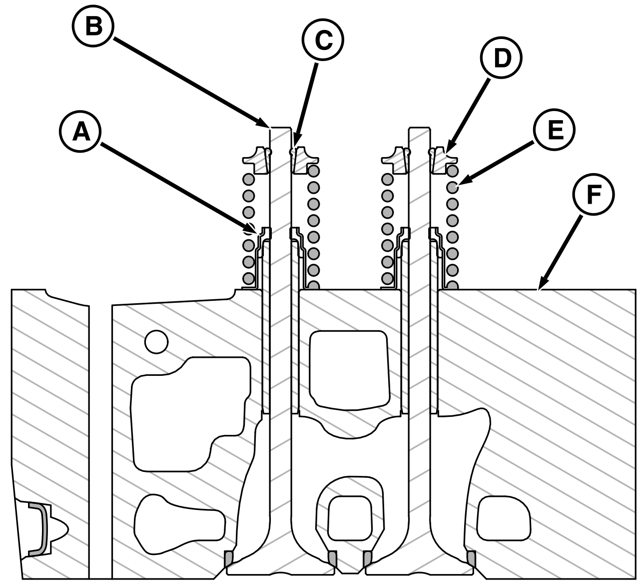
NOTE: Valve stem seals are to be in place before installation of valves in guides.

3. Install 24 valve stem seals (A) over guides in cylinder head (F).

A—Valve Stem Seal
B—Valve
C—Valve Retainer
D—Spring Retainer
E—Valve Spring
F—Cylinder Head Assembly



Cylinder Head and Valve Assembly



Valve Assembly

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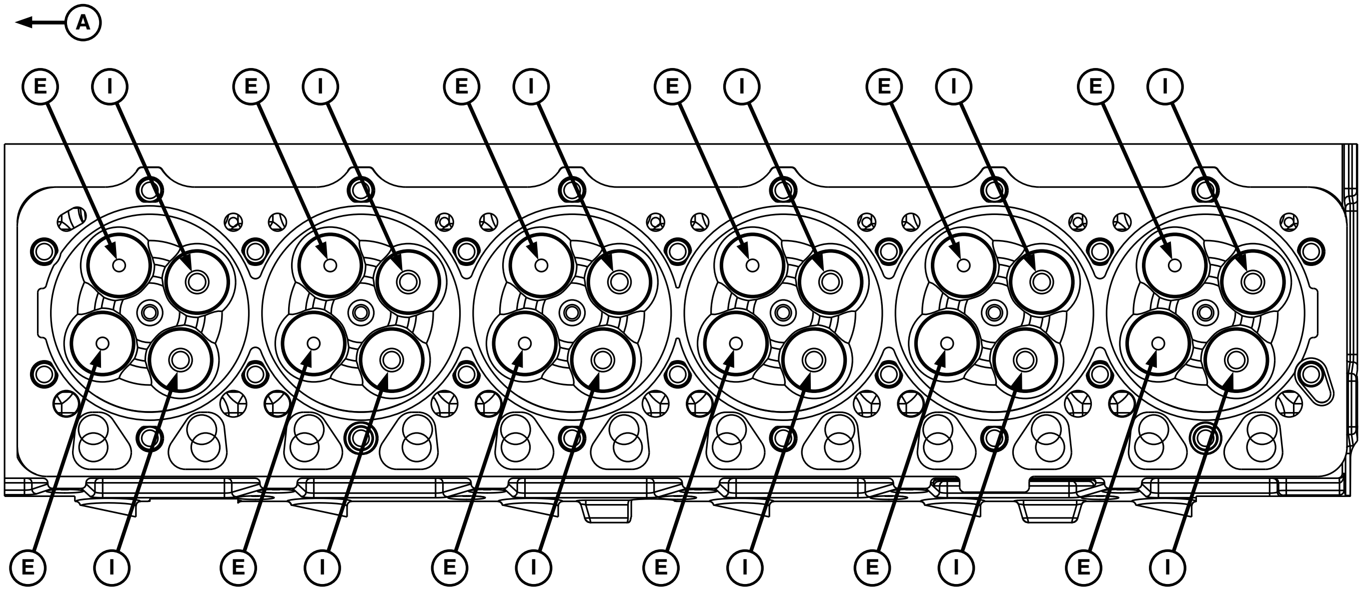
RE38635,000003C -19-07JAN05-1/2



Intake and Exhaust Valve Position

A—Front of Engine

NOTE: Exhaust valves are identified with a white mark in small cast depression in valve face. Intake valves are identified with a blue mark in a large cast depression as shown. Intake valves are also magnetic; exhaust valves are not.

4. Install 12 intake and 12 exhaust valves in head, two of each per cylinder. Position as shown, with the exhaust valves towards front of engine for each cylinder.

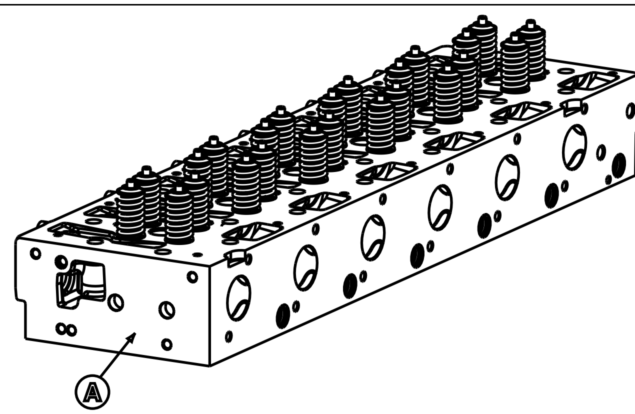
NOTE: Valve stems must move freely in guide bore and seat properly with insert.

NOTE: There is no top or bottom to valve springs (E): they may be installed either way.

5. Install 24 valve springs (E) over valve spring seals on cylinder head.
6. Install valve spring retainers (D) to each valve.
7. Install 2 valve retainers (C) to each valve.
8. Measure valve recess in head as directed earlier in this group.

RE38635,000003C -19-07JAN05-2/2

Cylinder Head — Installation



Cylinder Head Assembly

A—Front Face of Cylinder Head

IMPORTANT: ALWAYS thoroughly inspect new cylinder head gasket for possible manufacturing imperfections. Return any gasket that does not pass inspection.

Be sure cylinder head and block gasket surfaces are clean, dry, and free of any oil.

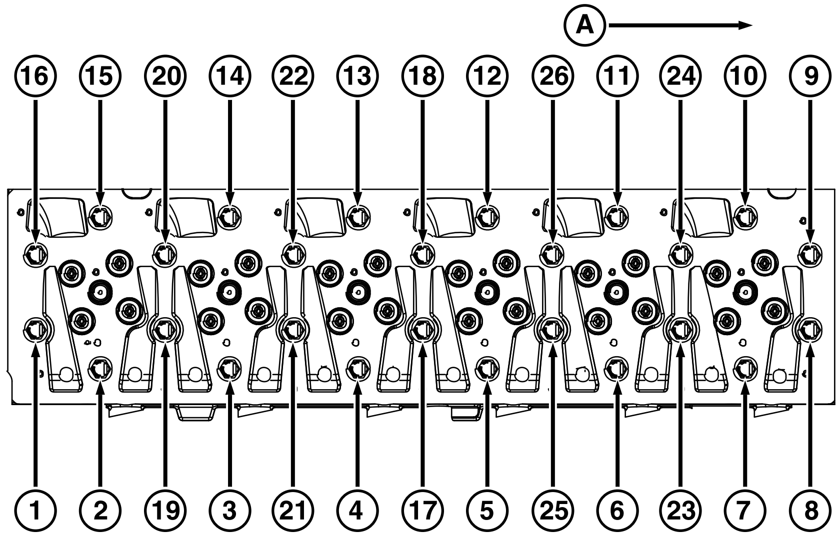
1. Put a new head gasket on cylinder block. Do not use sealant on gasket; install dry.

IMPORTANT: If cylinder head is lowered onto cylinder block and the head is not positioned correctly on locating dowels, remove cylinder head and install a new gasket. DO NOT try to reposition cylinder head on the same gasket again since the fire ring may possibly be damaged.

2. Lower cylinder head evenly to correct position on block using appropriate lifting equipment. Make sure that head is positioned correctly over dowels and sits flat on cylinder block top deck.

Continued on next page

RE38635,0000028 -19-12AUG10-1/2



Head Bolt Torque Sequence

A—Front of Engine

IMPORTANT: Only ASTM Grade 180 Flanged-Head cap screws are recommended for use on 6090 engines. ALWAYS use NEW cap screws when installing cylinder head. Cap screws may be used only one time.

DO NOT use multi-viscosity oils to lubricate cap screws, SAE30 is recommended.

3. Dip entire cap screw in clean SAE30 engine oil. Allow excess oil to drip off.

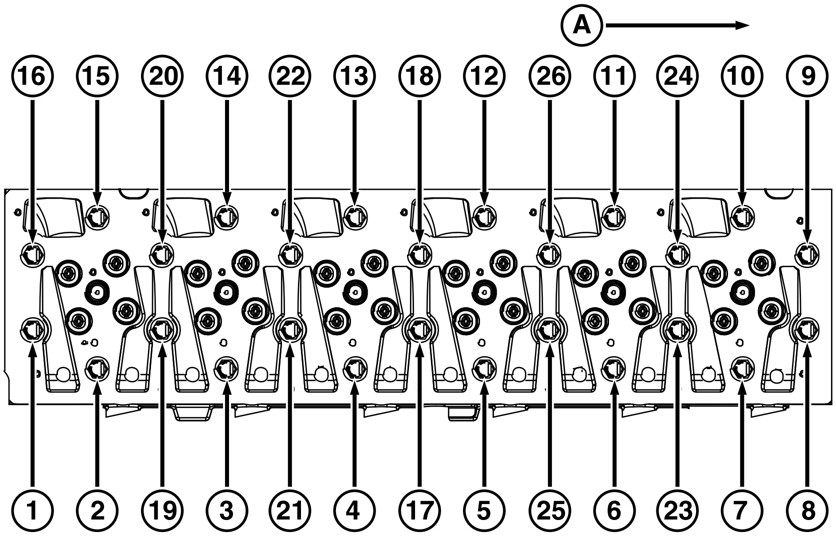
NOTE: All cylinder head cap screws for the 6090 engine are same length.

4. Install 26 special cap screws marked and tighten using the TORQUE-TO-YIELD tightening procedure, described next in this group.

   Arrow (A) points toward front of engine.

RE38635,0000028 -19-12AUG10-2/2

Cylinder Head Cap Screw Torque Procedure



Head Cap Screw Locations

A—Front of Engine

Arrow (A) points toward front of engine.

IMPORTANT: DO NOT use multi-viscosity oils to lubricate cap screws.

1. Lubricate cap screws with clean SAE30 engine oil and install in their proper locations as outlined previously.
2. Tighten cap screw No. 17 to 80 N·m (60 lb-ft), then sequentially start at cap screw No. 1 and proceed through cap screw No. 26, tightening all cap screws to specifications.

Specification

Cylinder Head Flanged-Head "SPECIAL" Cap Screws (No Washers)—Initial Torque....80 N•m (60 lb-ft)

3. Using an oil-proof pen, pencil, or marker, draw a line parallel to the crankshaft across the entire top of each cap screw head. This line will be used as a reference mark.

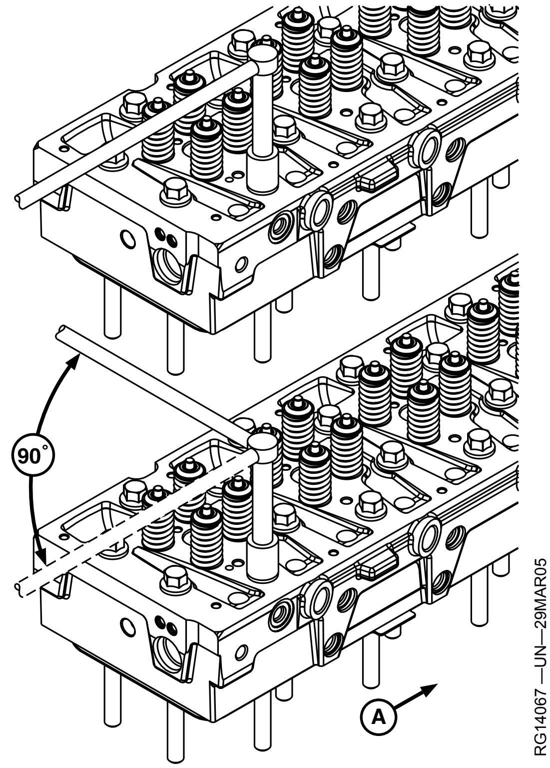
Continued on next page

RE38635,00000A0 -19-30MAR05-1/2

IMPORTANT: If a cap screw is accidentally tightened more than 90° in any one sequence, DO NOT loosen cap screw but make adjustments in the next tightening sequence.

4. Sequentially (start at cap screw No. 1 and proceed through cap screw No. 26) turn each cap screw 90°. Line on top of cap screw will be perpendicular to crankshaft.
5. Again, sequentially (start at cap screw No. 1 and proceed through cap screw No. 26) turn each cap screw 90°. Line on top of cap screw will now be parallel to crankshaft.
6. Finally, sequentially (start at cap screw No. 1 and proceed through cap screw No. 26). Turn each cap screw 90°, SO THAT LINE ON TOP OF CAP SCREW IS AS CLOSE AS POSSIBLE TO BEING PERPENDICULAR TO THE CRANKSHAFT. It is not necessary to obtain the final turn in one swing of the wrench. TOTAL AMOUNT OF TURN FROM STEPS 4, 5, AND 6 IS 270° ± 5°.

IMPORTANT: Cap screws MUST NOT be tightened more than a total of 270° ± 5°.



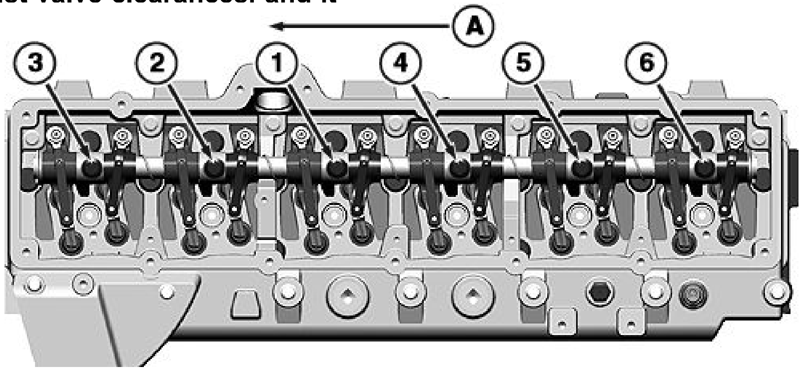
A—Front of Engine

Torque-to-Yield Cylinder Head Cap Screws

RE38635,00000A0 -19-30MAR05-2/2

Rocker Arm Assembly — Installation

IMPORTANT: When possible, install rocker arm assembly PRIOR to installing fuel injectors. It is easier to adjust valve clearances. and it eliminates the chance of damaging the injectors when installing rocker arm assembly.



Rocker Arm Shaft Assembly Torque Sequence

A—Front of Engine

1. Install push rods in holes from which removed.

NOTE: Index of valve bridges to valve stems is immaterial.

2. Assemble valve bridges to valve stems.
3. Lubricate rocker arm pedestal cap screws in cylinder head with SAE 30 diesel engine oil.
4. Lubricate rocker arm pedestal cap screws under head with SAE 30 diesel engine oil.
5. Assemble rocker arm assembly to head by guiding 6 flange head cap screws located in rocker arm pedestals into threads in cylinder head.
6. Seat rocker arm balls in push rod seats before tightening of rocker arm pedestal cap screws.
7. Align rocker arms centered on valve bridges.

IMPORTANT: Rocker arm mounting screws *cannot* be reused. Replace rocker arm mounting screws removed from engine with new screws.

8. In the sequence shown, initially tighten rocker pedestal-to-cylinder head capscrews to specifications below:

Specification

Initial Rocker Pedestal-to-Cylinder Head Cap Screw—Torque .... 20 N•m (15 lb-ft)

9. Loosen one cap screw at a time 90° minimum.
10. Finish tighten (torque-turn) cap screw to following specification:

Specification

Final Rocker Pedestal-to-Cylinder Head Cap Screw—Torque Turn .... 40 N•m +120° (30 lb-ft +120°)

11. Adjust engine valve clearance.

RE38635,000003B -19-31MAY07-1/1

Rocker Arm Cover Vent hose — Inspection

1. Check ventilator outlet hose on rocker arm cover for bent or damaged condition. Replace if necessary.
2. Clean ventilator hose if restricted.

RE38635,000003A -19-07JAN05-1/1

Final Assembly — Fuel Pump Side of Engine

1. Adjust valve clearance, if not previously done.
2. Install electronic injectors, wiring harness, fuel inlet connectors, fuel leak-off connectors, fuel delivery lines, and fuel leak-off lines. See INSTALL ELECTRONIC INJECTORS, in Group 090 of CTM385.

NOTE: Use of guide pins in intake manifold will ease assembly of rocker arm cover and gasket.

IMPORTANT: Install new rocker arm cover gasket each time rocker arm cover is reinstalled.

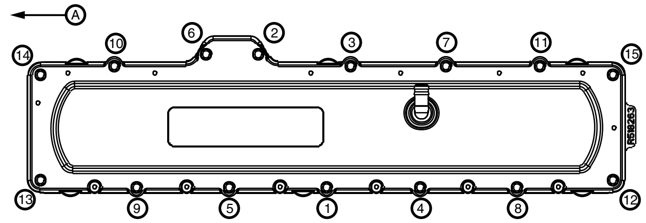
3. Install rocker arm cover gasket over guide pins.
4. Install rocker arm cover assembly over guide pins and gasket.
5. Remove guide pins and finger start 15 cap screws through cover and gasket into intake manifold.
6. Tighten cap screws to specifications in the sequence shown.

Specification

Rocker Arm
Cover-to-Intake Manifold
Cap Screws—Torque..35 N•m (26 lb-ft)

After 10 minutes re-torque the cap screws in sequence shown to specification.

RG13907 —UN—14JAN05



Rocker Arm Cover Torque Sequence

A—Front of Engine

Specification

Rocker Arm
Cover-to-Intake Manifold
Cap Screws—Torque..35 N•m (26 lb-ft)

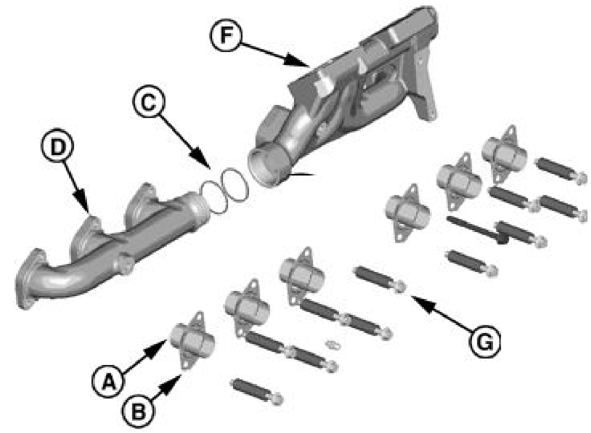
NOTE: Make sure ventilator outlet hose is open and adapter is clean. A restriction could cause high oil pressure and possible loss of oil.

7. Connect ventilator outlet hose to adapter on rocker arm cover and tighten clamp securely.
8. Install thermostat housing. See INSTALL THERMOSTAT HOUSING in Group 070.

AS58880,00000B5 -19-13APR09-1/1

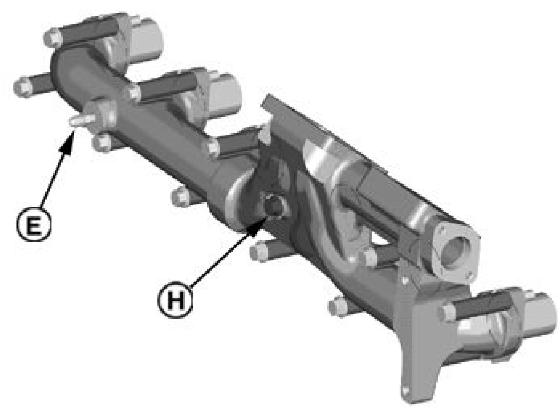
Final Assembly — Exhaust Manifold Side of Engine

A—Port Liner
B—Exhaust Manifold Gasket
C—Sealing Rings
D—Front Exhaust Manifold
E—Pressure Port Fitting
F—Rear Exhaust Manifold
G—Exhaust Manifold to Cylinder Head Cap Screws
H—Long Bolt - Manifold to Cylinder Head



RG13913 —UN—24JAN05

Exhaust Manifold Assembly



RG13914 —UN—24JAN05

Exhaust Manifold Hardware

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RE38635,00000A3 -19-27MAR09-1/5

Assemble Exhaust Manifold

1. Install 6 port liners (A) to cylinder head.

NOTE: Guide pins and port liners will keep gaskets from rotating during assembly.

2. Install 6 guide pins to cylinder head in top cap screw hole of each port.
3. Install gaskets (B), with tab pointing down, over guide pins and port liners.

NOTE: Position one sealing ring joint at 3:00 position and the other at 9:00 position as viewed when mounted on engine.

4. Install two new sealing rings (C) to front manifold. (D)
5. If necessary, install pressure port fitting (E) into front manifold.

Specification

Pressure Port Fitting to Front Exhaust Manifold—Torque.......20 N•m (15 lb-ft)

6. Install rear exhaust manifold (F) to front exhaust manifold (D).
7. Install exhaust manifold assembly over guide pins and port liners in cylinder head.

NOTE: It is not necessary to use an anti-seize compound on new stainless steel exhaust manifold cap screws.

8. Apply PT569 NEVER-SEEZ® Compound, **only to cap screws being reused**. Install 6 cap screws (G) through spacers and into bottom holes of exhaust manifold and into cylinder head. Tighten finger tight.
9. Remove guide pins. Install 5 cap screws through spacers and into top holes finger tight in exhaust manifold and cylinder head.

IMPORTANT: The long bolt (H) on the exhaust manifold assembly CAN NOT be reused. This bolt is not stainless steel and is thus affected by the exhaust heat.

10. Install one long bolt (H) into hole through thick portion of exhaust manifold into cylinder head finger tight.

NOTE: Be certain exhaust manifold gasket tab is facing down, under bottom cap screws, as shown.

11. Tighten 12 exhaust manifold capscrews in the order shown to specification.

Specification

Exhaust Manifold to Cylinder Head Cap Screws—Torque.......70 N•m (52 lb-ft)

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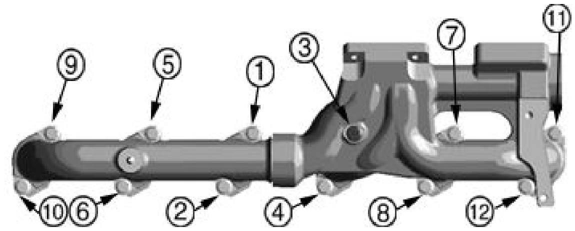
RG13915 —UN—28MAY05



Exhaust Manifold Torque Sequence

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RE38635,00000A3 -19-27MAR09-2/5

Assemble Exhaust Gas Recirculator (EGR)

1. Install EGR cooler assembly to intake manifold by starting 2 cap screws finger tight. Do not tighten.
2. Assemble spring washers to shoulder bolts.
3. Install shoulder bolts through holes in rear of EGR cooler and into exhaust manifold.
4. Tighten cap screws to specification.

Specification

EGR Cooler to Intake Manifold—Torque............34 N•m (25 lb-ft)
EGR Cooler to Exhaust Manifold Shoulder Bolts—Torque............34 N•m (25 lb-ft)

5. Install EGR coolant return line to EGR cooler assembly. Tighten screw securing line to cooler to specification.

Specification

EGR Coolant Return Line to Cooler Cap Screw—Torque............11 N•m (8 lb-ft)

6. Install constant tension hose clamp to end of EGR coolant return line. Install hose end of coolant return line over fitting on coolant pump.
7. Reposition constant tension clamp to secure hose to coolant pump fitting.
8. Install P clamp support for EGR coolant return line with loop toward engine. Tighten cap screw to specification.

Specification

P Clamp Cap Screw—Torque............30 N•m (22 lb-ft)

9. Install EGR tube and 2 new gaskets to exhaust manifold and EGR cooler. Tighten cap screws to specification.

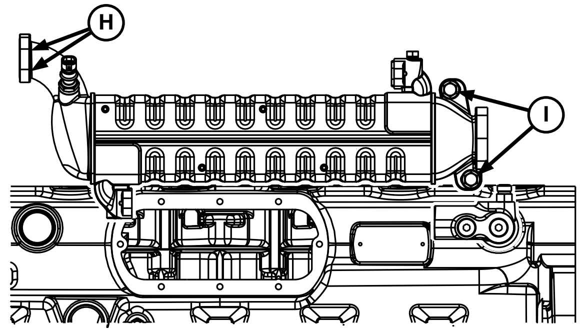
Specification

EGR Tube to Exhaust Manifold & EGR Cooler Cap Screws—Torque............34 N•m (25 lb-ft)

10. Install EGR coolant supply line (short end) into coolant manifold.
11. Orient opposite end of coolant supply line into EGR cooler. Install cap screw and tighten to specification.

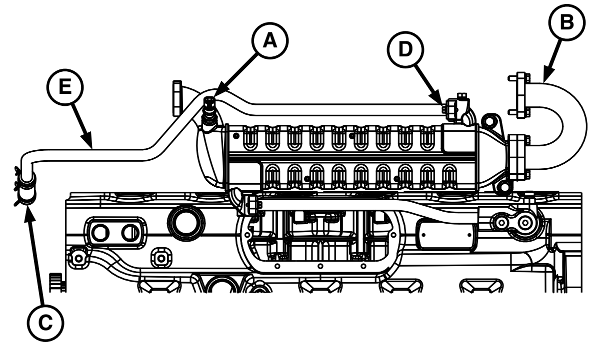
Specification

EGR Coolant Supply Line to Cooler & Coolant Manifold—Torque............11 N•m (8 lb-ft)



RG14201 —UN—26MAY05

EGR Cooler



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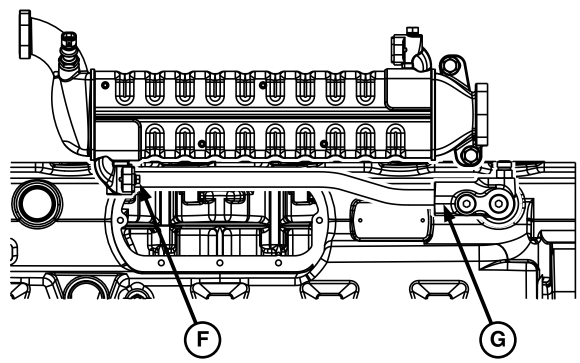
EGR Coolant Return Line & EGR Tube



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EGR Coolant Supply Line

A—EGR Exhaust Gas Temperature Sensor
B—EGR Tube
C—EGR Coolant Return Line to Coolant Pump
D—Coolant Return Line to Cooler
E—EGR Coolant Return Line
F—EGR Coolant Supply Line to Cooler
G—Coolant Supply Line to Coolant Manifold
H—EGR Cooler to Intake Manifold
I— Cooler Shoulder Bolts

Continued on next page

RE38635,00000A3 -19-27MAR09-3/5

Assemble Turbocharger

IMPORTANT: If turbocharger failed because of foreign material entering the air intake system, be sure to examine the system and clean as required to prevent a repeat failure.

Visually inspect the charge air cooler and piping for residual oil and clean if necessary. Oil may have accumulated from the failed turbo. Failure to clean residual oil from the intake system may result in engine failure.

If not previously done, prime (prelube) turbocharger rotating assembly prior to installing turbocharger on engine. Prelube center housing with clean engine oil through oil return (drain) hole.. Turn rotating assembly by hand to lubricate bearings.

NOTE: Two threaded guide studs may be used to hold turbocharger-to-exhaust manifold gasket in place and aid in turbocharger installation. Place guide pins in threaded manifold mounting holes.

1. Install new gasket (A) over guide pins.
2. Position turbocharger on exhaust manifold over guide pins, with compressor inlet (B) facing front of engine.
3. Apply PT569 NEVER-SEEZ® Compound to all turbocharger mounting cap screws. Install 2 cap screws through exhaust manifold into threaded holes of turbocharger finger tight.
4. Remove guide pins and install remaining 2 cap screws through turbocharger into exhaust manifold finger tight.
5. Tighten 4 cap screws to specification.

Specification

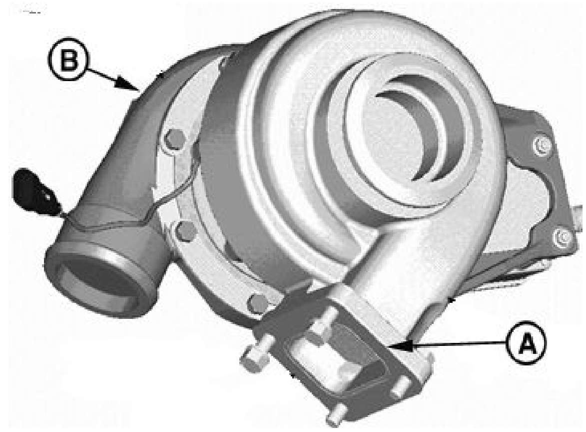
Turbocharger-to-Exhaust Manifold Cap Screws—Torque .... 40 N•m (30 lb-ft)

6. Install turbocharger oil supply line (C) to oil filter base and turbocharger. Tighten securely.
7. Install oil drain line (D) behind exhaust manifold with flange end toward turbocharger.
8. Install 2 serrated cap screws through flange.
9. Install new gasket over cap screws and install flange end of drain line to turbocharger bearing housing. tighten cap screws to specification.

Specification

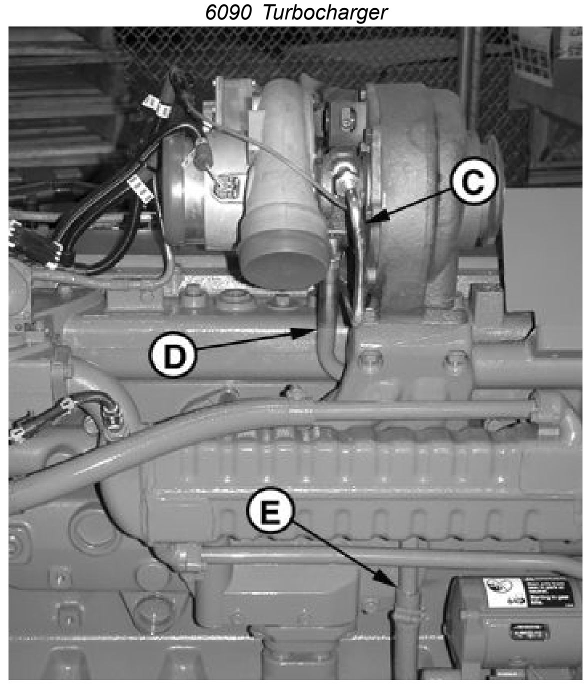
Turbocharger Oil Return Line—Torque .... 35 N•m (25 lb-ft)

10. Apply soap lubricant to inside diameter of turbo drain hose.
11. Install drain hose over end of drain line (E). Position tension clamp over hose and line joint.
12. Connect coolant supply line (G) to turbocharger actuator and tighten securely.



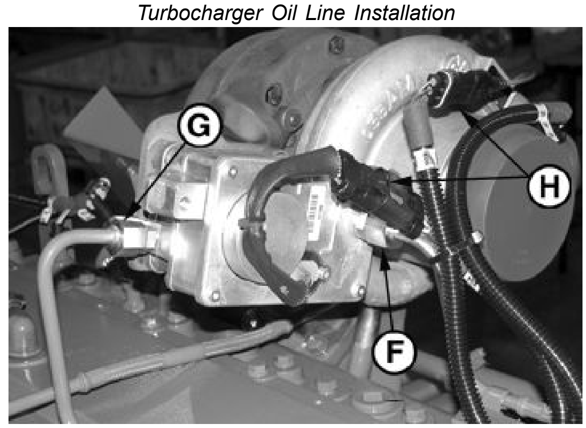
RG13926 —UN—28MAY05

6090 Turbocharger



RG13928 —UN—28MAY05

Turbocharger Oil Line Installation



RG13929 —UN—28MAY05

Turbocharger Actuator Coolant Lines

A—Turbocharger Gasket
B—Turbocharger Compressor Inlet
C—Oil Supply Line
D—Oil Drain Line
E—Oil Drain Line-to-Hose Joint
F—Actuator Coolant Drain Line
G—Actuator Coolant Supply Line
H—Sensor Connections

Continued on next page

RE38635,00000A3 -19-27MAR09-4/5

13. Connect coolant drain line to turbocharger actuator (F) and tighten securely.
14. Connect both sensors to wiring harness (H).
15. Connect air intake and exhaust piping to turbocharger. Tighten all connections securely. (For vehicle engines, refer to machine Technical Manual.)

IMPORTANT: BEFORE STARTING an engine with a new or repaired turbocharger, crank the engine over (but do not start) for several seconds to allow engine oil to reach turbocharger bearings. DO NOT crank engine longer than 30 seconds at a time to avoid damaging starting motor.

16. Start and run engine at low idle while checking oil inlet and air piping connections for leaks.

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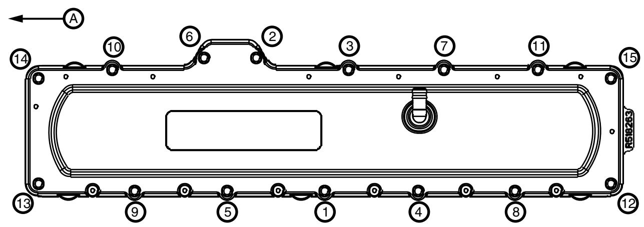
RE38635,00000A3 -19-27MAR09-5/5

Perform Engine Break— In

RG13907 —UN—14JAN05



Rocker Arm Cover Torque Sequence

1. Run engine at slow idle no load for 2 minutes. Check for liquid leaks.
2. Increase RPM to fast idle, then load down to 50 rpm above rated speed for 20 minutes.

NOTE: Dynamometer is the preferred load control, but engine can be loaded by matching drag loads to gear selection.

3. Recheck valve clearance and adjust as necessary. See CHECK VALVE CLEARANCE earlier in this group.

IMPORTANT: Always use a new rocker arm cover gasket when reinstalling cover.

4. Install rocker arm cover gasket and cover. Tighten rocker arm cover cap screws to specifications.

Specification

Rocker Arm
Cover-to-Cylinder Head
Cap Screw—Torque...35 N•m (26 lb-ft)

After 10 minutes re-torque the cap screws in sequence shown to specification.

Specification

Rocker Arm
Cover-to-Cylinder Head
Cap Screw—Torque...35 N•m (26 lb-ft)

Re-torque of cylinder head cap screws after engine break-in is not required.

IMPORTANT: After engine break-in, follow ALL recommended hourly service intervals outlined in your Operator's Manual.

AS58880,00000B6 -19-13APR09-1/1

Preliminary Liner, Piston, and Rod Checks

Scuffed or Scored Pistons:

- Overheating.
- Overfueling.
- Insufficient lubrication.
- Insufficient cooling.
- Improper piston-to-liner clearance.
- Coolant leakage into crankcase.
- Misaligned or bent connecting rod.
- Improperly installed piston.
- Low oil level.
- Improper operation.
- Incorrect connecting rod bearing clearance.
- Carbon build-up in ring groove.
- Improper engine break-in.
- Worn piston.
- Contaminated oil.
- Distorted cylinder liner.
- Plugged piston cooling orifice.
- Ingestion of dust through air intake.

Worn or Broken Compression Rings:

- Insufficient lubrication.
- Insufficient cooling.
- Improper ring installation.
- Improper timing.
- Abrasives in combustion chamber.

Clogged Oil Control Ring:

- Improper oil.
- Excessive blow-by.
- Contaminated oil.
- Improper periodic service.
- Low operating temperature.

Stuck Rings:

- Improper oil classification.
- Improper periodic service.
- Poor operating conditions.
- Coolant leakage into crankcase.
- Excessive cylinder liner taper.

Mottled, Grayish or Pitted Compression Rings:

- Internal coolant leaks.

Dull Satin Finish and Fine Vertical Scratches on Rings:

- Dirt and abrasives in air intake system.

Piston Pin and Snap Ring Failure:

- Misaligned connecting rod.
- Excessive crankshaft end play.
- Incorrect snap rings.

Broken Connecting Rod:

- Inadequate piston-to-liner clearance.
- Worn connecting rod bearing.
- Distorted cylinder line.
- Piston pin failure.

Cylinder Liner Wear and Distortion:

- Incorrectly installed compression rings.
- Insufficient lubrication.
- Uneven cooling around liner.
- Inadequate piston-to-liner clearance.
- Liner bore damage.

Warped Cylinder Block:

- Insufficient cooling.

RG,RG34710,1112 -19-06MAY99-1/1

Remove Pistons and Connecting Rod Assemblies

CAUTION: Do not drain engine coolant until it cools below operating temperature. Then slowly loosen coolant pump cover drain valve (A) and block drain valve (B) to relieve any pressure. Drain coolant and engine oil.

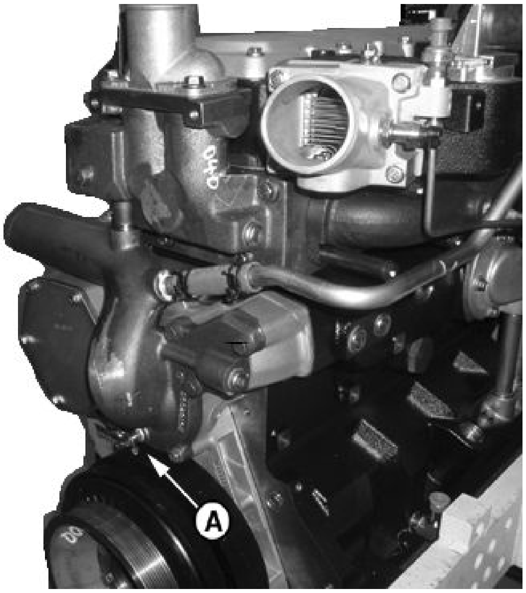
IMPORTANT: Both drain valves must be opened to completely drain engine block.

1. Drain all engine coolant and engine oil.

NOTE: If engine is to be completely disassembled, see ENGINE DISASSEMBLY SEQUENCE in Group 010.

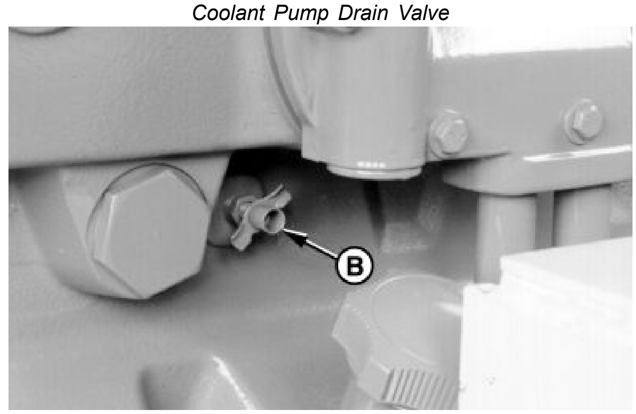
2. Remove cylinder head. See REMOVE CYLINDER HEAD in Group 020.
3. Remove oil pan and oil pump. See REMOVE ENGINE OIL PUMP in Group 060.

A—Coolant Pump Drain Valve B—Cylinder Block Drain Valve



RG14158 —UN—12APR05

Coolant Pump Drain Valve



RG7143 —UN—26NOV97

Cylinder Block Drain Valve

Continued on next page RE38635,000003F -19-11JAN05-1/3

IMPORTANT: Do not rotate crankshaft with cylinder head removed unless liners are bolted down. Bolt liners down before removing piston.

Cap screws and washers must be tightened to the following specifications to achieve an accurate reading when measuring liner standout (height above block). See MEASURE CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK), later in this group.

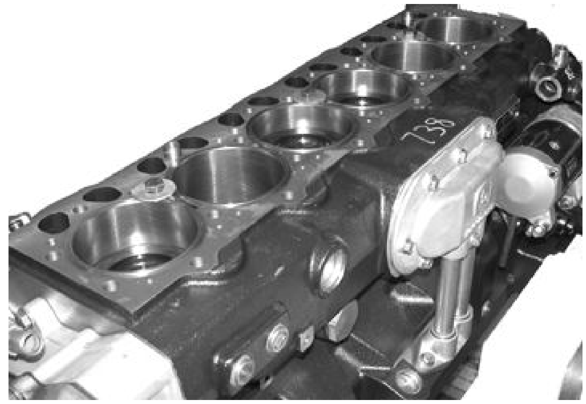
4. Use 9/16-18 cap screws, approximately 51 mm (2.0 in.) long and 5/8 in. I.D. 1-3/4 in. O.D. x 3.18 mm (1/8 in.) thick washers to bolt down cylinder liners in the locations as shown. Tighten cap screws to specifications.

Specification	
Cylinder Liner Cap Screws (For Checking Standout)—Torque	68 N·m (50 lb-ft)

As the cylinder liner wears, a ridge is formed at the top of piston ring travel zone. If this ridge gets too high, pistons and rings can be damaged when they are removed. Remove any ridges from liner bores with a scraper or ridge reamer before removing pistons.

5. Before removing pistons, visually inspect condition of cylinder liners with pistons at bottom dead center "BDC". Liners will require replacement if:

- The crosshatch honing pattern is not visible immediately below the top ring turn around area.
- Liners are pitted or contain deep vertical scratches that can be detected by the fingernail.



RG13983 —UN—19FEB05

Bolt Down Cylinder Liners

No further inspection is required if any one of the above conditions are found.

NOTE: Connecting rod bearing-to-journal oil clearance should be measured before removing piston/rod assembly.

Use PLASTIGAGE® as directed by the manufactured. Remember, the use of PLASTIGAGE® will determine bearing-to-journal oil clearance, but will not indicate the condition of either surface.

6. Rod bearing-to-journal oil clearance can be checked with PLASTIGAGE® if rod is connected to crankshaft. If rod is out of engine, measure I.D. of assembled connecting rod bearings and compare with O.D. of crankshaft journal.

PLASTIGAGE is a registered trademark of DANA Corp.

Continued on next page

RE38635,000003F -19-11JAN05-2/3

IMPORTANT: DO NOT use pneumatic wrenches to tighten or loosen rod cap screws. Using pneumatic wrenches may cause thread damage.

Keep bearing inserts with their respective rods and caps. Mark rods, pistons, and caps to insure correct assembly in same location as removed.

7. Remove rod cap screws and rod caps (A) with bearings (B).

   Crankshaft is shown removed, but piston and rod assembly can be removed with crankshaft installed.

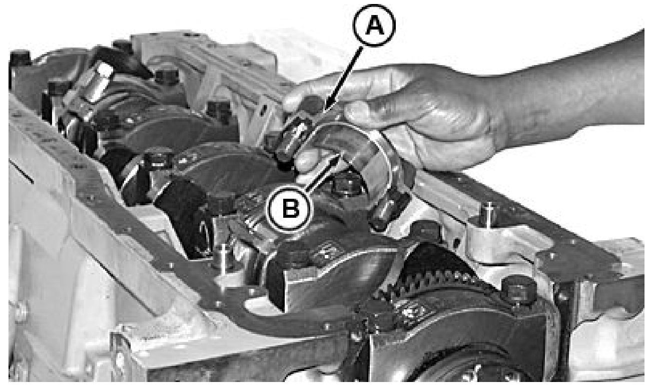
IMPORTANT: Be careful not to let rod nick crankshaft bearing surface as piston and rod assembly is removed.

Be extremely careful to not damage piston spray orifice. 6090 pistons are direct oil cooled, so correct orientation of orifice is critical.

If liners are to be reused, be extremely careful not to let connecting rod hit liner bore when removing piston and rod assembly.

Piston and liners are selectively fitted to maintain piston-to-liners clearance. Always keep matched pistons and liners together as a set and each set MUST BE installed in the same cylinder as removed.

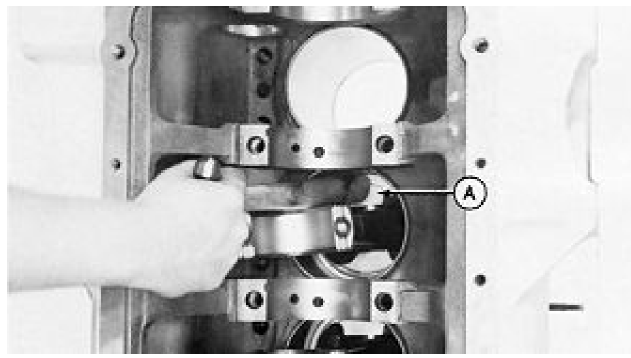
8. Gently tap piston (A) through top of cylinder block from the bottom. Once piston rings have cleared cylinder liner bore, hold on to piston to prevent piston from dropping.



RG10209 —UN—28AUG09

Removing Connecting Rod Caps

A—Rod Caps **B—Bearings**



RG3821 —UN—07DEC88

Removing Pistons

A—Piston

RE38635,000003F -19-11JAN05-3/3

Cylinder Liner — Standout Measurement

IMPORTANT: Remove all old gasket material, rust, carbon, and other foreign material from top deck of block. Gasket surface MUST BE CLEAN. Use compressed air to remove all loose foreign material from cylinder and top deck.

NOTE: Liners having obvious defects must be replaced as a matched piston and liner set.

NOTE: Cap screws should be located at each corner of liner when holding liner in place, especially if top liner packing and O-rings are installed. A total of 14 cap screws and washers are required.

NOTE: Use soft washers so damage to liner flange does not occur when cap screws are tightened.

1. Install bolts with flat washers (45 mm (1.75 inch) OD x 16 mm (.625 inch) ID) to cylinder head mounting bolt holes to secure cylinder liners. Flat washers should be at least 3.18 mm (1/8 in.) thick. Tighten cap screws to specifications.

Specification

Cylinder Liner Cap Screws (For Checking Liner Standout)—Torque...55 N•m (40 lb-ft)

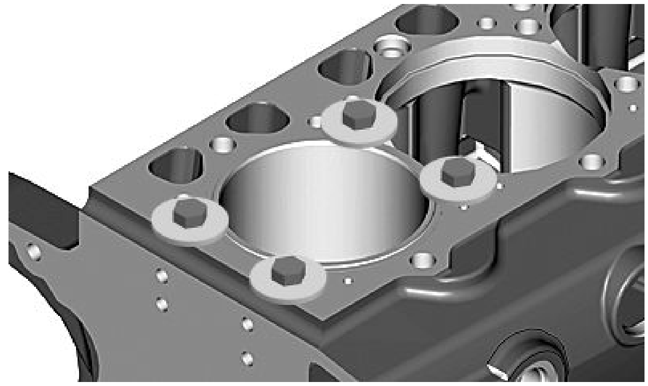
2. Use JDG451 Gauge Block (C) along with D17526CI (English, in.) or D17527CI (Metric, mm) Dial Indicator (B) or KJD10123 Gauge to measure the height (A) of bolted down liners that are not obviously defective before removal from block.

NOTE: Variations in measurement readings may occur within one cylinder and/or between adjacent cylinders.

3. Measure each liner with shims in four places, approximately at 1, 5, 7, and 11 o'clock positions as viewed from the rear of the engine (flywheel end). Record all measurements.
4. The 4 liner height readings should not vary greater than 0.08 mm (0.003 in). If variation exceeds this specification, remove liner and rotate in cylinder block 180°. If variation is still excessive, remove liner and rotate an additional 90°.
5. Remove any liner that does not meet standout specification at any location and measure liner flange thickness, as explained later in this group. Replace piston/liner sets as necessary.

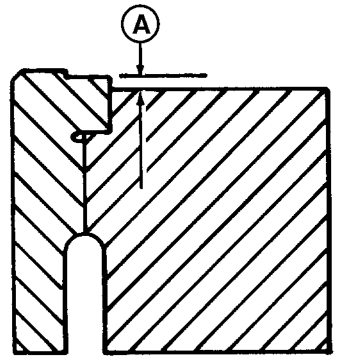
Specification

Cylinder Liners—Standout (Height Above Block)..0.102—0.178 mm (0.004—0.007 in.)



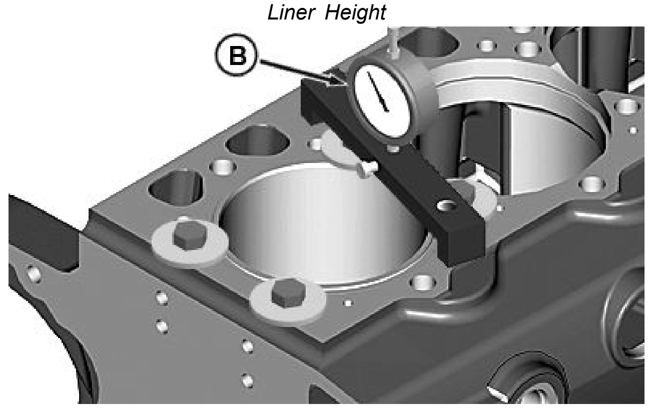
RG16868 —UN—07MAY09

Bolt Down Cylinder Liners



RG6439 —UN—03NOV97

Liner Height



RG16870 —UN—07MAY09

Measure Cylinder Liner Height

A—Liner Height **B—JDG451 Gauge Block**

If liner standout checks low, 0.051 mm, 0.102 mm, and 0.152 mm (.002 in, .004 in, and .006 in.) thick liner shims are available in service parts to increase liner standout back to within specifications. To install shims to liners, follow instructions as follows:

Continued on next page

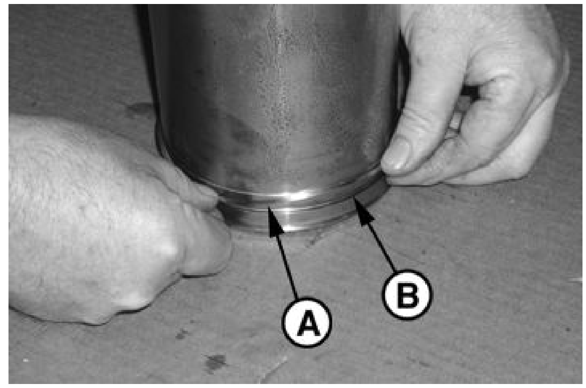
RE38635,000006F -19-12OCT10-1/2

Liner Shim — Installation

1. Turn liner upside down to rest on top of flange.

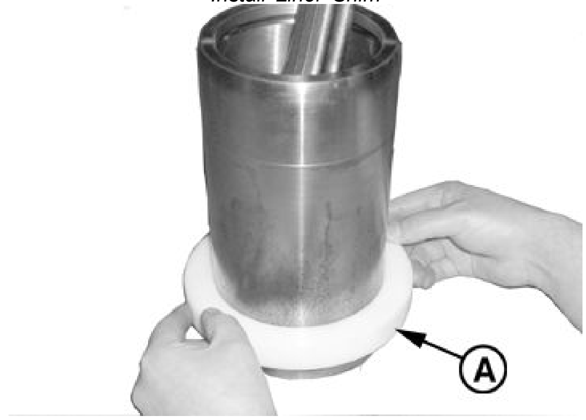
IMPORTANT: Use care when installing shim and so they do not twist or kink. Double check to be sure shim and are positioned squarely to flange.

2. Carefully install liner shim over OD of liner and slide past the packing step to liner body.
3. Use JDG10998 Shim Installation tool to help guide shim over liner until seated to underside of liner flange. Remove tool and set aside.
4. Repeat steps to check liner standout to verify it is within specification.



RG15895 —UN—19MAY09

Install Liner Shim



RG15908 —UN—19MAY09

JDG10998 Shim Installation Tool

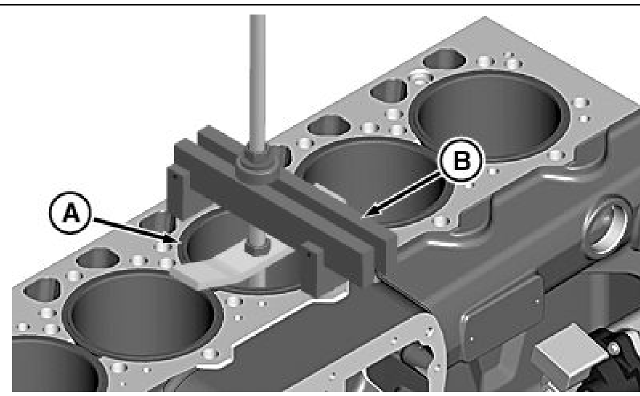
RE38635,000006F -19-12OCT10-2/2

Remove Cylinder Liners

1. Remove cap screws and washers securing liners to cylinder block.
2. Number cylinder liners and mark fronts to assure correct assembly.

A—Cylinder Liner

B—D01962A Cylinder Liner Puller



RG16871 —UN—23MAR09

Remove Cylinder Liner

Continued on next page

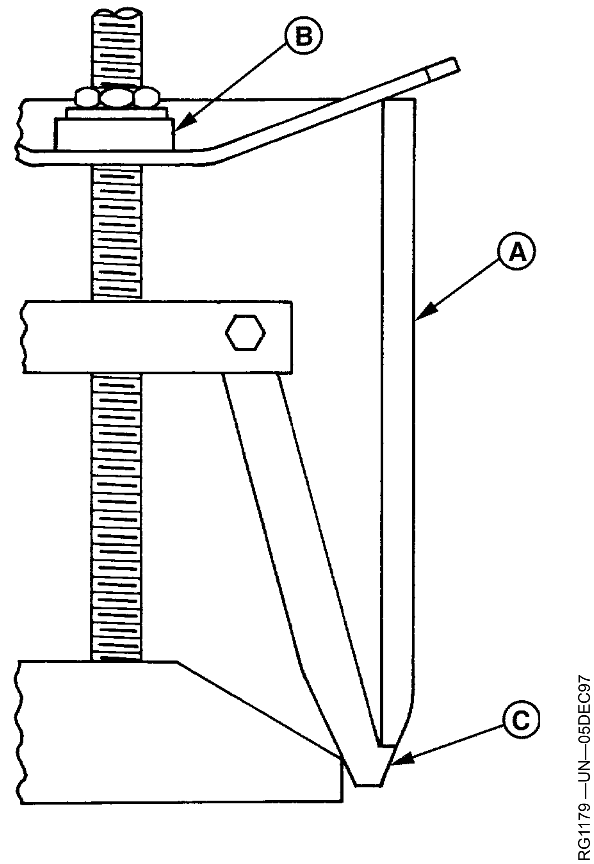
RE38635,00000B1 -19-15MAR11-1/3

IMPORTANT: Keep matched pistons and liners together. Liners must be reinstalled in same cylinder bore.

3. Use D1062AA or D01073AA Cylinder Liner Puller (B) to remove cylinder liner (A).

IMPORTANT: When using D01062AA (or D01073AA) Cylinder Liner Puller (B) to remove liners (A), be sure jaw (C) of puller is correctly positioned before attempting to remove liner.

DO NOT over tighten liner puller to remove liners. Doing so could easily break liners.

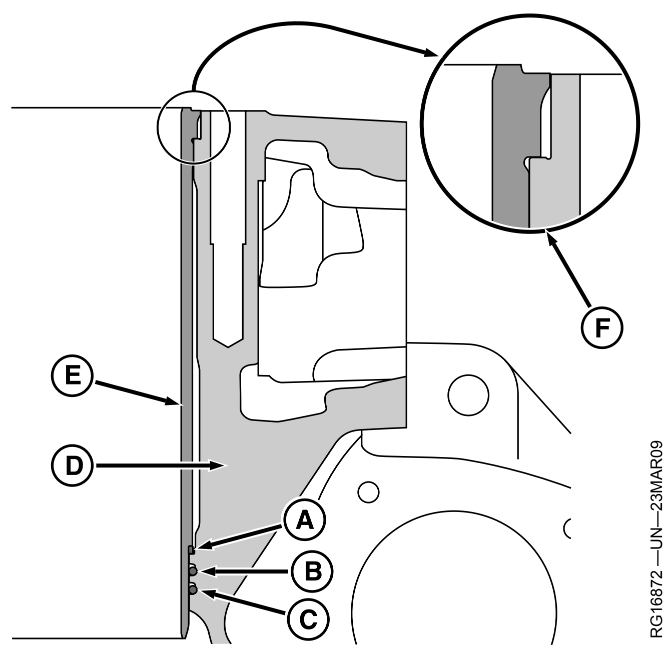


D01062AA or D017073AA Cylinder Liner Puller

RE38635,00000B1 -19-15MAR11-2/3

4. Remove the cylinder liner square packing (A) from liner (E).
5. Remove orange O-ring (B) and white O-ring (C) from cylinder block (D).

A—Square Packing (Neoprene)
B—Orange O-Ring (Silicone)
C—White O-Ring (Viton)
D—Cylinder Block
E—Cylinder Liner
F—Coolant Passage — Liner to Block



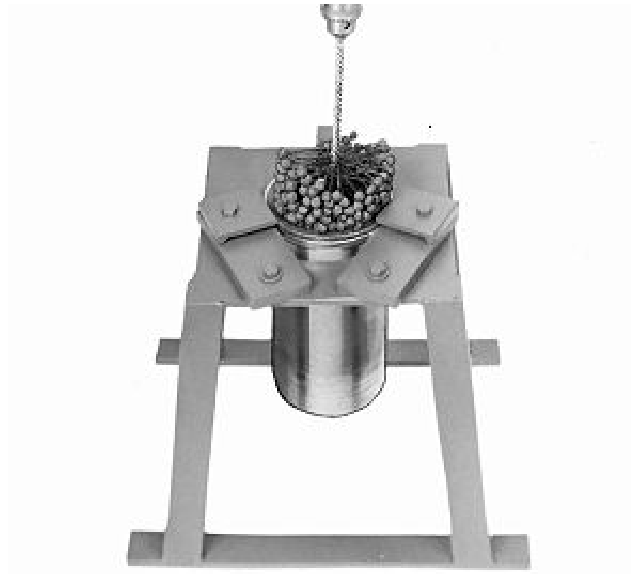
Cylinder Liner to Block Assembly

RE38635,00000B1 -19-15MAR11-3/3

Deglaze Cylinder Liners

1. Secure cylinder liner in a holding fixture. See DFRG3—CYLINDER LINER HOLDING FIXTURE, Group 190, for assembly of holding fixture.
2. Use D17005BR Flexible Cylinder Hone to deglaze cylinder liner.

NOTE: Use honing oil along with flex hone when deglazing liners.



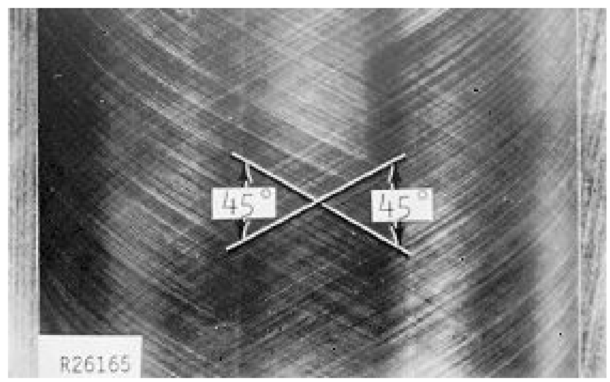
R26164 —UN—13DEC88

Deglazing Cylinder Liners

RG,RG34710,1116 -19-11MAY99-1/2

3. Use D17006BR Hone according to instructions supplied with tool to obtain a 45 ° cross-hatch pattern.

   Thoroughly clean liners after deglazing. See CLEAN CYLINDER LINERS, later in this group.



R26165 —UN—13DEC88

Honing Pattern on Cylinder Liners

RG,RG34710,1116 -19-11MAY99-2/2

Cylinder Liner — Cleaning

1. Use a stiff bristle brush to remove all debris, rust, and scale from O.D. of liners, under liner flange, and in O-ring packing areas. Make certain there are no nicks or burrs in areas where packings will seat.

IMPORTANT: Do not use gasoline, kerosene, or commercial solvent to clean liners. Solvents will not remove all the abrasives from liner walls.

2. Thoroughly clean liner I.D. with a 50 percent solution of hot water and liquid detergent.
3. Rinse thoroughly and wipe dry with a clean rag.
4. Swab out liner as many times as necessary with clean SAE 10W oil.
5. Clean liner until a white rag shows no discoloration.

RG,RG34710,1117 -19-04MAR10-1/1

Piston and Connection Rod Assembly — Tear Down

1. Remove piston snap rings (A). Remove piston pin (B) and connecting rod from piston.

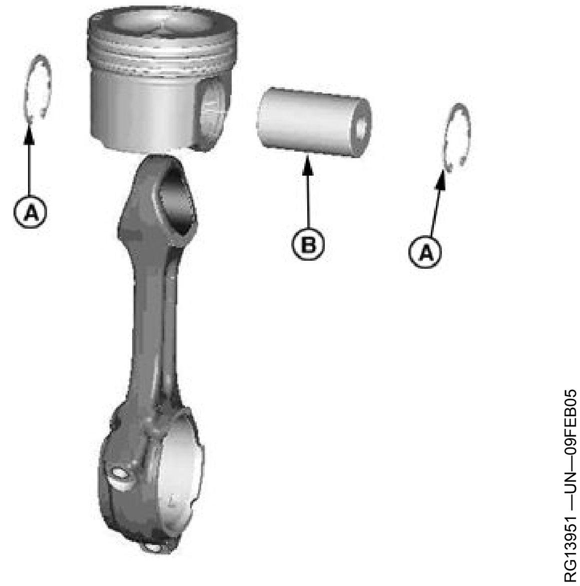
NOTE: Discard snap rings, DO NOT reuse.

If checking rings to determine cause of engine trouble, ring gap should be as follows:

Specification

No. 1 Piston Compression Ring—End Gap....0.35—0.55 mm (0.014—0.021 in.)
No. 2 Piston Compression Ring—End Gap....0.73—0.99 mm (0.030—0.039 in.)

A—Snap Rings **B—Piston Pin**

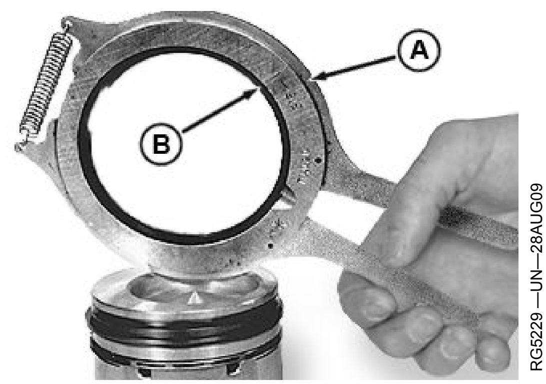


Disassemble Piston and Rod

RE38635,0000056 -19-09FEB05-1/2

2. Remove piston rings (B) using the JDE93 Piston Ring Expander (A). Discard all rings.

A—Piston Ring Expander **B—Piston Ring**



Removing Piston Rings

RE38635,0000056 -19-09FEB05-2/2

Clean Pistons

CAUTION: Always follow manufacturer's instructions, and safety steps exactly.

1. Clean piston ring grooves using a piston ring groove cleaning tool.

IMPORTANT: When washing pistons, always use a stiff bristle brush—NOT A WIRE BRUSH—to loosen carbon residue.

DO NOT bead blast ring groove areas.

2. Clean pistons by any of the following methods:

- Immersion-Solvent “D-Part”.
- Hydra-Jet Rinse Gun.
- Hot water with liquid detergent soap.

If cleaning with hot water and liquid detergent, soak pistons in a 50 percent solution of liquid household detergent and hot water for 30 to 60 minutes. Use a stiff bristle brush—NOT A WIRE BRUSH—to loosen carbon residue. Dry with compressed air.

RE38635,0000075 -19-19SEP05-1/1

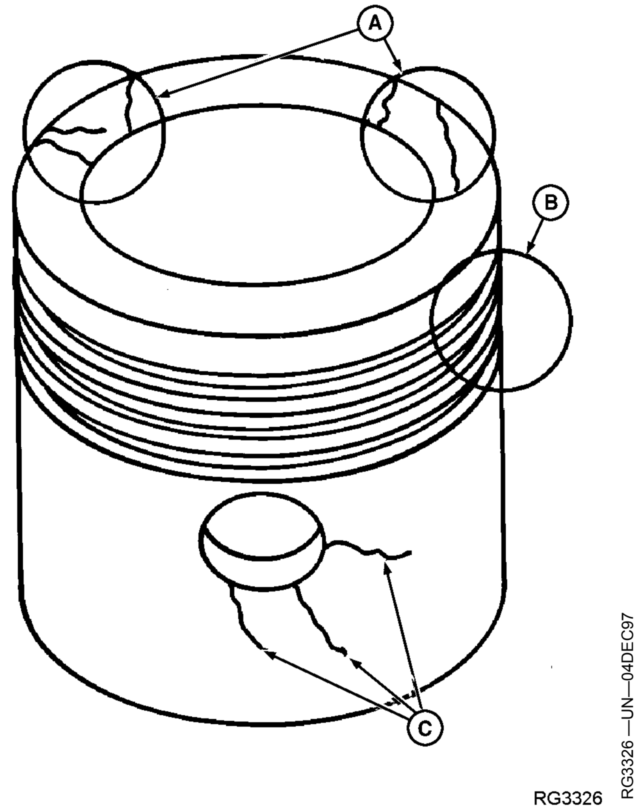
Visually Inspect Pistons

Carefully inspect pistons under magnification. Check for:

- Signs of fatigue
- Fine cracks in the piston head (A)
- Bent or broken ring lands (B)
- Cracks in the skirt (C) at inner and outer ends of piston pin bore
- Excessive piston skirt wear. (Original machining marks must be visible.)

If any imperfections are found, replace the piston.

A—Piston Head
B—Ring Lands
C—Skirt



Piston Defects (Exaggerated)

RG,RG34710,1120 -19-09JAN07-1/1

Inspect Piston Pin and Bore

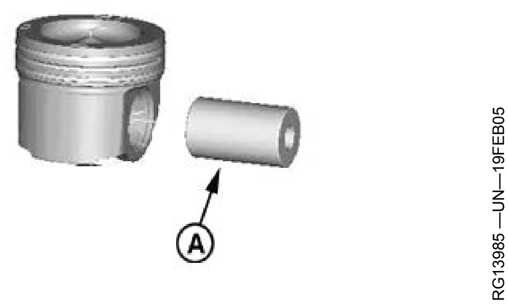
NOTE: Piston pin must be in good condition and not worn beyond specification given below.

1. Dip piston in clean engine oil.
2. Install pin (A) through piston.

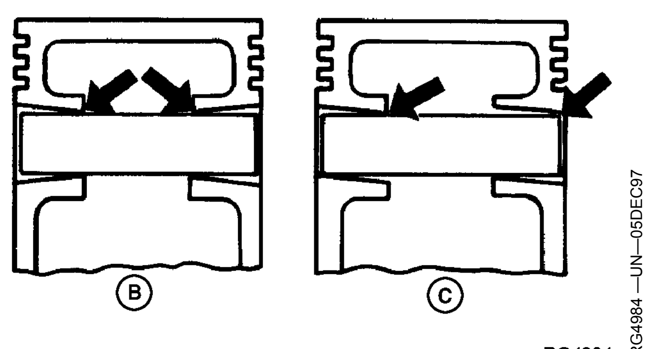
   Pin should pass through piston using only light thumb pressure.
3. Check taper in piston pin bore by inserting pin from both sides. If pin enters freely, but binds in the center, the bore could be tapered (B).
4. Insert pin in piston to check for bore alignment. Pin should not “click” or need to be forced into bore on opposite side (C).
5. Measure piston pin and piston bore specifications. If either are not within specification, replace pin, piston, and liner.

Specification	
Piston Pin—OD	47.602—47.608 mm (1.8741—1.8743 in.)
Piston Pin Bore—ID	47.655—47.675 mm (1.8762—1.8770 in.)

A—Piston Pin
B—Tapered Bore
C—Bore Out-of-Alingment



Check Piston Pin to Piston



Inspecting for Piston Pin Bore Wear

RE38635,0000041 -19-11JAN05-1/1

Visually Inspect Cylinder Liners

IMPORTANT: If liner pitting has occurred, check condition of coolant.

1. Inspect exterior length of liner for pitting (A). Check packing step for erosion (B). If pitting or erosion is observed, measure depth of pits with a fine wire or needle. Replace piston and liner if:
   - Depth of any pit is one-half or more of liner thickness (C).
   - Depth of erosion is one-half or more of the packing step (D).

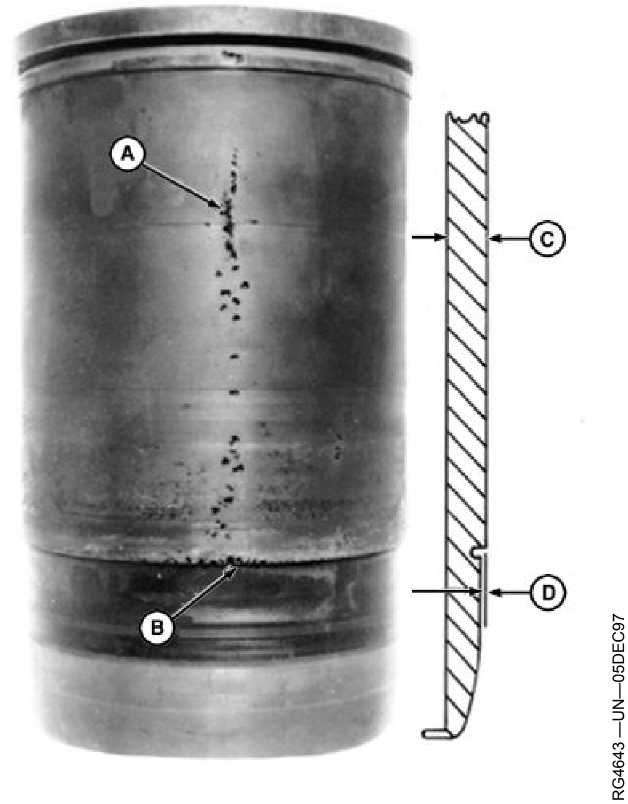
Specification

Cylinder Liner—Thickness .... 4.765—4.925 mm (0.188—0.194 in.)

Packing Step Dimension .... 1.45—1.55 mm (0.057—0.061 in.)

NOTE: Liners are reusable if the depth of pits or erosion is less than one-half the amount specified. When installing reusable liners, rotate 90° from original position. The liners should be also deglazed and new ring sets installed in pistons.

A—Liner Pitting
B—Liner Erosion
C—Liner Thickness
D—Packing Step



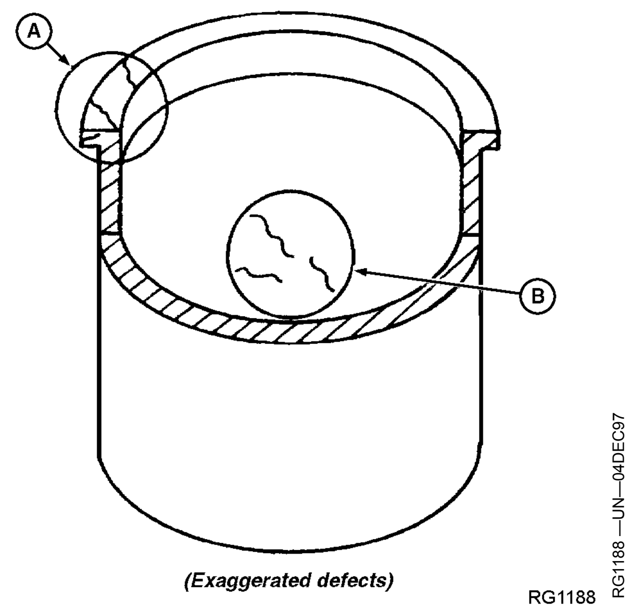
Inspecting Cylinder Liners

RE38635,0000042 -19-11JAN05-1/2

2. Visually examine liner I.D. Replace piston and liner if:
   - The crosshatch honing pattern is not visible immediately below the top ring turn-around area.
   - Liners are pitted or contain deep vertical scratches that can be detected by the fingernail.
3. Carefully examine liner for signs of fatigue, such as fine cracks in the flange area (A) and cracks in the ring travel area (B).

NOTE: Inspect block for cracks or erosion in the O-ring packing areas. See INSPECT AND CLEAN CYLINDER BLOCK later in this group.

A—Flange Area
B—Ring Travel Area



Cylinder Liner Defects (Exaggerated)

RE38635,0000042 -19-11JAN05-2/2

Cylinder Liner Manufacturing Date Code Explanation

A manufacturing date code will appear on the top flange of each liner, as shown. For example, 0424A means the liner was manufactured on the first shift on February 11, 2004.

0424A

First three digits “042” .... Numerical Day of Year (Feb 11 is the 42nd day of the year)

Fourth digit “4” .... Last Digit of Current Year

Fifth Digit “A” .... Production Shift of Manufacture (“A” = first, “B” = second, “C” = third.

Cylinder Liner Date Code

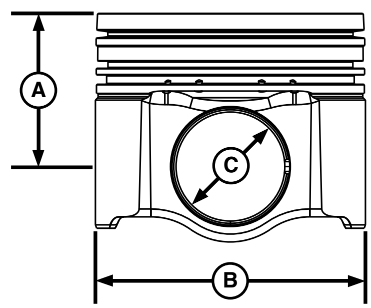
RE38635,0000043 -19-04MAR10-1/1

Piston to Liner — Clearance Check

1. Measure piston skirt diameter (B) at right angles to piston pin bore (C), 66 mm (2.60 in.) from the crown of the piston (A).
2. Record measurement and compare measurement obtained from matching liner.

Specification

Piston Skirt—OD 66 mm (2.60 in.) from Top (crown) of Piston................ 118.320—118.350 mm (4.6582—4.6594 in.)



Piston Skirt Diameter

A—Measuring Point - 66 mm from Crown
B—Piston Skirt Diameter
C—Piston Pin Bore

Continued on next page

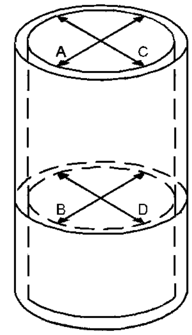
RE38635,0000044 -19-14JAN05-1/2

IMPORTANT: ALWAYS measure liners at room temperature.

3. Measure liner bore parallel to piston pin at top end of ring travel (A).
4. Measure bore in same position at bottom end of ring travel (B).
5. Measure bore at right angle to piston pin at top end of ring travel (C).
6. Measure bore in same position at bottom end of ring travel (D).
7. Compare measurements A, B, C, and D to determine if liner is tapered or out-of-round.
8. Compare liner I.D. with matched piston O.D.

Specification

Cylinder Liner—ID............. 118.390—118.410 mm (4.6610—4.6618 in.)
OD (Coolant Jacket Area)..127.94—128.24 mm (5.037—5.049 in.)
OD (At Upper Bore)..................129.08—129.14 mm (5.082—5.084 in.)
OD (At Lower Bore)..............125.044—125.120 mm (4.923—4.926 in.)
ID of Upper Bore in Block for Seating Liners ....129.155—129.205 mm (5.085—5.087 in.)
ID of Lower Bore in Block for Seating Liners ....125.133—125.183 mm (4.9265—4.9285 in.)
Liner-to-Block Clearance at Upper Bore ....0.026—0.126 mm (0.001—0.005 in.)
Liner-to-Block Clearance at Lower Bore ....0.012—0.140 mm (0.0005—0.0055 in.)
Maximum Out-of-Round ....0.051 mm (0.0020 in.)
Maximum Wear or Taper in Ring Travel Area.............................0.051 mm (0.0020 in.) maximum



RG10049 —UN—07JAN03

Measure Liner

Piston-to-Liner—New Part Clearance (At Bottom of Skirt)..........................0.040—0.090 mm (0.0015—0.0035 in.)
Maximum Clearance..0.152 mm (0.0060 in.)

Replace piston and liners (as a set) if they exceed wear specifications given.

RE38635,0000044 -19-14JAN05-2/2

Inspect Rod and Cap

1. Inspect rod and cap for wear or damage, such as chips or nicks in the joint areas.

IMPORTANT: Do not nick the joint surfaces of rod and cap. This is very critical on Precision Joint™ rods to assure proper seating. Never scrape joint surfaces (C) with a wire brush or other tool; the interlocking mating surfaces must be preserved.

2. Inspect in and around cap screw holes (B) in cap. If any defects are found, replace rod and cap.
3. Carefully clamp rod in a soft-jawed vise (cap end upward).
4. Install cap WITHOUT bearing.

IMPORTANT: Never use new connecting rod cap screws when checking rod bore I.D. Use new cap screws only for final assembly of connecting rods.

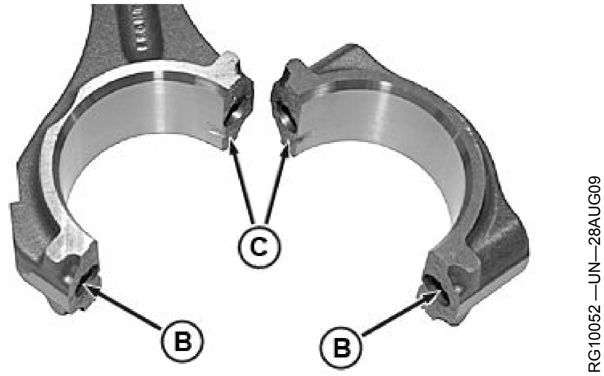
5. **On** Precision Joint™ **connecting rods**: Initially tighten rod cap screw closest to piston end, then tighten other cap screw to the following specifications.

Specification

Precision Joint™ Connecting Rod Cap Screw—Torque................. 95 N·m (71 lb-ft) plus 90–100° turn clockwise

See TORQUE-TURN CONNECTING ROD CAP SCREWS, described later in this group.

Precision Joint is a trademark of Deere & Company



Precision Joint™ Rod and Cap

Clamping Rod in Vise

B—Cap Screw Holes
C—Precision Joint™ Mating Surfaces

RE38635,0000078 -19-13SEP07-1/3

6. Using an inside micrometer, measure rod bore at center of bore and record measurements as follows:
   - At right angle to rod/cap joint (A).
   - At 45° left of measurement step "A" (B).
   - At 45° right of measurement step "A" (C).

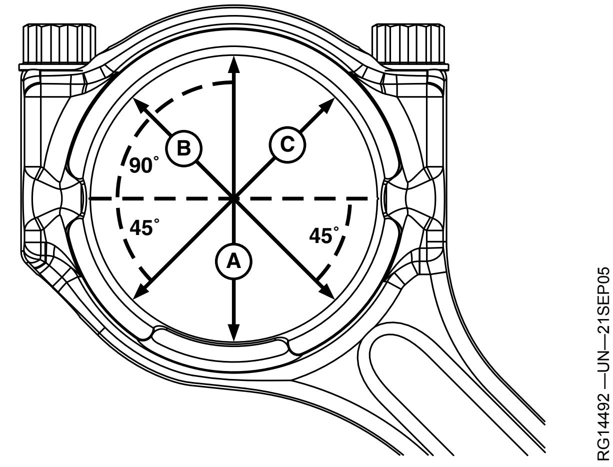
Specification

Connecting Rod Bore (Without Bearings)—ID.............87.487—87.513 mm (3.444—3.445 in.)

7. Compare the measurements. If difference between the greatest and least measurement is more than 0.04 mm (0.0016 in.), the rod and cap are out-of-round. Replace both connecting rod and cap.

Specification

Connecting Rod Bore—Maximum Out-of-Round.. 0.025 mm (0.0010 in.)



Measuring Connecting Rod Pin Bore

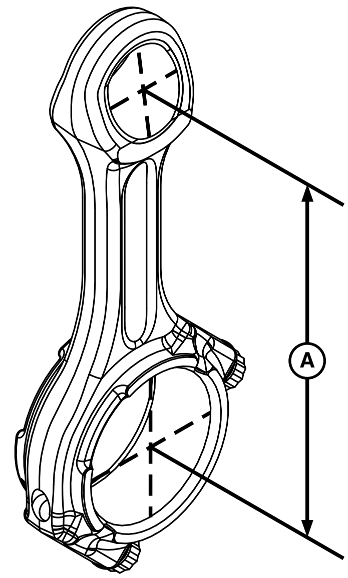
Continued on next page

RE38635,0000078 -19-13SEP07-2/3

8. Measure rod's piston pin bore-to-crankshaft bore center-to-center dimension (A) and compare with specification given. If measurement is not within specification, replace rod.

Specification

Centerline of Piston Pin Bore-to-Crankshaft Bore—Dimension.......................217.95—218.05 mm (8.581—8.585 in.)



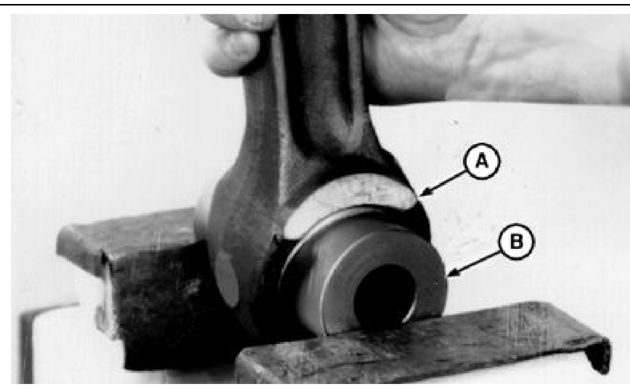
Measuring Connecting Rod Pin Bore-Crankshaft Bore

RE38635,0000078 -19-13SEP07-3/3

Piston Pin and Bushing — Inspection

1. Insert piston pin (B) through piston pin bushing and carefully clamp in a soft-jawed vise.
2. Rotate connecting rod (A) back and forth several times to make sure connecting rod moves freely on piston pin.
3. Remove piston pin from connecting rod.

A—Connecting Rod **B—Piston Pin**



Checking Piston Pin and Rod

Continued on next page RE38635,0000048 -19-14JAN05-1/2

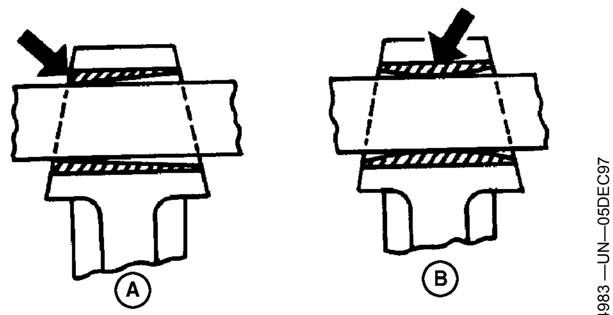
4. Insert pin from either side of rod bushing. If pin is free on one end, but tight on the other, the bore could be tapered (A). If pin enters freely from both sides, but is tight in the center, bore is bell-mouthed (B).

5. Measure I.D. of rod pin bushing and O.D. of piston pin. Compare measurements with specifications given below:

Specification

Piston Pin—OD	47.602—47.608 mm (1.8741—1.8743 in.)
Piston Pin Bore in Piston—ID	52.210—52.470 mm (2.0555—2.0657 in.)
Installed Connecting Rod Pin Bushing (After Boring)—ID	47.655—47.675 mm (1.8762—1.8770 in.)
Connecting Rod Pin-to-Bushing—Oil Clearance	0.047—0.079 mm (0.0019—0.0031 in.)
Wear Limit	0.102 mm (0.0040 in.)

6. If necessary, remove and replace piston pin bushing. See REMOVE PISTON PIN BUSHING, CLEAN AND INSPECT PIN BORE, later in this group.



Inspecting Piston Pin Bores

A—Tapered Bore **B—Bell-Mouthed Bore**

RE38635,0000048 -19-14JAN05-2/2

Piston Pin Bushing and Pin Bore — Removal

1. If necessary, remove pin bushing with the JDG337 and JDE98A Connecting Rod Bushing Service Sets.

   Use the following tools from the service sets:

   - JDG339 Cup (A)
   - JDG338 Adapter (B)
   - JDE98-4 Driver (C)
   - STD36104 Forcing Screw with Washer (D)

IMPORTANT: Use care to properly align the JDE98-4 Driver with bushing so that the connecting rod bushing bore is not damaged.

2. Clean rod bushing bore using a medium grit emery cloth, as burrs will distort bushing. Install bushing on opposite side of rod burr.
3. Measure rod bushing bore in three places approximately 45° apart. Compare the measurements with the specifications given below:

Specification

Connecting Rod Pin Bore—Diameter without Bushing.................................52.354—52.380 mm (2.0612—2.0622 in.)
Connecting Rod Pin Bore-to-Bushing—Press Fit...0.084—0.147 mm (0.0033—0.0058 in.)
Installed Service Connecting Rod Pin Bushing (Before Boring)—ID............................47.580—47.632 mm (1.8732—1.8753 in.)
Installed Service Connecting Rod Pin Bushing (After Boring)—ID............................47.655—47.681 mm (1.8762—1.8772 in.)

Removing Piston Pin Bushing from Rod

A—JDG339 Cup
B—JDG338 Adapter
C—JDE98-4 Driver
D—STD36104 Forcing Screw With Washer

IMPORTANT: If piston pin bushing bore diameter in rod is not within specification or bushing has spun in rod, discard rod and replace with a new one.

RE38635,0000049 -19-14JAN05-1/1

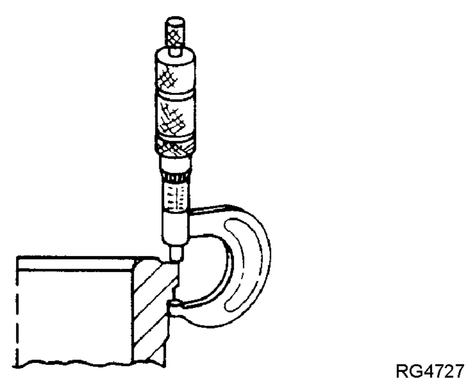
Measure Liner Flange

Measure cylinder liner flange thickness at several locations and compare with specification given below.

If liner flange is not within specification, either use liner shims as needed or replace piston and liner as a set if shims don't bring liner standout within specification. See RECHECK CYLINDER LINER STANDOUT and see INSTALL LINER SHIMS—IF REQUIRED, later in this group.)

Specification

Cylinder Liner Flange—Thickness.................... 11.989—12.039 mm (0.472—0.474 in.)
OD .... 135.10—135.16 mm (5.319—5.321 in.)



Measuring Liner Flange

RG,RG34710,1126 -19-02SEP08-1/1

Inspect and Measure Connecting Rod Bearings

Inspect connecting rod bearings for wear or damage.

IMPORTANT: Never use new connecting rod cap screws when checking rod bearing I.D. Use new cap screws only for final assembly of connecting rods.

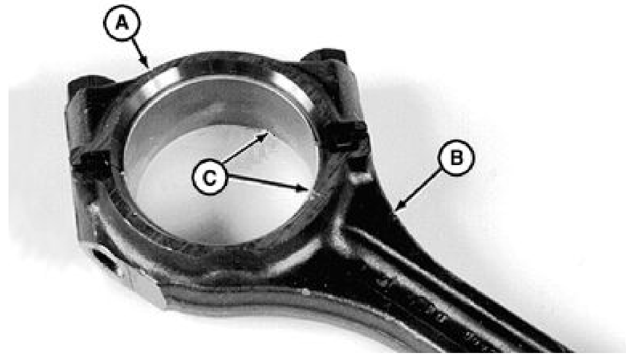
Rod bearing-to-journal oil clearance can be checked with PLASTIGAGE®, if rod is connected to crankshaft. If rod is out of engine, measure I.D. of connecting rod bearings and compare with O.D. of crankshaft journal.

1. With crankshaft removed, measure connecting rod journal O.D. at several points.
2. Carefully clamp rod in a soft-jawed vise and install connecting rod cap (A) on rod (B) with bearings (C) in correct position.
3. **On** Precision Joint™ **connecting rods**: Initially tighten rod cap screw closest to piston end, then tighten other cap screw to the following specifications.

Specification

Precision Joint™ Connecting Rod Cap Screw—Torque................. 95 N·m (71 lb-ft) plus 90–100° turn clockwise

PLASTIGAGE is a registered trademark of DANA Corp.
Precision Joint is a trademark of Deere & Company



RG7046 —UN—05DEC97

Connecting Rod Bearings

A—Rod Cap
B—Rod
C—Bearings

See TORQUE-TURN CONNECTING ROD CAP SCREWS, described later in this group.

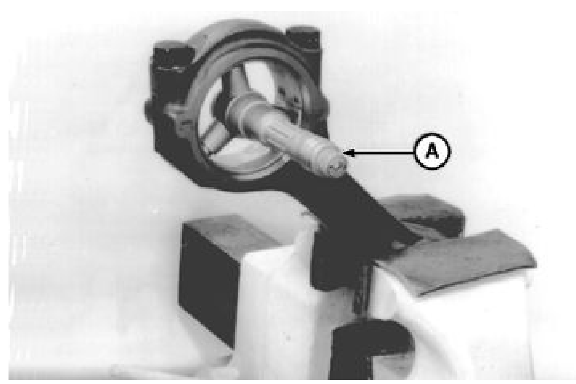
RE38635,000004A -19-08JUL09-1/2

4. Using an inside micrometer (A) measure I.D. of bearing.
5. Subtract O.D. of crankshaft journals from I.D. of rod bearings to obtain oil clearance.
6. Compare measurements with the following specifications.

Specification

Crankshaft Rod Journal—OD.......................... 83.482—83.508 mm (3.2867—3.2878 in.)
Assembled Connecting Rod Bearing—ID................... 83.537—83.589 mm (3.2889—3.2909 in.)
Connecting Rod Bearing-to-Journal (New Parts)—Oil Clearance................. 0.0254—0.102 mm (0.001—0.004 in.)

7. If bearings are worn or not within specification, replace connecting rod bearings.



RG3824 —UN—04DEC97

Measuring Connecting Rod Bearings

A—Inside Micrometer

RE38635,000004A -19-08JUL09-2/2

Piston Pin Bushing — Installation

IMPORTANT: Always push new bushing into rod from back side and burnish bushing after installation for proper form and seating in rod bore.

1. Lubricate rod bushing bore and bushing with clean engine oil. Install bushing using the JDG337 and JDE98A Connecting Rod Bushing Service Sets.

   Use the following tools from the above sets and assemble in sequence as shown:

   - STD36104 Forcing Screw With Washer (A)
   - JDE98A Drive (B)
   - JDG338 Adapter (C)
   - Service Bushing (D)
   - JDE98-3 Pilot (E)
   - JDE339 Cup (F)

IMPORTANT: Boring of the rod bushing should be done ONLY by experienced personnel on equipment capable of maintaining bushing specification.

2. After installation, bore I.D. of newly installed bushing to the following specifications.

Specification	
Connecting Rod Pin Bushing (After Boring)—ID	47.655—47.681 mm (1.8762—1.8772 in.)

   Remove all residue from boring operation.

3. Check rod pin-to-bushing clearance. See INSPECT PISTON PINS AND BUSHINGS, earlier in this group.

Installing Piston Pin Bushing in Rod

A—STD36104 Forcing Screw With Washer
B—JDE98A Driver
C—JDG338 Adapter
D—Service Bushing
E—JDE98-3 Pilot
F—JDE339 Cup

4. Replace rod pin as required.

RG,RG34710,1131 -19-23OCT97-1/1

Complete Disassembly of Cylinder Block (If Required)

If complete inspection and "Hot Tank" cleaning of cylinder block is required, refer to the appropriate group for removal of all external and internal mounted components listed below:

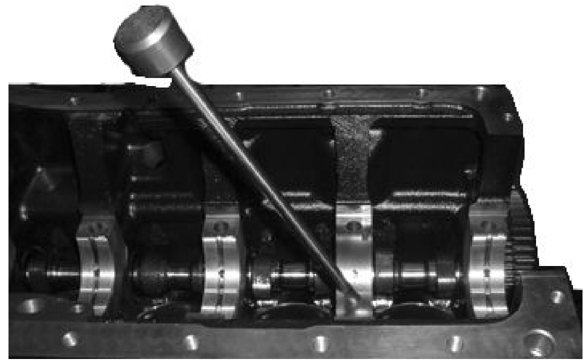
1. Remove crankshaft and pulley if not previously removed. (Group 040.)
2. Remove all remaining lubrication system components. (Group 060.)
3. Remove coolant pump and all remaining cooling system components (Group 070.)
4. Remove timing gear train and camshaft. (Group 050.)
5. Remove fuel injection pump and fuel filter assembly. (Group 090.)
6. If necessary to "Hot Tank" the block, remove oil gallery plugs, coolant gallery plugs, piston cooling orifices and the engine serial number plate.

RG,RG34710,1132 -19-23OCT97-1/1

Piston Cooling Orifices — Removal

1. Using a suitable driver, remove all six piston cooling orifices, as shown, and inspect each cooling orifice to make sure it is not plugged or damaged.
2. Use a soft wire and compressed air to clean orifice. Replace if condition is questionable.

IMPORTANT: A piston cooling orifice failure could cause damage to pistons, piston pins, rod pin bushings, and liners. If a piston cooling orifice is left out, low or no oil pressure will result.


RG13986 —UN—19FEB05

Remove Piston Spray Orifice

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Inspect and Clean Cylinder Block

NOTE: All components (including piston cooling orifices), coolant gallery plugs and oil gallery plugs must be removed from the cylinder block for inspection and cleaning. Refer to the proper group for removal of all external and internal mounted components.

1. Use D17015BR O-ring Bore Cleaning Brush or an equivalent brush to thoroughly clean all debris from cylinder liner O-ring bores.
2. Remove cylinder head locating dowels, if not previously removed. Clean out all threaded holes for cylinder head mounting cap screws in top deck of cylinder block. Use JDG681 Tap or an equivalent 9/16-12 UNC-2A tap approximately 88.9 mm (3.5 in.) long. Use compressed air to remove any debris or fluid which may be present in the cap screw hole.

IMPORTANT: If cylinder block is cleaned in a hot tank, be sure to remove any aluminum parts. Aluminum parts can be damaged or destroyed by hot tank solutions. Remove all serial number plates.


RG5796 —UN—05DEC97

Tap for Head Mounting Holes in Block

Continued on next page

RG,RG34710,1134 -19-23OCT97-1/2

3. Clean block thoroughly using cleaning solvent, pressure steam, or a hot tank.
4. Inspect liner support flange (C) for burrs. If burrs are present, use a small half-moon file and LIGHTLY file (in a circular motion) burr off at approximately a 60° angle. DO NOT let file hit top deck of cylinder block (B) while filing.

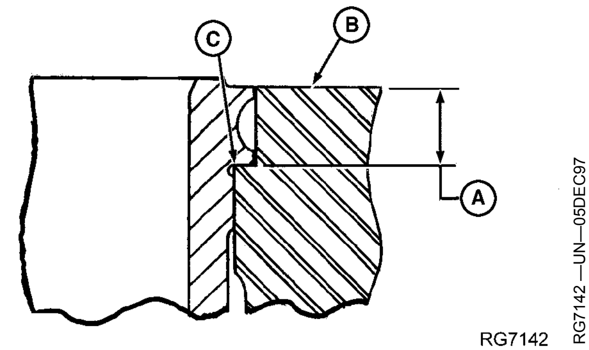
NOTE: DO NOT file liner support flange excessively. Excess filing can damage liner support flange and allow an improper liner fit. Thoroughly clean all filings from cylinder block.

5. Measure liner flange counterbore depth (A) in block and compare with specification given below.

Specification

Cylinder Block Flange
Counterbore—Depth................. 11.913—11.963 mm (0.469—0.471 in.)

Carefully inspect block for cracks or any other physical damage. If a cracked block is suspected, pressure-test the block. A procedure for pressure testing is outlined in FOS (Fundamentals of Service) Manual-ENGINES. Replace block if there is evidence of a crack or physical damage.



Measuring Liner Flange Counterbore Depth in Block

A—Liner Flange Counterbore Depth
B—Top Deck Of Cylinder Block
C—Liner Support Flange

RG,RG34710,1134 -19-23OCT97-2/2

Measure Cylinder Block

Refer to the appropriate groups for a more detailed description of the features being measured. Compare measurements with specifications given below.

1. Assemble and measure main and thrust bearing bores. Compare measurements with specifications given below:

Specification

Crankshaft Main Bearing—Bore ID without Bearing	101.651—101.67 mm (4.0020—4.0030 in.)
Surface Width	36.28—36.78 mm (1.428—1.448 in.)
Crankshaft Thrust Bearing—Bore ID without Bearing	101.651—101.67 mm (4.0020—4.0030 in.)
Surface Width (No. 5 Main)	37.44—37.54 mm (1.474—1.478 in.)
Overall Cap Width	41.81—42.31 mm (1.646—1.666 in.)

If any main or thrust bearing cap assembled I.D. is not within specification, blank (generic) bearing caps are available and must be line bored to specification by a qualified machine shop. See MAIN BEARING CAP LINE BORE SPECIFICATIONS in Group 040.

2. Measure camshaft follower bore diameter at all bore locations.

Specification

Camshaft Follower—Bore ID in Block	28.550—28.600 mm (1.124—1.126 in.)
Follower OD (New)	28.495—28.521 mm (1.1219—1.1229 in.)
Follower-to-Bore Clearance	0.029—0.105 mm (0.0011—.004 in.)

If any one camshaft follower bore is not within specification, install a new cylinder block.

3. Measure camshaft bore diameter at all locations and record readings. Compare measurements with specifications given in chart below:

Specification

Camshaft	
Bushing—Installed ID	67.076—67.102 mm (2.6408—2.6418 in.)
Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
Minimum Runout of Bore in Block	0.038 mm (0.0015 in.)
Bushing-to-Journal Clearance	0.0063—0.115 mm (0.0025—0.0045 in.)

If camshaft bushing bore diameter in block is more than specified, install a new cylinder block.

IMPORTANT: The centerline of the main bearing bore-to-top deck of cylinder block MUST BE 352.35—352.50 mm (13.872—13.878 in.). If not, replace cylinder block.

4. Measure cylinder block top deck flatness using D05012ST Precision Straightedge and feeler gauge and compare to following specifications. Resurface as required.

Specification

Cylinder Block Top Deck—Maximum Out-of-Flat	0.10 mm (0.004 in.) over entire length or width
Straightness	0.025 mm (0.001 in.) per any 305 mm (12.0 in) of Length
Maximum Wave Depth	2.0 micrometers (79 micro-inch)
Main Bearing Bore Centerline-to-Top Deck Distance	352.35—352.50 mm (13.872—13.878 in.)

RE38635,0000076 -19-19SEP05-1/1

Piston Cooling Orifices — Installation

1. Use a soft wire and compressed air to clean orifices. Replace if condition is questionable.

IMPORTANT: A piston cooling orifice failure could cause damage to pistons, piston pins, rod pin bushings, and liners. If a piston cooling orifice is left out, low or no oil pressure will result.

IMPORTANT: The 9 L engine has directed oil piston cooling. Be certain orifice is installed in proper orientation to liner bore.

2. Locate JDG1948 piston cooling orifice installation tool (A) in main bearing diameter.
3. Coat 12 mm (1/2 in.) of piston cooling orifice with LOCTITE® Threadlocker medium strength 242 (Blue), as shown.

NOTE: Installation tool and cooling orifice have matching surfaces to properly align orifice in block. If surfaces are not aligned, the installation screw can not be started.

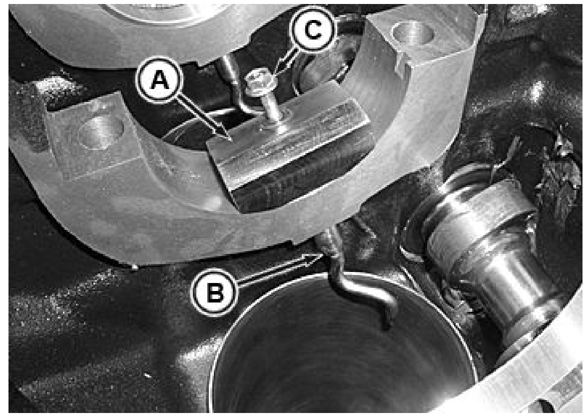
4. Install piston cooling orifice (B) in block from liner side, as shown. When tool and orifice are in proper alignment, the installation screw (C) will be in an up position.
5. Assemble installation screw into cooling orifice with fingers. This will begin to seat cooling orifice in block.
6. Tighten installation screw to specification to seat orifice in block.

Specification

Piston Cooling Orifice into
Cylinder Block—Torque.................................. 15—17 N·m (11—13 lb-ft)

7. Verify installation depth by removing screw (C) from installation tool. Reassemble screw loosely in installation tool. The ring on the screw shank (D) should be even with or above top surface of tool.

A—JDG1948 Piston Spray Orifice Installation Tool
B—Piston Spray Orifice
C—JDG1948 Installation Tool Screw
D—Depth Verification Mark



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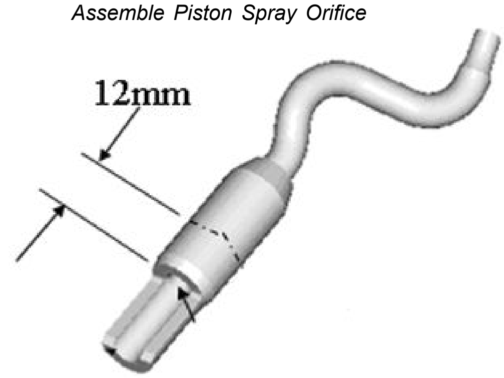
Assemble Piston Spray Orifice



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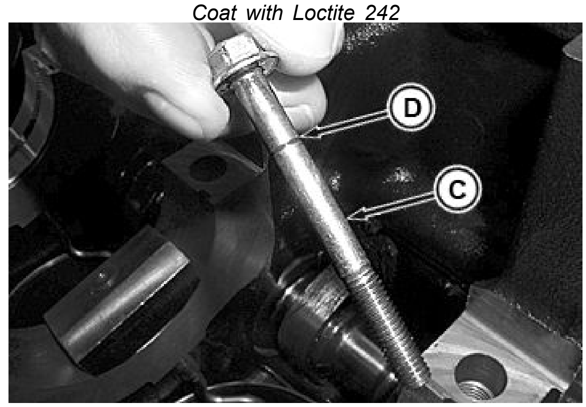
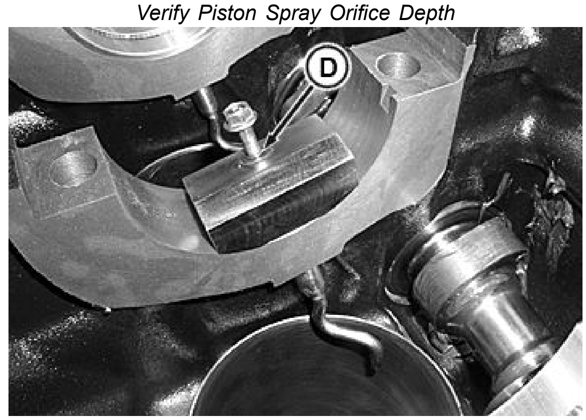
Coat with Loctite 242



RG13954 —UN—31AUG09

Verify Piston Spray Orifice Depth



RG13953 —UN—31AUG09

Verification of Depth

LOCTITE is a trademark of Loctite Corp.

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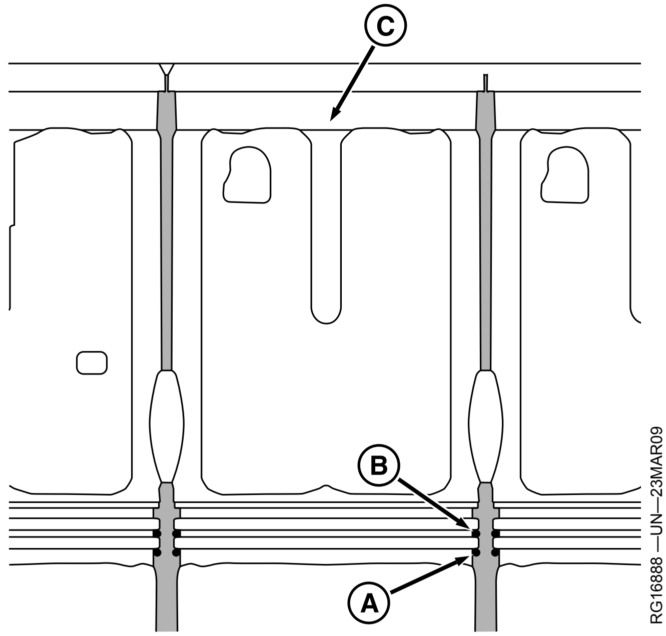
Install Packing on Cylinder Liner and O-Rings in Block

IMPORTANT: DO NOT use oil on cylinder liner packing or O-rings. Oil can cause the orange packing to swell, which squeezes liner and could possibly cause a scored piston.

1. Pour AR54749 Soap Lubricant into a suitable container.
2. Dip new packings and O-rings in soap before installation. Do not leave packings or O-ring in soap to soak.
3. Install the white O-ring (A) in the lower O-ring groove in the cylinder block (C).
4. Install the orange silicone O-ring (B) in the upper O-ring groove in the cylinder block.

A—O-Ring — White
B—O-Ring — Orange
C—Cylinder Block



Install Cylinder Liner Seals

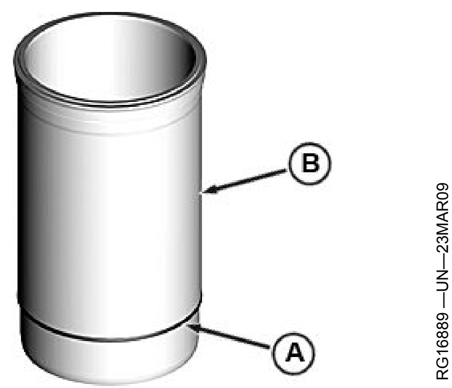
RE38635,00000B0 -19-15MAR11-1/2

5. Turn cylinder liner (B) upside down and install the square neoprene packing (A) over outside of liner.
6. Slide packing down firmly against second shoulder on liner.

NOTE: Make sure the square packing is not twisted.

7. Coat the liner packing sealing area of the cylinder liner and block O-rings with liquid soap.

A—Square Neoprene Packing
B—Cylinder Liner



Install Liner Packing

RE38635,00000B0 -19-15MAR11-2/2

Install Cylinder Liner in Block

IMPORTANT: Install cylinder liners into same cylinder block bore as removed.

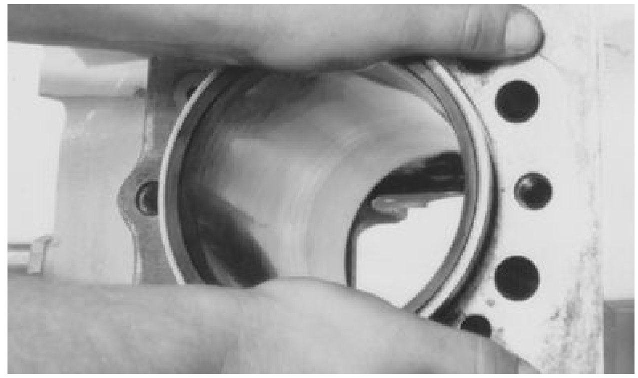
DO NOT scuff the liner packing across the upper counterbore.

Pitted or eroded liners that meet reuse guidelines should be rotated 90° from their removed position. See VISUALLY INSPECT CYLINDER LINERS earlier in this group for reuse guidelines.

1. Install liner in block bore with manufacturing data code (stamped on flange) toward front of engine, unless liner O.D. is pitted or eroded.

   If liner O.D. is pitted or eroded, but still within acceptable service limits, rotate liner 90° from it's removed position. Pitted sections of the liner should be facing the front or rear of engine.

2. A resistance will be felt when cylinder liner is aligned in pilot bore.



RG2772 —UN—04DEC97

Installing Cylinder Liners in Block

3. Using only the pressure of both palms, the cylinder liner should drop to a point nearly flush with upper flange of the cylinder liner and cylinder block.

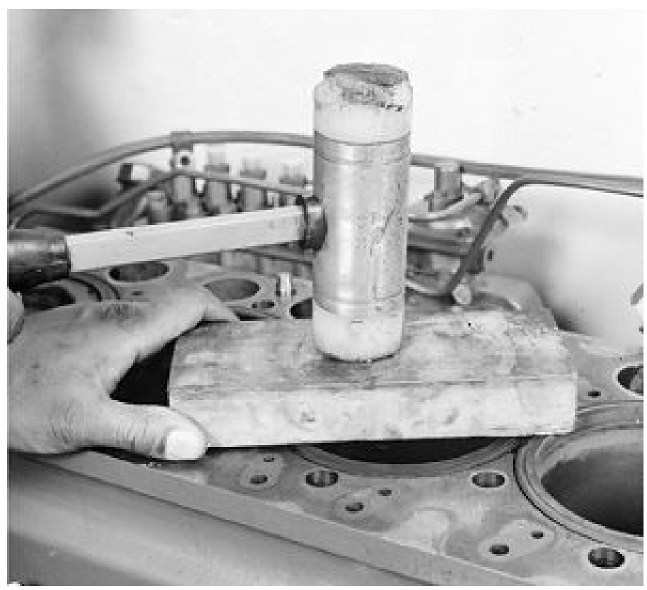
RG,RG34710,1140 -19-23OCT97-1/2

4. Finish seating cylinder liners using a clean, hardwood block and hammer.
5. Gently tap hardwood block over top of cylinder liner with mallet.

NOTE: Cylinder liner will protrude over top of cylinder block more than normal due to uncompressed packings and O-rings.

IMPORTANT: If you suspect a packing may have sheared or displaced during liner installation, remove and examine the liner and packing assembly. If no damage is found, check packings for proper position. Resoap packings and reinstall liner assembly.

6. Hold liners in place with large flat washers and cap screws. Turn cap screws snug but do not tighten.
7. Clean cylinder liner bores with waterless hand cleaner after installation. Wipe dry with clean towels.
8. Apply clean engine oil to liner bores immediately to prevent corrosion.



RG6092 —UN—27JAN92

Seating Cylinder Liners in Block

RG,RG34710,1140 -19-23OCT97-2/2

Install Piston and Connecting Rod

Install Rings on Pistons

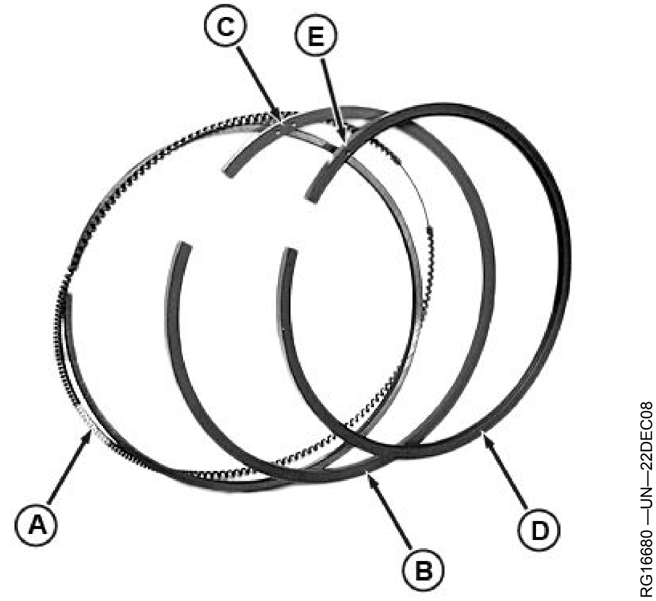
IMPORTANT: If pistons are changed then, use piston marked with a blue paint dot on the underside of the skirt.

IMPORTANT: Full keystone compression ring (D) installs in top piston ring groove. The top ring can be identified by a single punch mark (E) and PINK paint stripe. The punch mark also designates ring orientation. The side of the ring with the punch mark faces to TOP OF PISTON.

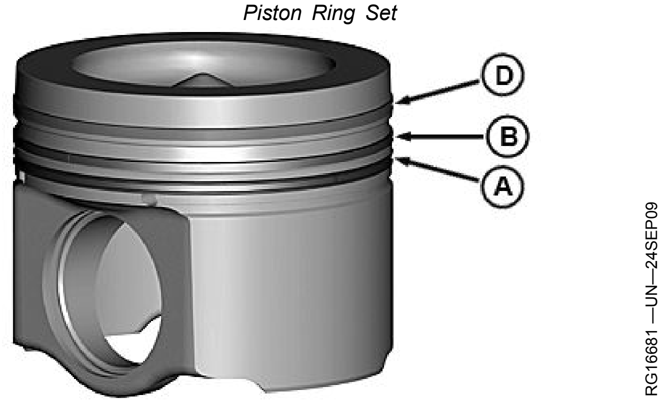
The rectangular second ring (B) with double punch marks (C) and LIGHT BLUE paint stripe is installed in middle groove of piston. The punch marks must face TOP OF PISTON.

The bottom oil control ring has no punch marks for orientation, but has a WHITE paint strips for identification. This ring is installed in bottom groove of piston, over the top of the oil control expansion ring (A). There is no top or bottom orientation to the oil control ring.

1. Using JDE93 Ring Expander, install oil control ring with expander ring (A) and **white** paint stripe to the bottom groove of piston. There is no top or bottom to the oil control ring.
2. Install the number 2 compression ring (B) with **light blue** paint stripe and double punch mark in the middle piston groove. **The punch marks must face top of piston**.
3. Install the number 1 compression ring (C) with **pink** paint stripe and single punch mark in the top piston groove. **The punch mark must face top of piston**.



Piston Ring Set



Install Rings to Piston

A—Oil Control or Expander Ring
B—Middle (Second) Compression Ring
C—Double Punch Marks on top of Middle Ring
D—Keystone Top Compression Ring
E—Single Punch Mark on Top Ring

Continued on next page

RE38635,00000AF -19-11AUG11-1/6

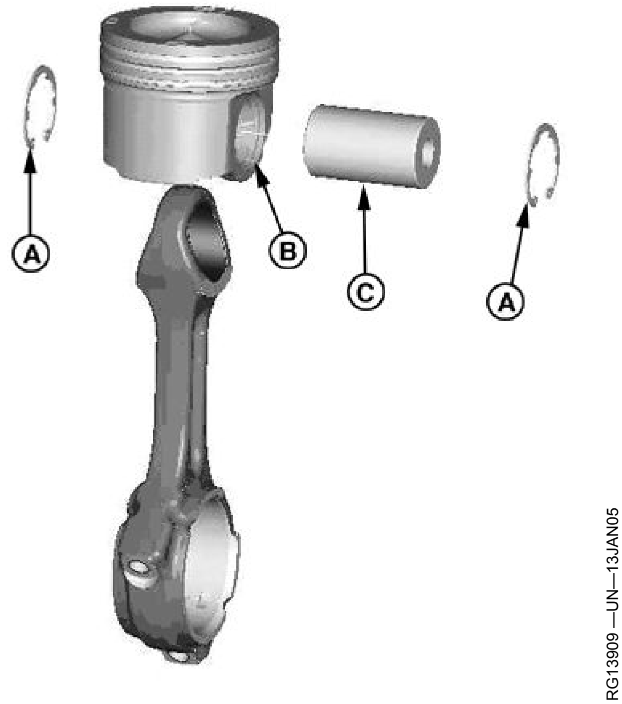
Install Piston on Connecting Rod

IMPORTANT: Piston must be installed on same connecting rod from which they were removed and new piston pin snap rings must be used.

If a new piston and liner assembly is to be installed, DO NOT remove piston from liner. Push piston out of liner bottom only far enough to install piston pin.

Orientation of the piston is not required on 9 L engine. Only the connecting rod has orientation ("front") markings.

1. Install one snap ring (A) into piston pin bore groove
2. Lubricate piston pin (C), piston and rod bores with clean engine oil.
3. Install piston pin through piston and rod bores until pin seats against previously installed snap ring.
4. Install second snap ring (A) into piston pin bore groove, securing piston pin. Be sure snap ring is seated securely in the piston bore grooves.
5. Check for free movement of the piston on rod.
6. Check for free movement of the piston pin in rod and piston by pushing against both snap rings.



Assemble Piston to Connecting Rod

A—Snap Ring
B—Piston
C—Piston Pin

RE38635,00000AF -19-11AUG11-2/6

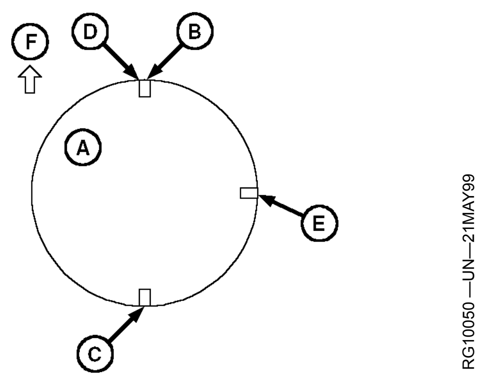
Install Piston and Rod Assembly into Block

NOTE: New rings are furnished with the correct end gap, therefore, fitting to the liner is not necessary.

1. Stagger ring gaps on piston as shown, with gap of top ring facing the front of the engine.

NOTE: If crankshaft was removed, see INSTALL MAIN BEARINGS AND CRANKSHAFT in Group 040.

2. Lubricate all parts in piston & rod assembly (piston, rings, liners and I.D. of JDG1963 Piston Ring Compressor) with clean engine oil.



Position of Piston Ring Gaps

A—Top of Piston
B—Top Compression Ring Gap
C—Oil Control Ring Gap
D—Expander Ring Gap
E—Bottom Compression Ring Gap
F—Front of Engine

Continued on next page

RE38635,00000AF -19-11AUG11-3/6

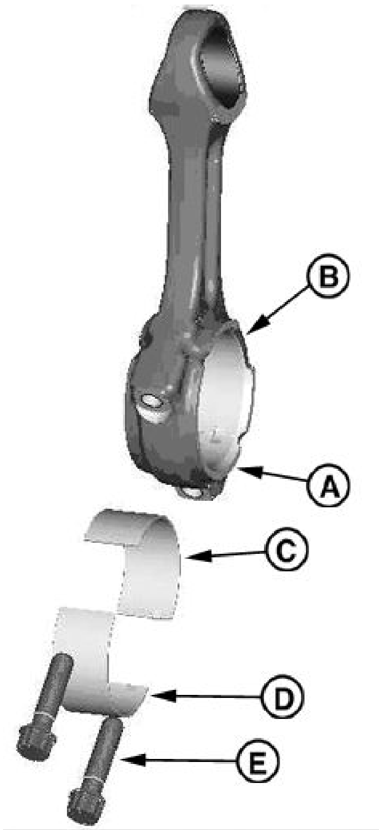
3. Remove rod cap (A) from rod assembly (B) and install upper rod bearing (C) into rod half. Install lower rod bearing (D) into rod cap.
4. Lubricate crankshaft journal and liner bore with clean engine oil.
5. Carefully place ring compressor with piston and rod over liner.

IMPORTANT: Be sure crankshaft journals, liner walls, and piston spray jets are not damaged when installing piston and rod in liner. Be especially careful with the directed cooling spray jets.

NOTE: Be sure the word "FRONT" on rod faces toward the front of the engine.

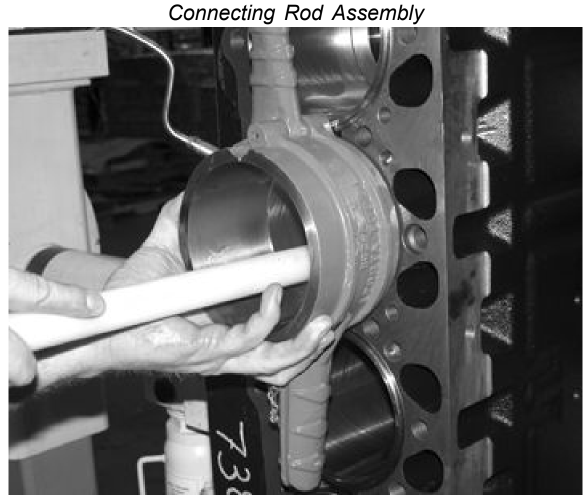
6. With piston centered in ring compressor and rings staggered correctly, push piston into liner, as shown, until top ring is inside the liner.

A—Connecting Rod Cap
B—Connecting Rod
C—Upper Rod Bearing
D—Lower Rod Bearing
E—Connecting Rod Cap Screws



RG13910 —UN—13JAN05

Connecting Rod Assembly



RG14190 —UN—28MAY05

Installing Piston & Rod Assembly in Liners Using JDG1963 Ring Compressor

Continued on next page

RE38635,00000AF -19-11AUG11-4/6

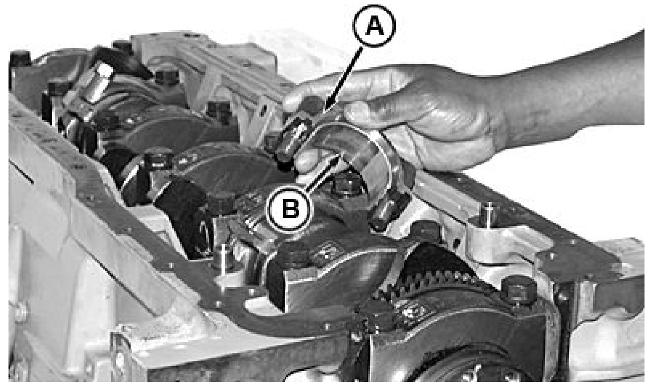
7. Apply clean engine oil to bearing inserts (B) and matching crankshaft rod journals.

IMPORTANT: On Precision Joint™ rods, make sure cap is properly aligned on rod with interlocking surfaces sealing tightly and edges aligned. Be sure the rod cap is seated correctly on to the rod, then install rod cap bolts. DO NOT use the rod bolts to seat the cap to the rod. Mismatch problems can occur. DO NOT reverse cap on rod. Match pads on side of rod and cap.

When installing caps, make sure stamped numbers (C) on rod and cap are positioned on the same side.

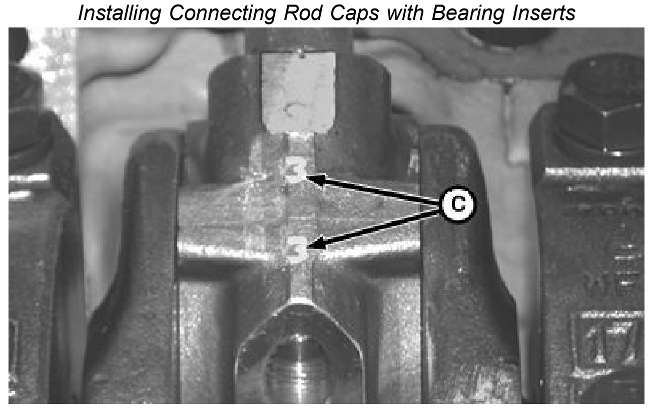
8. Install connecting rod caps (A).

A—Connecting Rod Caps
B—Bearing Inserts
C—Stamped Numbers



RG10209 —UN—28AUG09

Installing Connecting Rod Caps with Bearing Inserts



RG10215 —UN—23JUN99

Stamped Numbers

Precision Joint is a trademark of Deere & Company

RE38635,00000AF -19-11AUG11-5/6

IMPORTANT: NEVER use connecting rod cap screws more than once for final engine assembly. Once rod cap screws have been tightened to final torque-turn specifications, they must not be reused for another final assembly.

9. Dip NEW cap screws and washers in clean engine oil. Make sure bore threads and all threads on cap screws are thoroughly oiled.

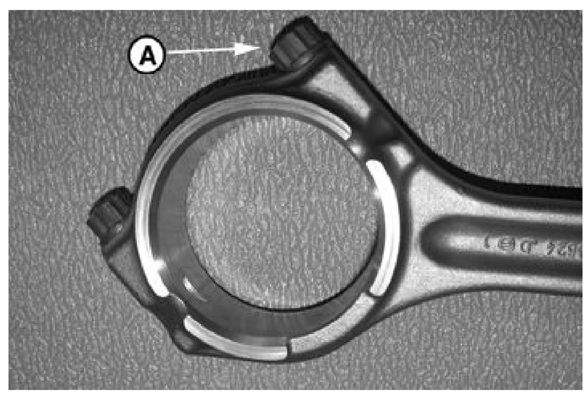
IMPORTANT: DO NOT use pneumatic wrenches to install connecting rod cap screws. Doing so may damaged threads. Use speed-handle wrench instead.

10. **On** Precision Joint™ **connecting rods**: Initially, tighten cap screw closest to piston end to specifications. Next, tighten the other cap screw. Feel rod-to-cap joint to check for proper alignment.

Specification

Precision Joint™
Connecting Rod Cap
Screw—Torque................. 95 N•m (71 lb-ft) plus 90–100° turn clockwise

Precision Joint is a trademark of Deere & Company



RG14186 —UN—28MAY05

Connecting Rod

A—Tighten This Cap Screw First

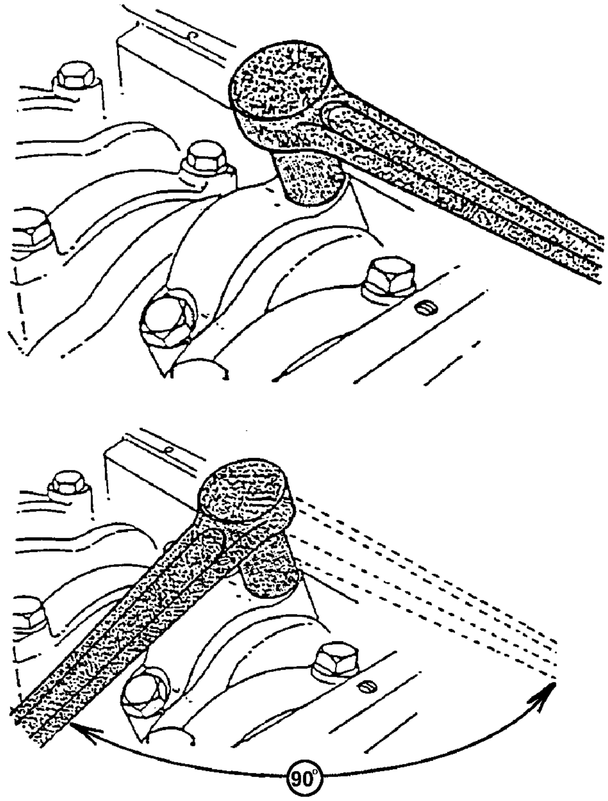
See TORQUE-TURN CONNECTING ROD CAP SCREWS, described next in this group.

RE38635,00000AF -19-11AUG11-6/6

Torque-Turn Connecting Rod Cap Screws

Using Engine Axis Method to Torque-Turn Connecting Rod Cap Screws:

1. After tightening cap screws to torque values, mark connecting rod cap and socket.
2. Position handle of wrench parallel to centerline of engine crankshaft axis.
3. Tighten 1/4 turn (90–100°) clockwise until handle of wrench is perpendicular to centerline of engine crankshaft axis as shown.



RG7047 —UN—05DEC97

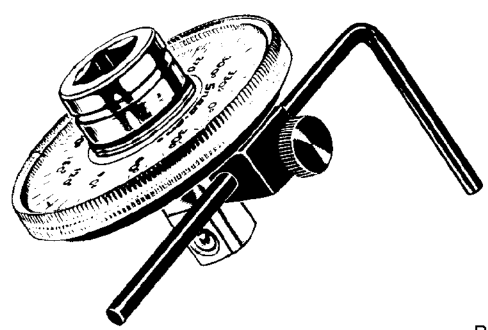
RG7047

Tightening Rod Cap Screws by TORQUE-TURN Method

RG,RG34710,1142 -19-23OCT97-1/2

Using JT05993 Torque Angle Gauge to Torque-Turn Connecting Rod Cap Screws:

After tightening cap screws to initial torque values provided earlier, follow directions provided with gauge and TORQUE-TURN each cap screw 90°–100°.



RG5698 —UN—05DEC97

RG5698

JT05993 Torque Angle Gauge

RG,RG34710,1142 -19-23OCT97-2/2

Check Engine Rotation for Excessive Tightness

1. Rotate crankshaft several revolutions to be sure engine rotates without excessive tightness.
2. Check liners for deep scratches caused by an improperly installed or broken piston ring.
3. Check side clearance of rods. Must have slight side-to-side movement.

RG,RG34710,1143 -19-23OCT97-1/1

Complete Final Assembly

NOTE: Refer to the proper group for installation of components.

1. Install camshaft, and timing gear cover. (Group 050.)
2. Install oiling system components. (Group 060.)
3. Install cylinder head using a new gasket and cap screws. Install valve train components. (Group 20)
4. Install fuel injection system components. (See Group 090 in appropriate CTM for specific fuel system.)
5. Install thermostat housing and coolant bypass pipe, if removed. (Group 070.)
6. Install vibration damper and crankshaft pulley. (Group 040.)
7. Install alternator. (Group 100.) To install fan and fan belt, see machine Technical Manual.
8. Install exhaust manifold, exhaust gas recirculator assembly, and intake assembly. (Group 080.)
9. Install starting motor. (Group 100.)
10. Fill engine with clean oil and proper coolant.
11. Install engine in vehicle (if removed). (See machine Technical Manual.)
12. Perform engine break-in. (Group 020)

RE38635,0000047 -19-13JAN05-1/1

Crankshaft and Main Bearing Failure Analysis

Scored Main Bearing:

(Diagnosis also applies to connecting rod bearing.)

- Oil starvation.
- Contaminated oil.
- Engine parts failure.
- Excessive heat.
- Poor periodic service.

Galled or "Wiped" Bearings:

- Fuel in lubricating oil (incomplete combustion).
- Coolant in lubrication system (cracked block, liner seal failure, or leaking coolant pump seal with plugged hole).
- Insufficient bearing oil clearance.
- Parts not lubricated prior to engine operation.
- Wrong bearing size.

Inconsistent Wear Pattern:

- Misaligned or bent connecting rod.
- Warped or bowed crankshaft.
- Distorted cylinder block.

Broken Main Bearing Caps:

- Improper installation.
- Dirt between bearing and crankshaft journal.
- Low oil pressure.
- Oil pump failure.

Cracked, Chipped or Broken Bearings:

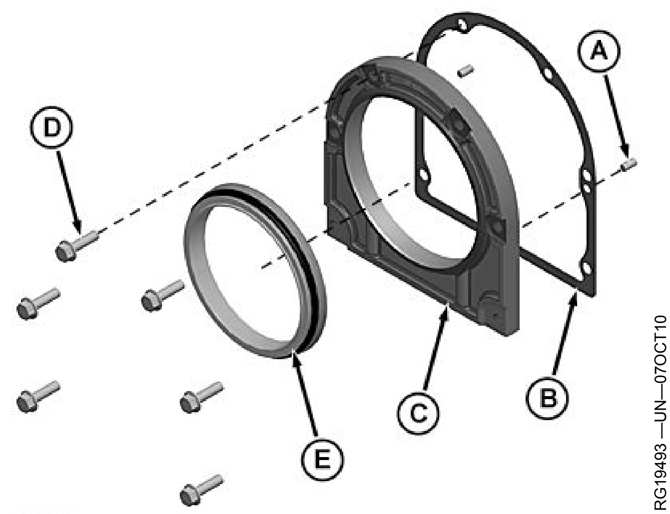
- Overspeeding.
- Excessive idling.
- Lugging.
- Excessive oil clearance.
- Improper installation.

RG,RG34710,1149 -19-23OCT97-1/1

Crankshaft Rear Oil Seal Assembly General Information

The 9.0 L rear crankshaft oil seal is the same seal as used on 8.1 L engines. The change to adopt the 8.1 L rear seal was done because:

- better reliability
- lower cost
- Allows use of a common rear oil seal housing for both 8.1 L and 9.0 L engines.



Unitized Rear Oil Seal Assembly

A—Dowel Pins
B—Rear Oil Seal Housing Gasket
C—Rear Oil Seal Housing
D—Socket Head Screws - Housing to Block
E—Crankshaft Rear Oil Seal

RE38635,00000C9 -19-15JUN11-1/1

Crankshaft Rear Oil Seal Assembly Handling Precautions

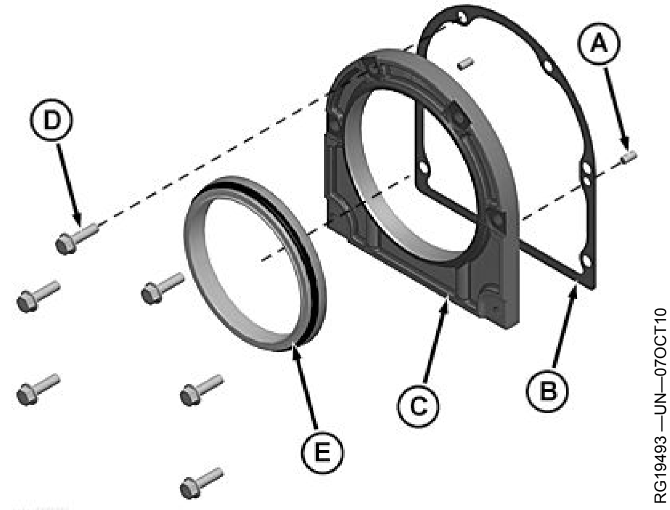
Use the following precautions for handling seal and wear sleeve:

Seal and wear sleeve are assembled. DO NOT SEPARATE. If parts become separated, discard and replace with a new assembly. Attempts to reassemble will cause the wear sleeve to damage the seal allowing engine oil to leak past seal.

Always install seal and wear sleeve assembly immediately after removal from plastic bag to avoid possible dirt contamination.

No lubricant of any kind is to contact seal when installing. Use of a lubricant may result in premature seal failure.

Install oil seal/wear sleeve assembly as shown in the instructions. Incorrect installation will result in an oil leak.



Unitized Rear Oil Seal Assembly

A—Dowel Pins
B—Rear Oil Seal Housing Gasket
C—Rear Oil Seal Housing
D—Socket Head Screws - Housing to Block
E—Crankshaft Rear Oil Seal

RE38635,00000CB -19-15JUN11-1/1

Crankshaft Rear Oil Seal & Oil Seal Housing — Installation

IMPORTANT: The seal used on the 9.0L engine is the same as used on the 8.1L. The housing is now located to the cylinder block with dowel pins.

Engines shipped PRIOR to the change in rear seal will require both the seal and housing to be replaced

Engines shipped with this configuration (AFTER serial number break) would only need the seal replaced if service is required.

Serial Number Breaks:

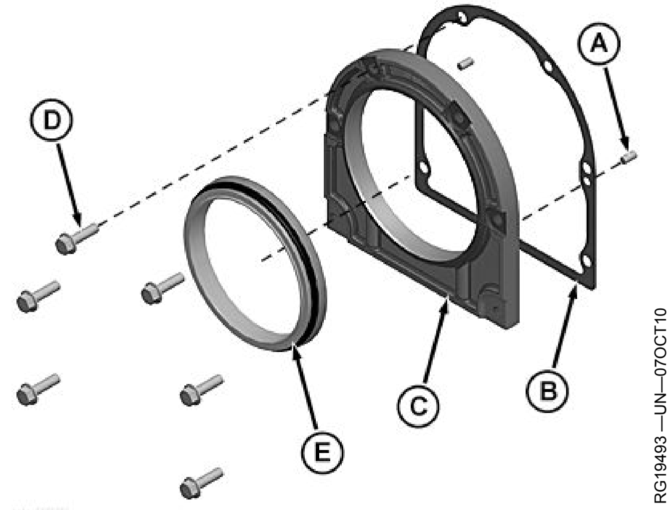
- **RG6090L090545**
- **RG6090B005490**
- **RG6090G002017**

1. Clean cylinder block mounting surface for rear oil seal housing.
2. If necessary, using a dowel pin driver, install oil seal housing dowel pins (A) in cylinder block at 3:00 and 9:00 positions. Drive dowel pins in to specified protrusion from block face.

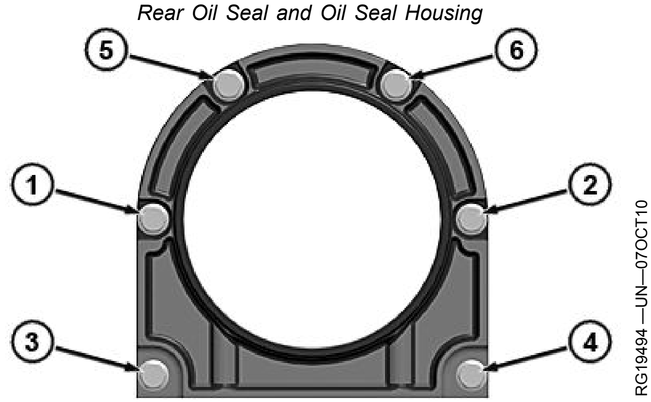
Specification	
Dowel Pin to Rear Cylinder Block Face—Protrusion	6.5 mm (0.25 in.)

3. Install gasket (B) over dowel pins.
4. Align rear oil seal housing (C) to dowel pins and gasket and slide into position against block face.
5. Apply thread sealant to threads of 6 socket head cap screws (D).
6. Install cap screws finger tight through rear oil seal housing to cylinder block.
7. Torque cap screws to specification in the sequence shown.

Specification	
-6- Cap Screws — Oil Seal Housing to Cylinder Block—Torque	37 N•m (27 lb-ft)



Rear Oil Seal and Oil Seal Housing



Torque Sequence — Rear Oil Seal Housing

A—Dowels -2-
B—Gasket — Rear Oil Seal Housing
C—Rear Oil Seal Housing
D—Flange Head Cap Screws -6-
E—Crankshaft Rear Oil Seal

8. Trim the housing gasket flush with the bottom of the housing. Discard gasket remnant.

Continued on next page

RE38635,000006A -19-12OCT10-1/3

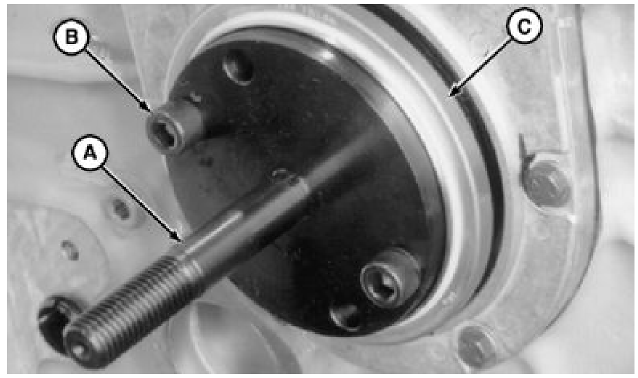
9. Install JDG477 (85) Pilot (A) on end of crankshaft using the Allen head cap screws (B) supplied with tool set. Tighten cap screws securely.

IMPORTANT: Handle seal and wear sleeve assembly carefully.

When installing the JDG478 Driver on JDG477 (85) Pilot and crankshaft flange to position oil seal assembly, locate crossbar of installer at right angle (90°) to Allen head cap screws. This allows the crossbar to bottom on pilot, not head of cap screws, assuring correct installation.

NOTE: Unitized seal assembly must be installed in correct orientation. Seal is stamped **this side out** *on rear, or outward, side of seal.*

10. Carefully start oil seal/wear sleeve assembly (C) over JDG477 (85) Pilot and crankshaft with open side of seal toward engine.



Installing Crankshaft Rear Oil Seal/Wear Sleeve

A—Pilot
B—Allen Head Cap Screws
C—Oil Seal/Wear Sleeve Assembly

RE38635,000006A -19-12OCT10-2/3

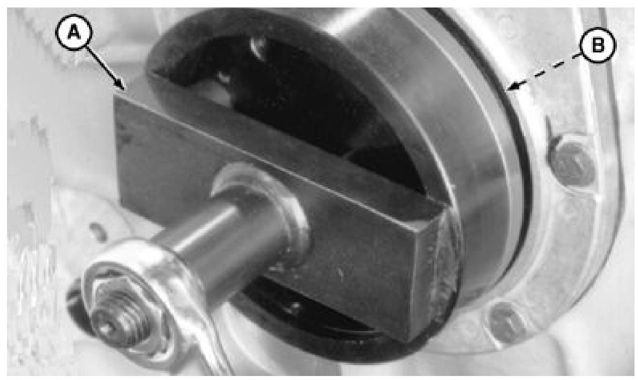
11. Position JDG478 Driver (A) so that hole in the cross plate goes over threaded stud of pilot. Install washer and nut on stud.

NOTE: When properly installed the seal should be flush to 1 mm inward (toward front of engine) from crankshaft flange face.

12. Tighten nut to draw JDG478 Driver in until crossbar bottoms on JDG477 (58) Pilot. When the tool bottoms, seal and wear ring assembly (B) will be correctly positioned.

13. Remove JDG476 (85) Tool Set from engine.

A—Driver **B—Wear Ring Assembly**



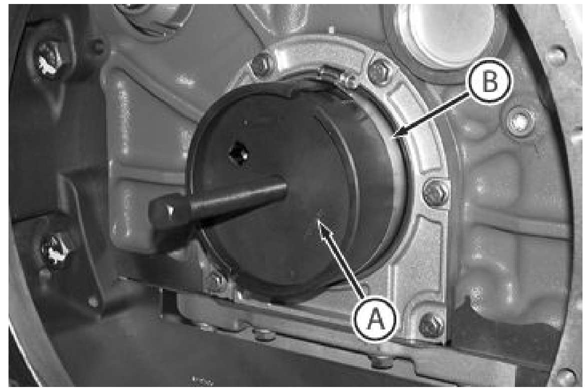
Crankshaft Rear Oil Seal/Wear Sleeve Installed

RE38635,000006A -19-12OCT10-3/3

Crankshaft Unitized Rear Oil Seal — Removal

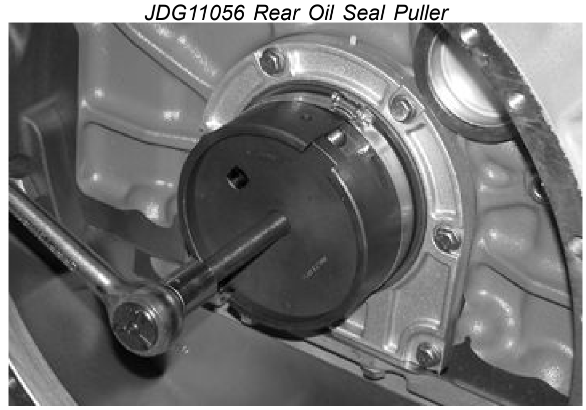
1. Remove Flywheel
2. Install JDG11056 seal puller (A) to rear oil seal so internal jaws engage in groove of seal.
3. While holding puller jaws engaged with seal, tighten clamp (B) to secure puller.
4. Use 19 mm socket or wrench to turn forcing screw clockwise to pull seal from crankshaft flange. Discard seal.

A—JDG11056 SealPuller
B—Clamp
C—Removed Rear Oil Seal



RG15943 —UN—16JUL09

JDG11056 Rear Oil Seal Puller



RG15944 —UN—16JUL09

Remove Rear Oil Seal

RG15945 —UN—16JUL09

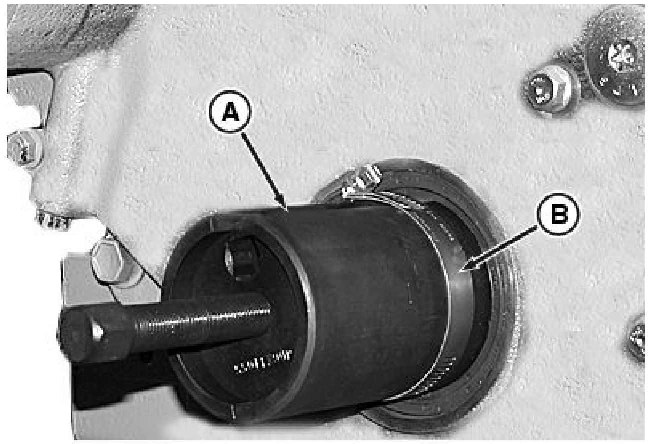
Oil Seal Removed from Engine

SS01820,0000044 -19-16JUL09-1/1

Crankshaft Unitized Front Oil Seal — Removal (6090AFM75 & 6090HFG86)

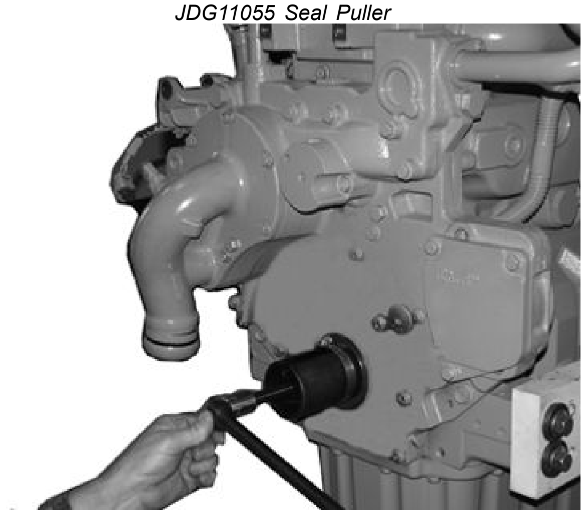
1. Install JDG11055 seal puller tool so jaws in tool engage with lip in seal groove.
2. Holding tool in line with seal, tighten clamp on tool OD.
3. With 19 mm socket or wrench, turn tool forcing screw clockwise to remove seal from crankshaft nose. Discard seal.

A—JDG11055 Front Seal Puller B—Clamp



RG15940 —UN—19AUG09

JDG11055 Seal Puller


RG15941 —UN—21JUL09

Remove Front Crankshaft Oil Seal


RG15942 —UN—16JUL09

Removed Seal and Tool

RE38635,000006B -19-08OCT10-1/1

Crankshaft Unitized Front Oil Seal — Installation (6090AFM75 & 6090HFG86)

Tools:
• JDG11004 — Seal Guide Sleeve and Driver

Consumables:
• No consumables

1. **Crankshaft Unitized Front Oil Seal Installation**

   a. Place JDG11004 seal pilot (A) over crankshaft nose.

   b. Install forcing screw (B) into crankshaft nose until it bottoms. Tighten lock nut (C) to secure pilot to crankshaft nose.

IMPORTANT: Orientation of oil seal is critical. The side of seal with groove faces outward. Match the groove of seal with raised notch on face of JDG11004 seal press tool, as shown. When oriented correctly, the seal will fit flush with face of installation tool.

   c. Carefully install unitized front crankshaft oil seal (D) over pilot OD.

   d. Install JDG11004 seal press tool (E) over guide sleeve. Using hex nut (F) on forcing screw, turn nut clockwise to drive seal onto crankshaft nose. Press seal until tool bottoms out on guide sleeve.

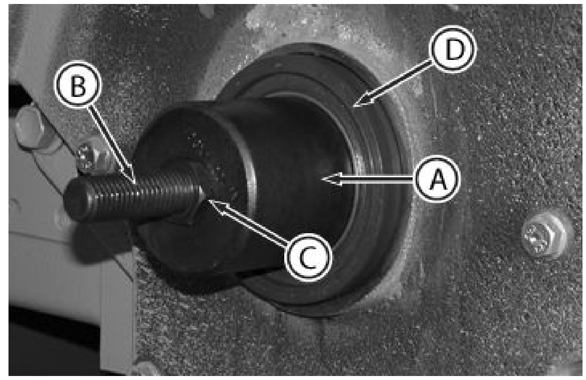
   e. Remove seal press tool and guide sleeve.

2. Perform Crankshaft Vibration Damper — Installation

   Tools:
   • No special tools required

   Consumables:
   • No consumables

A—JDG11004 Seal Pilot
B—Forcing Screw
C—Lock Nut
D—Unitized Front Oil Seal
E—JDG11004 Seal Press
F—Hex Forcing Nut



RG15969 —UN—18AUG09

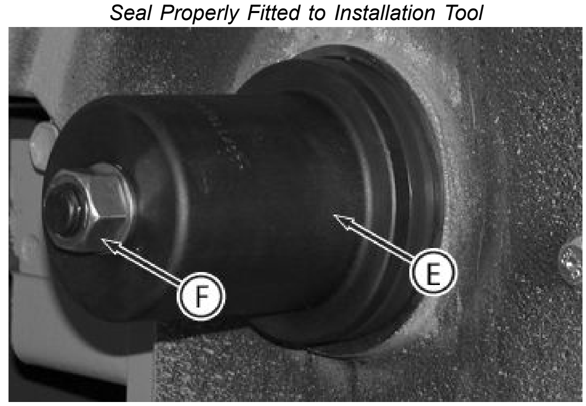
Front Seal Pilot and Forcing Screw


RG15979 —UN—04NOV09

Raised Notch on JDG11004 Seal Driver


RG15980 —UN—04NOV09

Seal Properly Fitted to Installation Tool



RG15970 —UN—18AUG09

Front Seal Press

RE38635,000006C -19-08OCT10-1/1

Crankshaft Unitized Rear Oil Seal — Installation (6090AFM75 & 6090HFG86)

Tools:
• JDG10997 Rear Crankshaft Oil Seal Installation Tool

Consumables:
• No consumables

1. **Crankshaft Unitized Rear Oil Seal Installation**

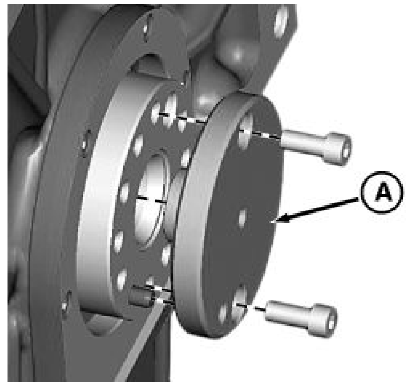
   a. Install JDG10997 seal pilot plate tool (A) to the crankshaft rear flange. Secure pilot with 2 cap screws installed through pilot into crankshaft flange. Tighten cap screws securely.

IMPORTANT: Orientation of rear oil seal is critical. The side of seal with groove faces outward. Match the groove of seal with raised notch on face of JDG10997 seal press tool, as shown. When oriented correctly, the seal will fit flush with face of installation tool.

   b. Carefully install rear oil seal (C) to OD of pilot plate tool.

   c. Install JDG10997 seal driver (B) and forcing screw to pilot plate tool. Turn forcing screw clockwise until seal driver bottoms out.

A—Seal Pilot Plate Tool
B—Seal Driver
C—Rear Oil Seal



RG16690 —UN—19AUG09

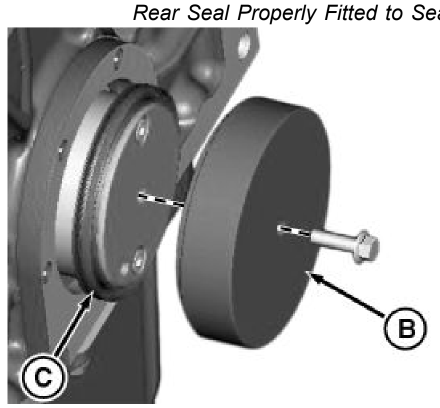
Seal Pilot Plate Tool Installation

RG15938 —UN—21JUL09

Raised Notch on JDG10997 Seal Driver

RG15939 —UN—21JUL09

Rear Seal Properly Fitted to Seal Driver



RG16691 —UN—19AUG09

Seal Driver Installation

Continued on next page

RE38635,000006D -19-08OCT10-1/2

d. For reference, note the distance from outer edge of seal (D) to rear face of crankshaft flange (E).

Specification

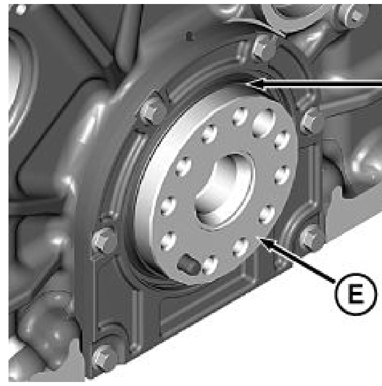
Outside Edge of Seal to Flange Face of Crank—Maximum Distance.. 14.6 mm (0.578 in.)

2. Perform Flywheel — Installation

   Tools:
   • No special tools required

   Consumables:
   • LOCTITE® 242 medium strength thread locker.

3. Perform Flywheel Housing — Installation



Complete Installation of Rear Seal

D—Outside Edge of Seal **E—Flange Face of Crankshaft**

LOCTITE is a registered trademark of Loctite Corp.

RE38635,000006D -19-08OCT10-2/2

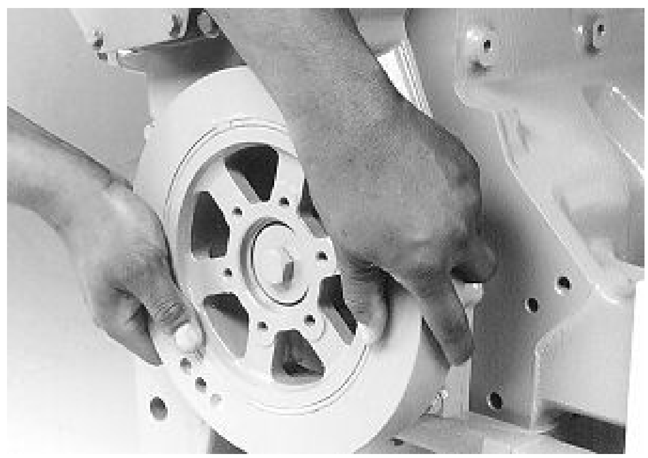
Inspect Vibration Damper

IMPORTANT: The damper assembly is not repairable and should be replaced every 5 years or 4500 hours, whichever occurs first. Also, replace damper whenever crankshaft is replaced or major engine overhaul is performed. Dual dampers should always be replaced as a matched set.

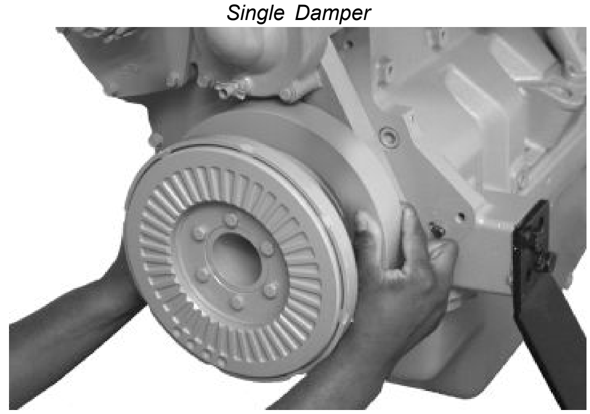
Do not immerse the vibration damper or the damper pulley in cleaning solvent. Doing so may damage the rubber portions of this assembly.

Never apply thrust on outer ring of damper. Damper is sensitive to impact damage, such as being dropped or struck with a hammer.

1. Relieve tension or remove V-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.



Single Damper



Dual Damper

Continued on next page

DPSG,OUOE003,28 -19-17DEC98-1/2

3. Check vibration damper radial runout by positioning a dial indicator so preloaded probe (A) contacts damper O.D.

4. Rotate crankshaft using JDE81-1 or JDG820 Flywheel Turning Tool.

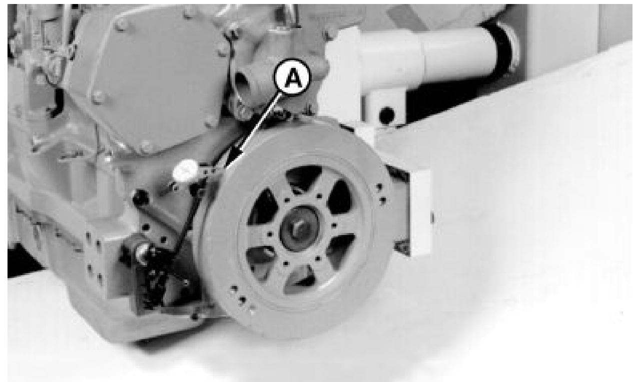
5. Note total dial indicator movement. Compare reading with specification below.

Specification

Vibration
Damper—Maximum
Radial Runout.. 1.02 mm (0.040 in.)

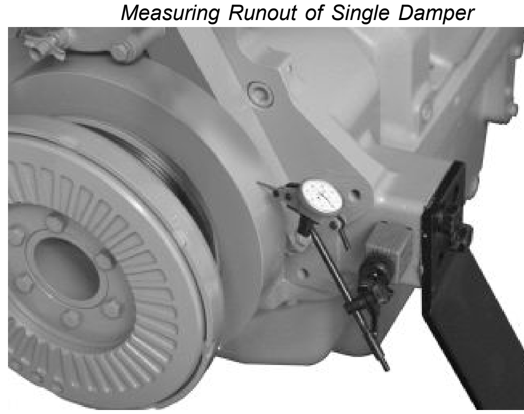
If runout exceeds specifications, replace vibration damper. See <u>REMOVE CRANKSHAFT VIBRATION DAMPER</u> later in this group.

A—Preloaded Probe



RG7065 —UN—26NOV97

Measuring Runout of Single Damper


RG7370 —UN—05JAN98

Measuring Runout of Dual Damper

DPSG,OUOE003,28 -19-17DEC98-2/2

Check Crankshaft End Play

1. Completely engage then release the clutch lever.

2. Place a dial indicator on damper face.

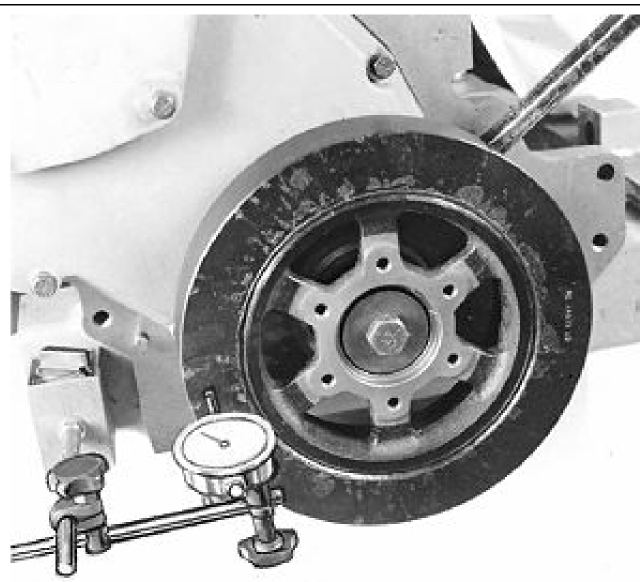
IMPORTANT: Use care not to damage or distort the timing gear cover or bearing inserts when prying. Do not pry on outer inertia ring of damper.

3. Pry with flat bar between the damper pulley and timing gear cover.

Specification

Crankshaft—End Play................0.038—0.380 mm (0.0015—0.0150 in.)

NOTE: New thrust bearings will usually restore proper end play.


RG5934 —UN—28AUG91

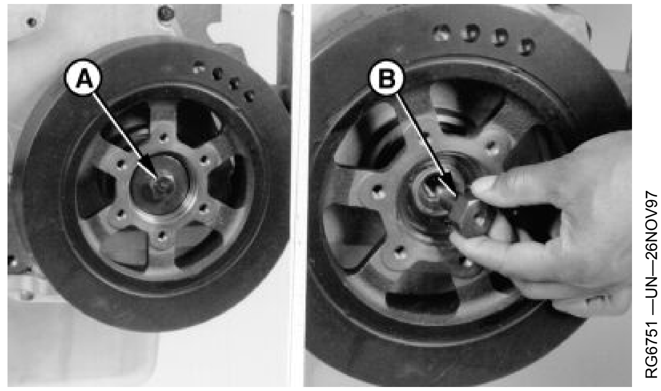
Checking Crankshaft End Play

RG,RG34710,1153 -19-23OCT97-1/1

Remove Crankshaft Vibration Damper

IMPORTANT: DO NOT use a jaw-type puller to remove vibration damper. Damage could result to the damper. Never apply thrust on outer ring of damper. Do not drop or hammer on damper.

1. Remove pulley from damper, if equipped (shown removed).
2. Remove cap screw (A) and washer securing damper to crankshaft.
3. Install JDG10545 Thread Protector (B) in nose of crankshaft.



Preparing to Remove Crankshaft Vibration Damper

A—Cap Screw **B—JDG10545 Thread Protector**

RE38635,000005F -19-19JUN07-1/2

CAUTION: Plan a safe handling procedure to avoid personal injury or damage to damper.

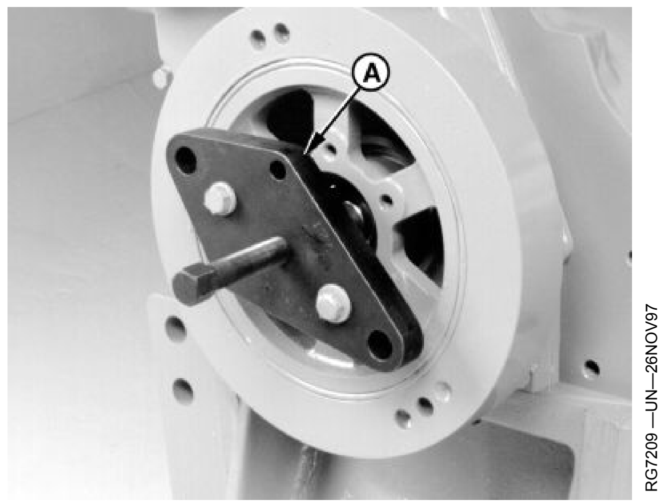
4. Remove damper from crankshaft using JDG721 Hub Puller (A).

NOTE: D01207AA (OTC518) Puller Set (not shown) may also be used to remove damper.

5. Check crankshaft pulley ID and crankshaft OD for pulley.

Specification

Crankshaft Pulley—ID............47.594—47.630 mm (1.8738—1.8752 in.)
Crankshaft—OD for Front
Pulley.....................................47.650—47.676 mm (1.8759—1.8770 in.)



Removing Crankshaft Vibration Damper

A—JDG721 Hub Puller

RE38635,000005F -19-19JUN07-2/2

Remove Crankshaft Front Oil Seal and Wear Sleeve

IMPORTANT: Whenever front oil seal is replaced, the wear sleeve must also be replaced.

NOTE: If timing gear cover is going to be removed from engine, remove front seal and wear sleeve after timing gear cover is removed.


RG6471 —UN—05DEC97

Center Punching Front Oil Seal Casing

RE38635,0000060 -19-19JUN07-1/5

To Remove Front Oil Seal:

1. Check oil seal and wear sleeve for wear, damage, or leakage.
2. Center punch seal casing at 12 O'clock position.
3. Drill 3.175 mm (1/8 in.) hole in casing.


RG6472 —UN—05DEC97

Drilling Hole in Front Oil Seal Casing

RE38635,0000060 -19-19JUN07-2/5

4. Using JDG719 Seal Puller along with JDE38-2 Shank, JDE38-3 Hammer, and metal screw, remove seal.
5. Remove keyway from key slot of crankshaft.


RG6473 —UN—05DEC97

Removing Front Oil Seal

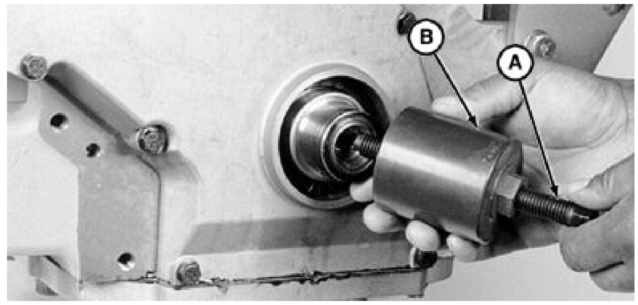
Continued on next page

RE38635,0000060 -19-19JUN07-3/5

To Remove Wear Sleeve Using JDG10544:

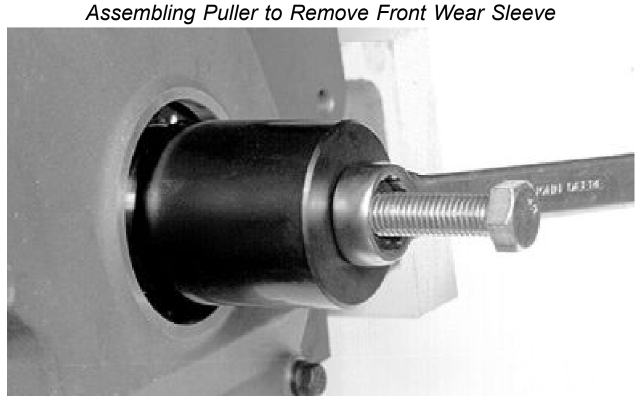
1. Start fully threaded centering screw (A) through hex head end of puller (B) from JDG10544 Front Wear Sleeve Puller until head of screw is approximately 1/2 in. from hex on puller.
2. Thread centering screw into nose of crankshaft until it bottoms. Back screw out one full turn after it bottoms.
3. Tighten puller until it is securely threaded onto wear sleeve. Back centering screw out one full turn and tighten threaded puller onto wear sleeve again.
4. Remove centering screw from nose of crankshaft and puller.

A—Centering Screw **B—Hex End of Puller**



RG6753 —UN—05DEC97

Assembling Puller to Remove Front Wear Sleeve



RG7728 —UN—05DEC97

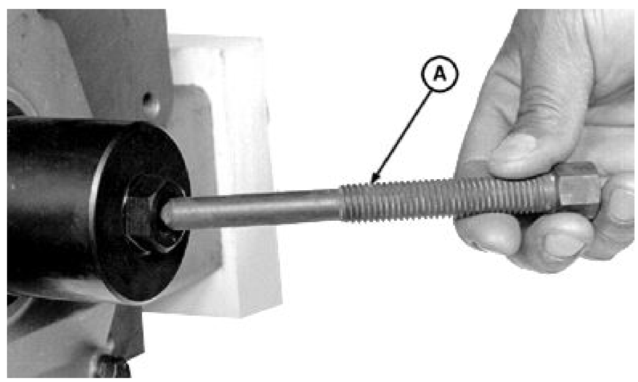
Installing Puller to Remove Front Wear Sleeve

RE38635,0000060 -19-19JUN07-4/5

5. Install partially threaded forcing screw (A) into puller and tighten until bottoms in nose of crankshaft. There in no thread engagement in crankshaft; just with puller.
6. Continue to tighten forcing screw until puller and wear sleeve are free from crankshaft flange.
7. Inspect crankshaft flange for nicks or burrs. Clean up flange with a light file and emery cloth.
8. Measure front oil seal bore runout in timing gear cover and compare to the following specifications.

Specification

Crankshaft Front Oil Seal Bore in Timing Gear Cover—Maximum Radial Runout.. 0.254 mm (0.010 in.) Maximum



RG7729 —UN—05DEC97

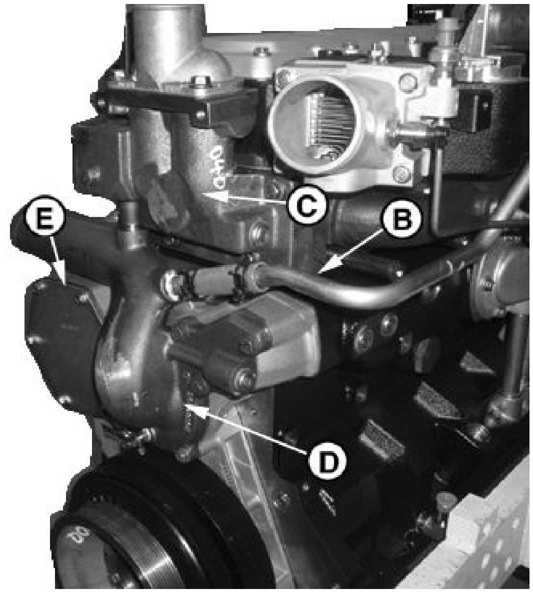
Removing Front Wear Sleeve

A—Forcing Screw

RE38635,0000060 -19-19JUN07-5/5

Remove Timing Gear Cover—Engine Removed

1. Remove engine oil pan. Remove engine oil pump assembly if crankshaft is to be removed.
2. Disconnect engine speed sensor connector (shown disconnected) from sensor (C).
3. Remove injection pump drive gear cover (E).
4. Disconnect coolant piping from EGR (B) and remove coolant pump cover (D) with coolant bypass tube. Remove and discard gaskets.
5. Remove front auxiliary drive assembly, if equipped. See REMOVE, INSPECT AND INSTALL CRANKSHAFT GEAR-DRIVEN AUXILIARY DRIVE in Group 050.
6. Remove remaining cap screws and remove timing gear cover with coolant pump. Remove and discard gasket.
7. Remove front oil seal from timing gear cover and discard seal.
8. Remove front wear sleeve from crankshaft flange and discard sleeve.



RG13967 —UN—16FEB05

Removing Timing Gear Cover

B—EGR Coolant Return Line
C—Thermostat Housing & Bypass Tube
D—Coolant Pump Cover
E—Fuel Pump Cover

RE38635,000000D -19-17MAY05-1/1

Inspect and Measure Flywheel

1. Inspect the clutch contact face for scoring, overheating, or cracks. Replace flywheel if defective.
2. Examine flywheel ring gear for worn or broken teeth. Replace ring gear if defective, as described later in this group.

IMPORTANT: Maintain constant end pressure on crankshaft to hold shaft against thrust bearing when measuring flywheel or housing face.

3. Measure flywheel housing face run-out, flywheel face flatness, and pilot bearing bore concentricity, as outlined later in this group. Resurface flywheel face or replace as required.

RG,RG34710,1158 -19-23OCT97-1/1

Check Flywheel Housing Face Runout

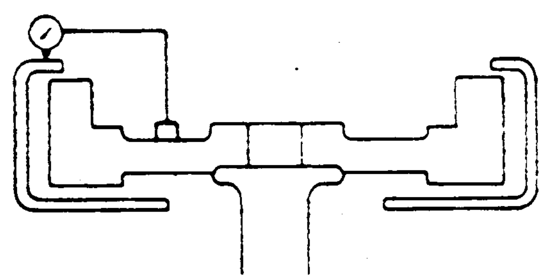
1. Mount dial indicator on flywheel. Set pointer to contact PTO mounting surface on flywheel housing at right angles. Pointer should not contact holes in flywheel housing.

IMPORTANT: Maintain constant end pressure on crankshaft to hold shaft against thrust bearing when measuring flywheel housing face runout.

2. Rotate flywheel by turning crankshaft. Read total dial indicator movement.

Specification

Flywheel Housing
Face—Runout.......................... 0.20 mm (0.008 in.) Maximum Variation

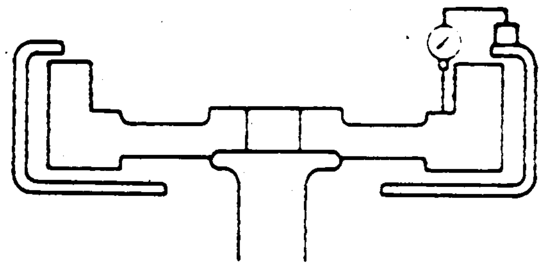


R22212 —UN—14DEC88

Checking Flywheel Housing Face Runout

RG,RG34710,1159 -19-23OCT97-1/1

Check Flywheel Face Flatness



R22213 —UN—14DEC88

1. Mount dial indicator base on flywheel housing. Position pointer to contact driving ring mounting surface. Do not allow pointer to contact driving ring mounting holes.

IMPORTANT: Maintain constant end pressure on crankshaft to hold shaft against thrust bearing when measuring flywheel face runout.

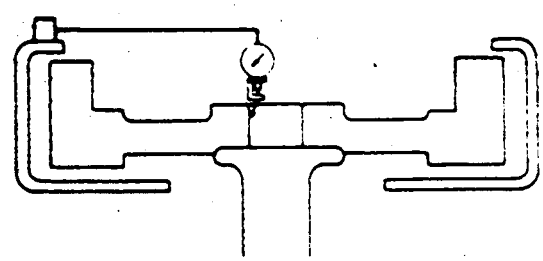
2. Rotate flywheel by turning crankshaft. Read total dial indicator movement. Resurface flywheel face or replace as required.

Specification

Flywheel
Face—Flatness......................... 0.23 mm (0.009 in.) Maximum Variation
Flatness.. 0.013 mm (0.0005 in.) Maximum Variation per 25 mm (1.0 in.) of Travel

RG,RG34710,1160 -19-23OCT97-1/1

Check Pilot Bearing Bore Concentricity



R22214 —UN—14DEC88

Checking Flywheel Pilot Bearing Bore

1. Mount dial indicator on flywheel housing face and position pointer to contact I.D. of pilot bearing bore in flywheel.
2. Rotate flywheel by turning crankshaft. Read total dial indicator movement.

Specification

Flywheel Pilot Bearing
Bore—Concentricity................ 0.127 mm (0.005 in.) Maximum Variation

RG,RG34710,1161 -19-23OCT97-1/1

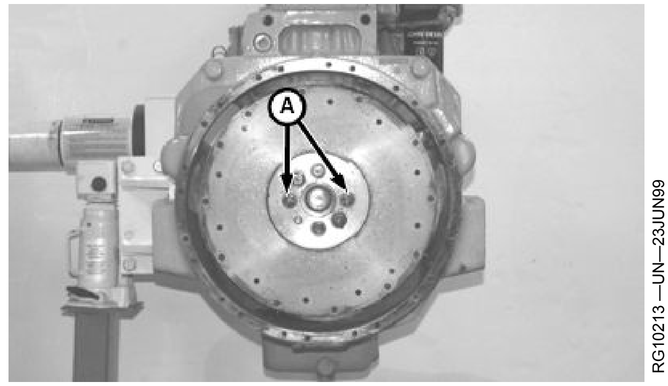
Remove Flywheel

CAUTION: Flywheel is heavy. Plan a proper lifting procedure to avoid injury.

NOTE: SAE 1 flywheel housings MUST BE removed before flywheel can be removed from engine. See REMOVE SAE 1 FLYWHEEL HOUSING, later in this group.

1. Remove two flywheel attaching cap screws (A), and install two pilot studs in their place.
2. Remove remaining cap screws, remove drive hub (if equipped), and carefully pull flywheel from crankshaft.
3. Check condition of dowel pin in crankshaft rear flange. Dowel pin must not be cracked or chipped. Measure protrusion of dowel pin from face of flange. If dowel pin is damaged, or protrusion is not within specifications, replace dowel pin.

NOTE: When replacing dowel pin, crankshaft must be removed to prevent damage to crankshaft thrust bearings.



Removing Flywheel

A—Cap Screws

Specification

Crankshaft Dowel Pin—Protrusion....................13.5—14.5 mm (0.53—0.57 in.) From Crankshaft Rear Flange

RG,RG34710,1162 -19-10JUN99-1/1

Remove SAE 1 Flywheel Housing

CAUTION: Flywheel housing is heavy. Plan a proper lifting procedure to avoid injury.

1. Remove attaching cap screws.
2. Remove flywheel housing.
3. Inspect mounting holes in flywheel housing for thread damage.

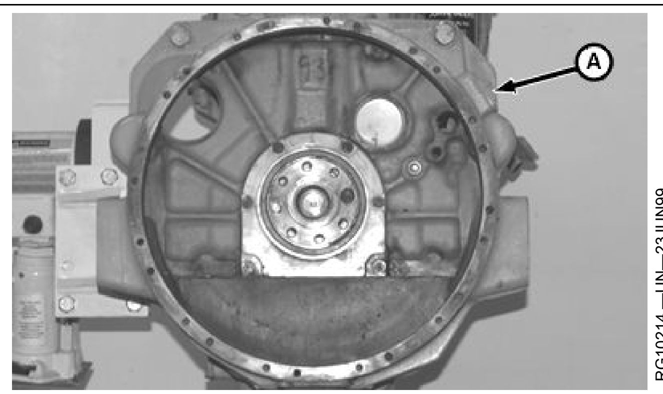
RG,RG34710,1163 -19-23OCT97-1/1

Remove SAE 2 and 3 Flywheel Housing

CAUTION: Flywheel housing (A) is heavy. Plan a proper lifting procedure to avoid injury.

NOTE: The flywheel MUST be removed before removing SAE 2 or 3 flywheel housings. See REMOVE FLYWHEEL earlier in this group.

1. Remove flywheel housing attaching cap screws.
2. Remove flywheel housing.
3. Inspect mounting holes in flywheel housing for thread damage.



Removing Flywheel Housing

A—Flywheel Housing

RG,RG34710,1164 -19-23OCT97-1/1

Replace Flywheel Ring Gear

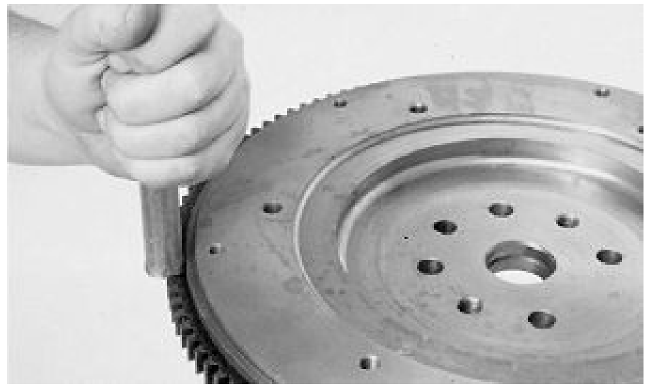
CAUTION: Oil fumes or oil can ignite above 193°C (380°F). Use a thermometer and do not exceed 182°C (360°F). Do not allow a flame or heating element to be in direct contact with the oil. Heat the oil in a well ventilated area. Plan a safe handling procedure to avoid burns.

1. If ring gear is damaged, place the flywheel on a solid flat surface.
2. Remove ring gear with a brass drift and hammer.

IMPORTANT: If flame heat is used, be sure gear is heated uniformly around circumference. DO NOT OVERHEAT. Overheating may destroy original heat treatment of gear. SEE CAUTION.

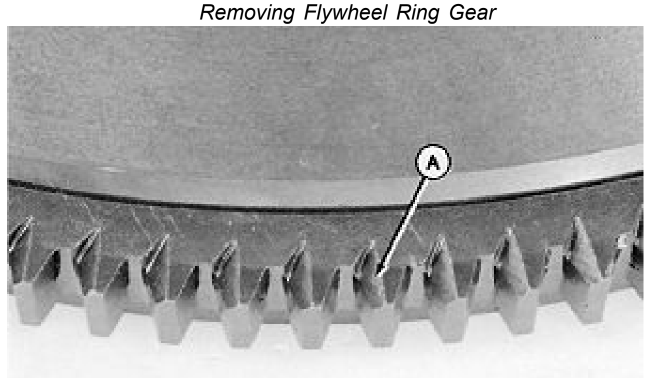
3. Heat new ring gear to 148°C (300°F) using either heated oil, oven heat, or flame heat.
4. Install ring gear against shoulder of flywheel so chamfered side (A) is on engine side of flywheel.

A—Chamfered Side



T90596 —UN—14OCT88

Removing Flywheel Ring Gear



RG3838 —UN—14OCT88

Installing Flywheel Ring Gear

RG,RG34710,1165 -19-23OCT97-1/1

Remove Rear Oil Seal Housing—Engine Removed

1. Remove flywheel. See REMOVE FLYWHEEL in this group.
2. Remove engine oil pan. See REMOVE OIL PAN in Group 060.
3. Remove eight button head screws (A) from rear seal assembly (B). Remove rear oil seal and wear sleeve assembly. See REMOVE CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE in this group.

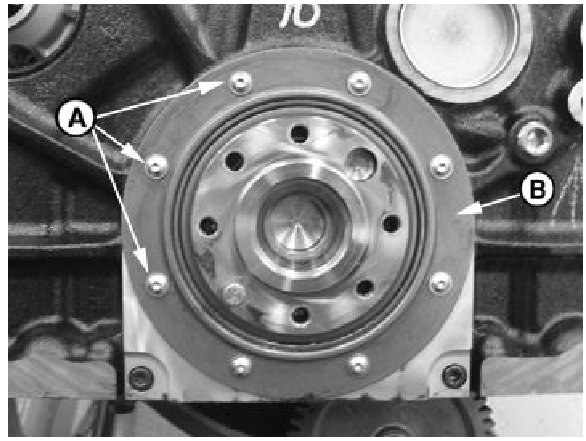
IMPORTANT: Whenever rear oil seal is replaced, also replace rear wear sleeve as a matched assembly.

4. Remove six socket head screws (C) from rear seal housing (D). Remove housing from cylinder block flange.

IMPORTANT: The preferred method of removing the rear wear sleeve is with JDG1020 Rear Wear Sleeve Puller. If removing wear sleeve with a chisel, DO NOT gouge crankshaft flange. Nicks or burrs should be removed with a medium-grit stone. A polishing cloth (180-grit or finer) may also be used when a stone is not available.

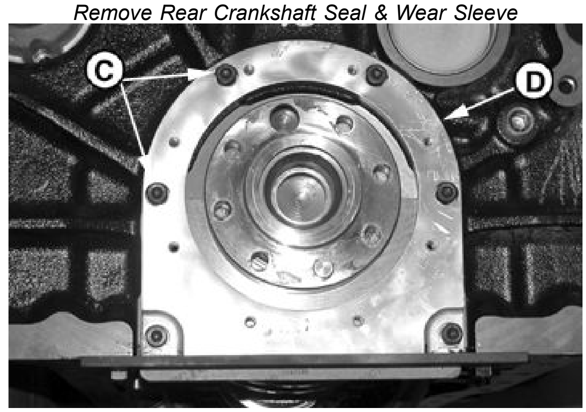
5. Remove rear wear sleeve from crankshaft flange.

A—Rear Crankshaft Seal Button Head Screws
B—Rear Crankshaft Seal Assembly
C—Rear Crankshaft Seal Housing Socket Head Screws
D—Rear Crankshaft Seal Housing



RG14065 —UN—17MAR05

Remove Rear Crankshaft Seal & Wear Sleeve



RG14066 —UN—17MAR05

Remove Rear Crankshaft Seal Housing

RE38635,000007E -19-17MAR05-1/1

Remove Main Bearing Caps

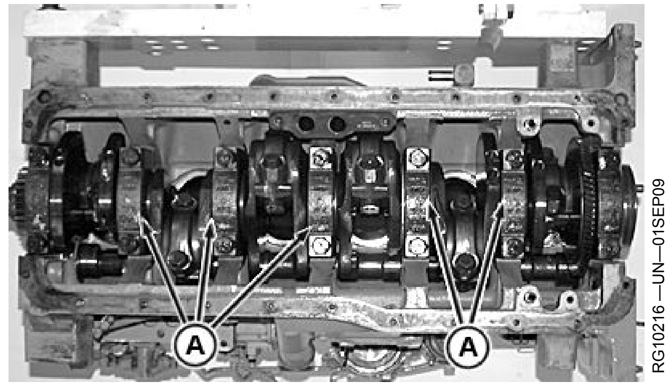
IMPORTANT: Before removing main bearing caps (A), check for proper torque on all main bearings. Also, check each bearing cap to make sure they are numbered for reassembly on the same numbered main bearing bosses. Keep matched main bearings with their respective main bearing cap for comparison with crankshaft journal (surface wear) from which removed.

If arrows are stamped on main bearing caps, note direction arrows are pointing to aid in reassembly.

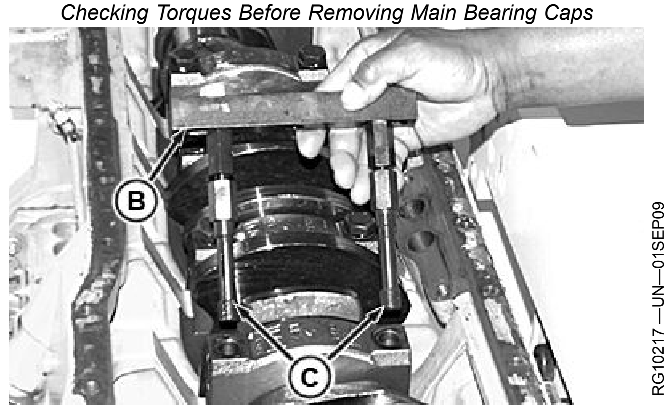
NOTE: When removing main bearings and caps, leave No. 1 and 7 main bearing caps installed until all of the connecting rod caps have been removed.

1. Remove main bearing cap screws.
2. Install JDG1069 Puller (B) so that tips (C) of blind hole puller legs are below bearing cap half.
3. Tighten hex of actuator pin securely while holding collet portion of puller leg with second wrench.
4. Tighten both cap screws (D) on cross block finger tight.

A—Main Bearing Caps
B—Puller
C—Tips
D—Cap Screws



Checking Torques Before Removing Main Bearing Caps



Installing Main Bearing Cap Puller

Tightening Main Bearing Cap Puller

Continued on next page

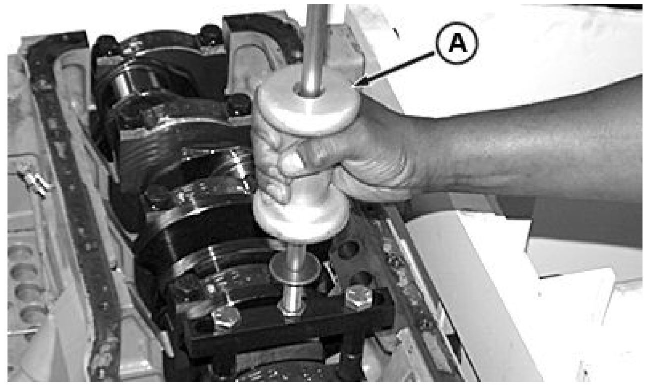
RE38635,00000CC -19-15JUN11-1/2

5. Attach D01300AA Slide Hammer (A) to cross block, tighten nut securely.

NOTE: Main bearing cap screws are a one time use item.

6. Remove main bearing cap by sliding up on hammer weight. Set bearing cap aside in order that it was removed. Discard main bearing cap screws.
7. Use PLASTIGAGE® to measure journal-to-bearing oil clearance on each main bearing as they are removed. See CHECK MAIN BEARING OIL CLEARANCE later in this group.

A—Slide Hammer



RG10219 —UN—01SEP09

Using Slide Hammer to Loosen Bearing Cap

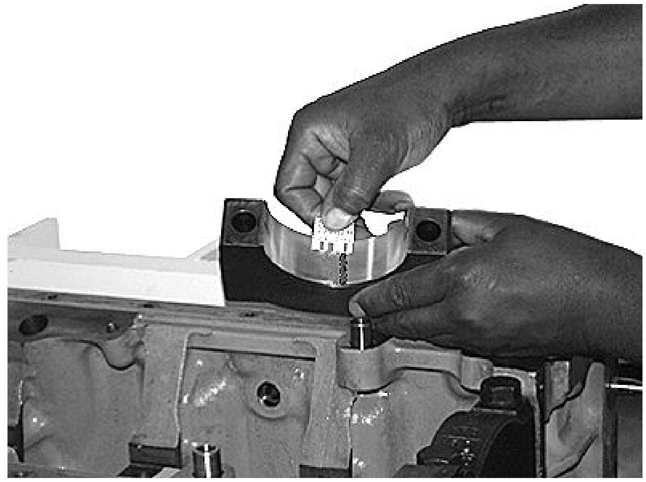

RG10220 —UN—01SEP09

Removing Main Bearing Cap

PLASTIGAGE is a registered trademark of DANA Corp.

RE38635,00000CC -19-15JUN11-2/2

Check Main Bearing Oil Clearance



Checking Main Bearing Oil Clearance

The use of PLASTIGAGE® will determine bearing-to-journal wear (oil clearance) but will not determine condition of the bearing or journal surfaces.

1. Place a strip of PLASTIGAGE® in the center of the main bearing cap (with insert) about three-fourths of the width of the bearing.
2. Use oil (SAE30) on PLASTIGAGE® to prevent smearing.
3. Install cap and tighten to specifications.

Specification

Main Bearing Caps—Torque.. 230 N·m (170 lb-ft)

4. Remove cap and compare width of PLASTIGAGE® with scale provided on wrapper to determine oil clearance.

Specification

Crankshaft Main Bearing-to-Journal—Oil Clearance.................................. 0.030—0.107 mm (0.0012—0.0042 in.)

PLASTIGAGE is a registered trademark of DANA Corp.

RG,RG34710,1169 -19-24JUN99-1/1

Remove Connecting Rod Caps and Remove Crankshaft

1. Rotate crankshaft using JDG820 or JDE81-1 Flywheel Turning Tool until connecting rod caps can be removed easily. You will be able to remove rod caps at each position.

2. Remove all connecting rod caps (A) with bearings (B), then remove No. 1 and 7 main bearing caps and bearings. See REMOVE PISTONS AND CONNECTING ROD ASSEMBLIES in Group 030.

CAUTION: Crankshaft is very heavy. Plan a proper handling procedure to avoid injury.

NOTE: Install a screw on each end of crankshaft to aid in lifting crankshaft.

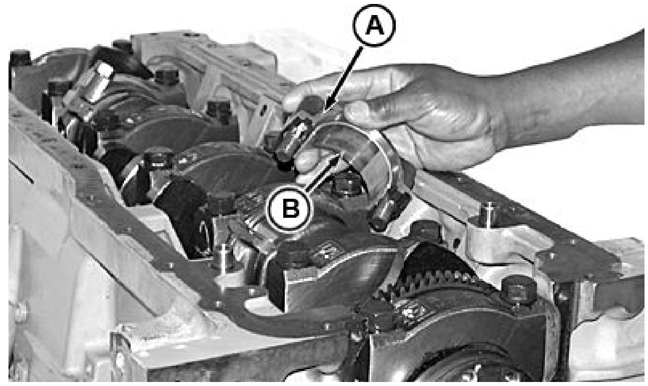
3. Install a cap screw in each end of crankshaft and attach a lifting strap to crankshaft as shown. Using proper lifting equipment, carefully raise crankshaft out of cylinder block.

4. Clean crankshaft, especially oil passages, using solvent and compressed sir.

5. Put crankshaft on clean V-blocks.

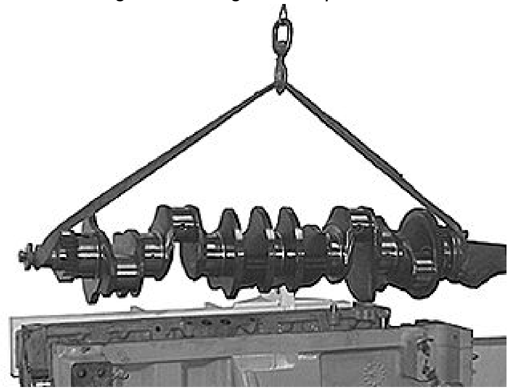
6. Remove rear wear sleeve from crankshaft flange, if not previously done, using one of the following methods:

   - Use JDG1020 Wear Sleeve Puller (same tool as for 6125 engines) to remove wear sleeve from crankshaft, as described earlier in this group. Position crankshaft rod journals in V-blocks so that crankshaft does not rotate while removing wear sleeve.
   - Use the ball side of a ball peen hammer and tap wear sleeve across its width in a straight line (to deform and stretch sleeve).



RG10209 —UN—28AUG09

Removing Connecting Rod Caps



RG10222 —UN—19AUG09

Removing Crankshaft

A—Connecting Rod Caps **B—Bearing**

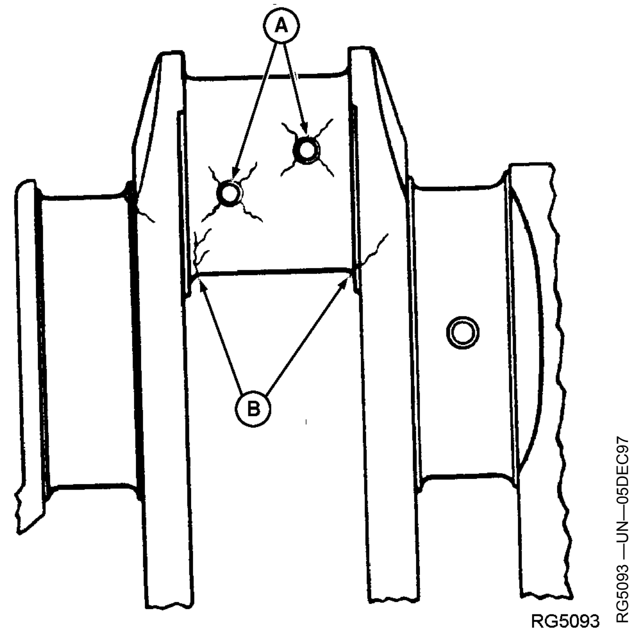
   - Score (but do not cut) the wear sleeve in several places around O.D. with a blunt chisel.

RE38635,000007F -19-02SEP08-1/1

Crankshaft — Inspection

NOTE: If crankshaft damper damage was discovered during teardown, the crankshaft should be magna-fluxed. This will verify whether of not it has microscopic cracks or fissures. See INSPECT VIBRATION DAMPER, in this group.

1. Thoroughly clean crankshaft. Clear restrictions from all oil passages.
2. Inspect crankshaft for signs of load stress, cracks, scratches on journals. Also check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft since heat treatment has probably been destroyed.
3. Inspect (front) crankshaft gear and (rear) oil pump drive gear for cracks, chipped teeth, or excessive wear. Replace gear(s) as required. See REPLACE CRANKSHAFT GEAR and REPLACE (CRANKSHAFT) OIL PUMP DRIVE GEAR, later in this group.
4. Inspect the keyway for evidence of cracks or wear. Replace crankshaft as necessary.
5. Carefully inspect rear hub of crankshaft in area of wear sleeve contact surface for evidence of rough or grooved condition. Any imperfections here will result in oil leaks. Slight ridges may be cleaned up with emery or crocus cloths.
6. Check each journal for evidence of excessive overheating or discoloration. If either condition exists, replace crankshaft since heat treatment has probably been destroyed.
7. Carefully check the crankshaft for cracks in the area of rod journal holes (A) and at journal fillets (B). Replace crankshaft if any cracks are found.



Inspecting Crankshaft

A—Rod Journal Holes **B—Journal Fillets**

IMPORTANT: Small cracks may not be visible to the eye. Use a method such as the Fluorescent Magnetic Particle method. This method magnetizes the crank, using magnetic particles which are fluorescent and glow under `black light'. The crankshaft must be de-magnetized after inspection.

RG,RG34710,1171 -19-23OCT97-1/1

Measure Assembled I.D. of Bearings and O.D. of Crankshaft Journals

NOTE: Also inspect and measure assembled I.D. of connecting rod bearings. Compare measurements with connecting rod journal O.D. on crankshaft. See INSPECT AND MEASURE CONNECTING ROD BEARINGS in Group 030.

1. With crankshaft removed from engine, install main bearing caps with bearing inserts. Be sure inserts are installed correctly.
2. Torque Turn main bearing cap screws to specifications.

Specification

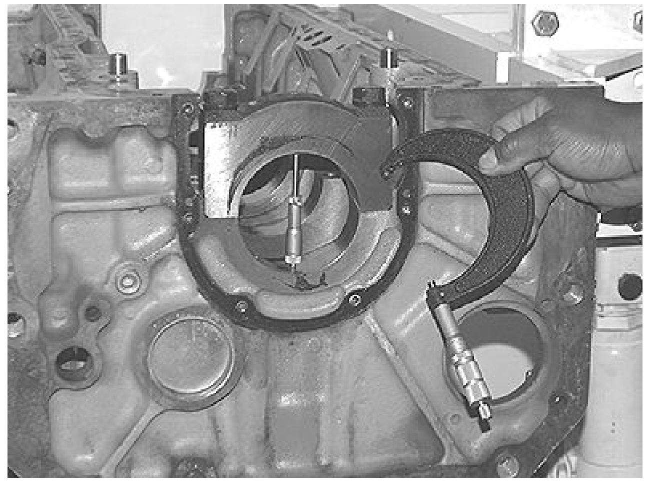
Crankshaft Main Bearing Cap Screws—Initial Torque.. 122 N•m (90 lb-ft)

3. After initial torque, turn main bearing cap screws an additional 120 degrees.
4. Measure I.D. of all assembled bearings in four locations 90° apart with an inside micrometer. Compare measurements with the following specifications.

Specification

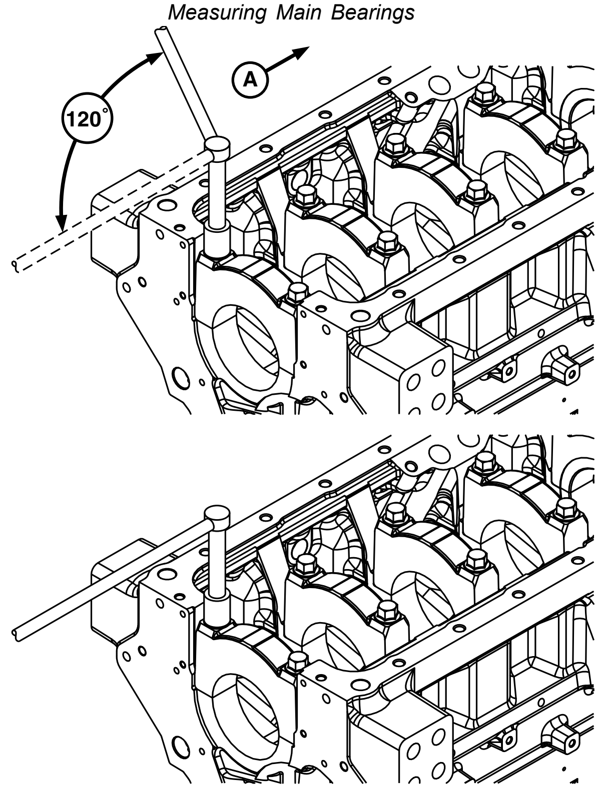
Crankshaft Main Bearing—ID With Bearing..................................95.270—95.320 mm (3.7508—3.7528 in.)
ID Without Bearing ....101.651—101.677 mm (4.0020—4.0030 in.)

A—Front of Engine



RG10223 —UN—18JUN99

Measuring Main Bearings



RG14068 —UN—29MAR05

Torque Turn Main Bearing Cap Bolts

Continued on next page RE38635,0000080 -19-17MAR05-1/2

5. Measure O.D. of all respective crankshaft main journals in four locations 90° apart. Compare measurements with the following specifications.

Specification

Crankshaft Main
Journal—OD..........................95.196—95.222 mm (3.7479—3.7490 in.)

NOTE: At this time, undersize or oversize bearings are not yet available for service. However, oil clearance must be 0.030—0.107 mm (0.0012-0.0042 in.). Replace bearings as needed.

Use crankshaft journal O.D. measurements to determine if journal is out-of-round or tapered.

Specification

Crankshaft Main
Journal—Taper per 25.4
mm (1.0 in.) length.. 0.0025 mm (0.0001 in.)
Out-of-Roundness .... 0.025 mm (0.0010 in.)

RG10224 —UN—18JUN99

Measuring Crankshaft Main Journals

RE38635,0000080 -19-17MAR05-2/2

Main Bearing Cap Line Bore Specifications

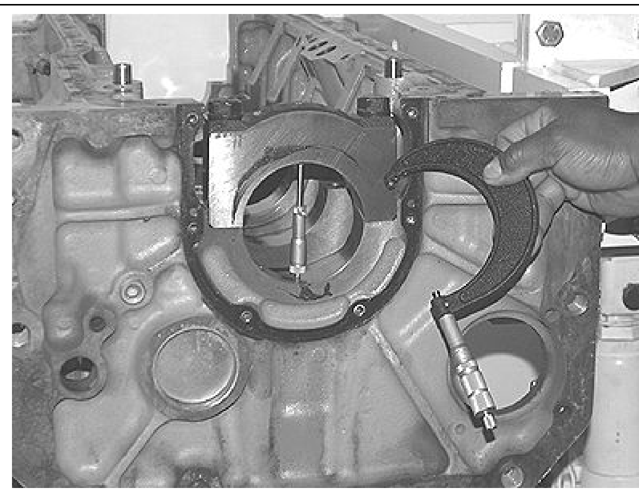
If any main bearing cap assembled I.D. is not within specification, blank (generic) bearing caps are available and must be line bored to specification. Replace individual bearing caps as needed.

1. Measure main bearing cap surface width.

Specification

Crankshaft Main Bearing
Cap—Surface Width......................36.28—36.78 mm (1.428—1.448 in.)

2. With crankshaft removed from cylinder block, install main bearing caps without bearing inserts.



RG10223 —UN—18JUN99

Measuring Main Bearing Cap Bores

Continued on next page

RE38635,0000081 -19-17MAR05-1/2

3. Tighten main bearing cap screws to specifications.

Specification

Crankshaft Main Bearing Cap Screws—Initial Torque.. 122 N•m (90 lb-ft)

4. After initial torque of 122 N•m, turn bolts an additional 120° as shown.

5. Measure I.D. of all bearing caps with an inside micrometer. Main bearing cap I.D. should be as follows:

Specification

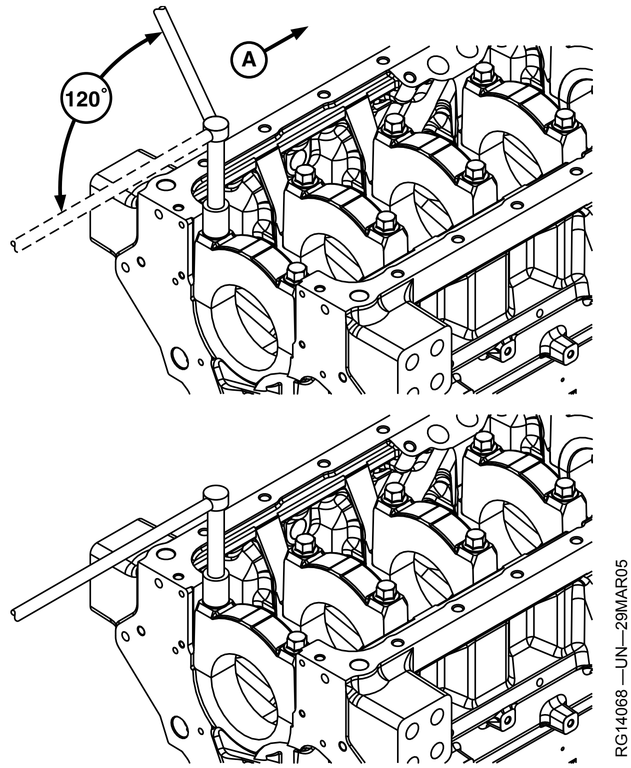
Main Bearing Assembled ID—ID.................................... 95.270—95.320 mm (3.7508—3.7528 in.)

If any main bearing cap assembled I.D. is not within specification, blank (generic) bearing caps are available and must be line bored to finished specification. Replace individual bearing caps as needed.

IMPORTANT: Main bearing cap line boring should be done ONLY by experienced personnel on equipment capable of maintaining bore specifications.

Specification

Main Bearing Cap Bore—ID Without Bearings (Standard)........... 101.651—101.677 mm (4.0020—4.0030 in.)
Diameter Variation .... 0.013 mm (0.0005 in.) maximum
Diameter Taper .... 0.008 mm (0.0003 in.) maximum
Straightness Variation (Any Bore-to-Adjacent Bore)... 0.038 mm (0.0015 in.) maximum
Straightness Variation (5 Center Bore-to-End Bore .... 0.076 mm (0.0030 in.) maximum
Centerline of Bore-to-Top Deck .... 352.35—352.50 mm (13.872—13.878 in.)



Torque Turn Main Bearing Cap Bolts

RE38635,0000081 -19-17MAR05-2/2

Thrust Bearing New Part Specifications

IMPORTANT: Install thrust bearing in cylinder block and tighten to specification before regrinding or polishing thrust surfaces to assure that all surfaces on bearing and on block web are correctly aligned.

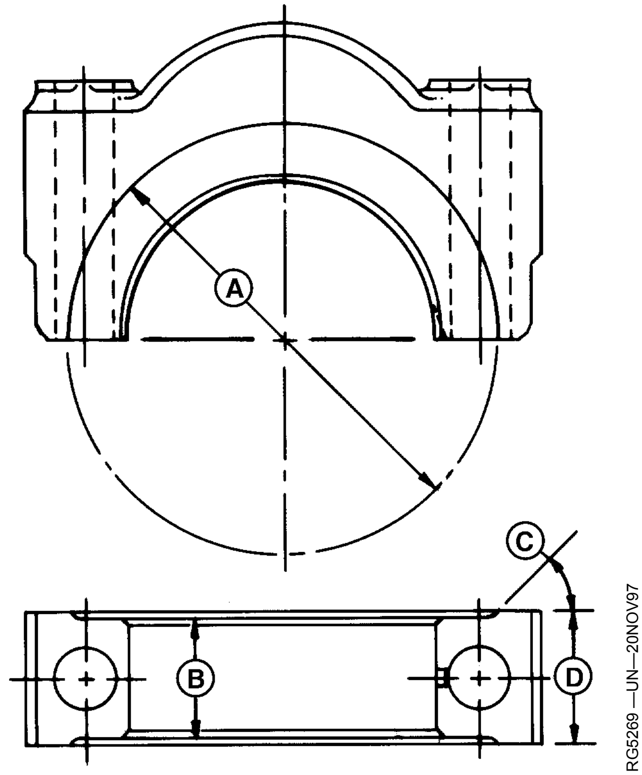
Specification

A—Thrust Washer Clearance[1]—Base Circle OD...129.286—130.810 mm (5.09—5.15 in.)
B—Thrust Bearing Cap—Surface Width......................37.44—37.54 mm (1.474—1.478 in.)
C—Thrust Washer Clearance— Relief Angle..45°
D—Thrust Bearing Cap—Overall Width (—1995)..41.81—42.31 mm (1.646—1.666 in.)
Overall Width (1995—)..................39.16—39.66 mm (1.542—1.561 in.)

Maximum runout for thrust surface is as follows:

Specification

Thrust Bearing Surface—Maximum Runout..0.25 mm (0.0010 in.)



Thrust Bearing Measurements

A—Thrust Washer Clearance Base Circle
B—Thrust Surface Thickness
C—Relief Angle
D—Bearing Cap Overall Width

[1] *Thrust (washer) surfaces on bearing cap must be flat in respect to mating thrust (washer) surfaces in cylinder block.*

RG,RG34710,1174 -19-10JUN99-1/1

Replace (Crankshaft) Oil Pump Drive Gear

IMPORTANT: Protect all machined surfaces of crankshaft from grinding debris and weld spatter when removing old gear and installing new gear. DO NOT use a cutting torch to remove failed gear.

1. Using a rotary grinding wheel or parting disc, grind weld beads (A) until flush with crankshaft flange.
2. Remove gear (B) by alternately striking gear at each weld location using a brass drift and soft lead mallet.
3. After removal of gear, clean up O.D. of crankshaft flange and remove any burrs or remaining weld bead to eliminate interference when installing new gear.

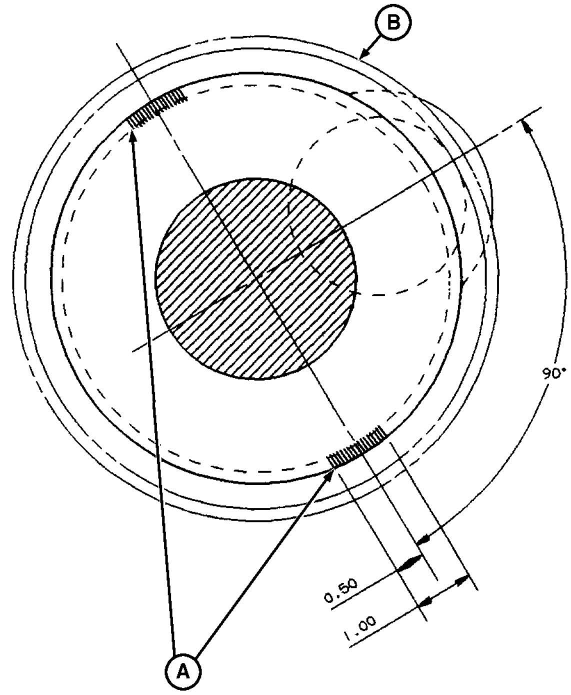
CAUTION: Oil fumes or oil can ignite above 193°C (380°F). Use a thermometer and do not exceed 182°C (360°F). Do not allow a heating element to be in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

IMPORTANT: DO NOT OVERHEAT GEAR. SEE CAUTION. Overheating may also destroy original heat treatment of gear.

4. Heat crankshaft gear to 148°C (300°F) using either heated oil or oven heat.
5. Drive gear onto crankshaft flange until flush against shoulder.

NOTE: When driving oil pump onto crankshaft flange, the beveled edge of gear teeth should face the flywheel end of crankshaft.

6. Weld two 25.4 mm (1 in.) beads according to illustration using 1/8 in. diameter 7018 welding rod.



RG5018 RG5018 —UN—05DEC97

Removing Crankshaft Oil Pump Drive Gear

A—Weld Beads **B—Gear**

Grind away excess weld to eliminate the possibility of interference with cylinder block.

RG,RG34710,1177 -19-23OCT97-1/1

Replace Crankshaft Gear

NOTE: Remove crankshaft gear for replacement only; it is not necessary to remove gear for crankshaft removal.

1. Install JDG787 Thread Protector in nose of crankshaft.
2. Protect crankshaft wear sleeve surface with masking tape.
3. Remove crankshaft gear using [1]D01251AA Puller or an equivalent puller.
4. Discard gear after removal.
5. Remove Woodruff key from crankshaft keyway.
6. Remove masking tape.

CAUTION: Oil fumes or oil can ignite above 193°C (380°F). Use a thermometer and do not exceed 182°C (360°F). Do not allow a heating element to be in direct contact with the oil. Heat the oil in a well-ventilated area. Plan a safe handling procedure to avoid burns.

IMPORTANT: Crankshaft gear must be installed on crankshaft before crankshaft is installed in engine, otherwise damage to thrust bearings could occur.

If flame heat is used, be sure gear is heated uniformly around circumference. DO NOT OVERHEAT. See CAUTION. Overheating may also destroy original heat treatment of gear.

7. Heat crankshaft gear (if removed) to 148°C (300°F), using either heated oil or oven heat.
8. Install Woodruff key in crankshaft.
9. Place gear on crankshaft flange. Be sure key on crankshaft is properly aligned with keyway in gear.

IMPORTANT: When installing gear, do not gouge or nick crankshaft flange.

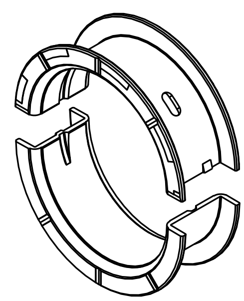
10. Use JDH7 Driver to firmly seat gear against crankshaft flange.
11. Once gear cools, reseat gear using JDH7 Driver.

[1]*Part of D01047AA 17-1/2 and 30-Ton Puller Set.*

RG,RG34710,1178 -19-01JUL09-1/1

Inspect Thrust Bearings

Check thrust surfaces of the thrust bearing and the thrust bearing journal on crankshaft and replace as necessary.



RG14188 —UN—18MAY05

6090 Main Thrust Bearing

RE38635,000000E -19-19MAY05-1/1

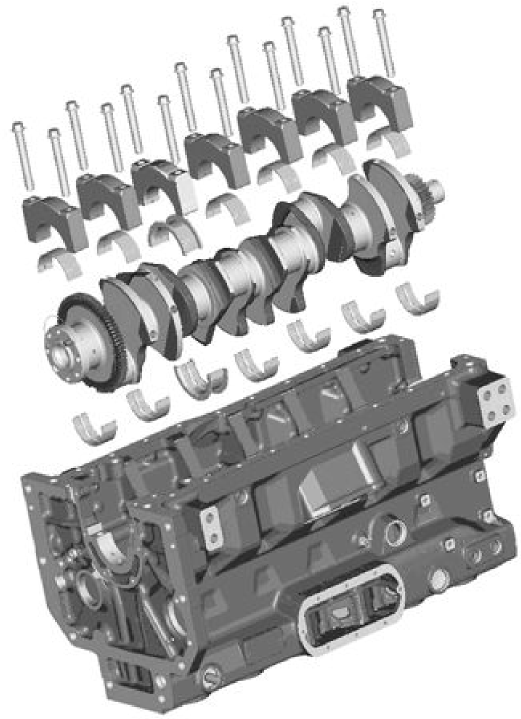
Install Main Bearings and Crankshaft

IMPORTANT: If new main or thrust bearing inserts or thrust washers are installed, they must be installed as a matched set.

During assembly, apply a liberal coating of clean engine oil to:

- Inside diameter of main bearing inserts and thrust bearing inserts
- Entire O.D. of crankshaft main bearing journal

1. Install six main bearing inserts in block except No. 5 thrust bearing insert. Be sure locating tabs on inserts are properly positioned with slot in block web.
2. Install No. 5 main thrust bearing insert in block.
3. Check to make sure that oil holes in main bearing web are properly aligned with oil holes in bearing inserts.



RG14073 —UN—18MAR05

Crankshaft & Bearing Assembly

Continued on next page

RE38635,00000CD -19-15JUN11-1/3

CAUTION: Crankshaft is heavy. Plan a proper lifting procedure to avoid injuries.

4. Carefully position crankshaft onto main bearing inserts using a hoist and lift sling, as shown.

NOTE: Main bearing cap screws ore one time use only.

5. Dip new main bearing cap screws (A) in clean engine oil. Allow excess oil to drain from cap screws. Apply a liberal amount of oil to bearing inserts in caps.
6. Assemble cap screws to main bearing caps and install each bearing cap (B) with assembled bearings (C) with the recesses and tabs aligned in matching order. Make sure bearing tabs also match up before tightening cap screws.

NOTE: Make sure main bearing caps are installed on the bearing bosses from which they were removed. The numbers (D) stamped on the caps should be on the same side as the numbers on the block. Bearing caps have the numbers 1—7 stamped on top face and block castings have only the No. 1 and No. 7 cylinders stamped for reference

If there is an arrow (E) on cap, arrow is normally on the camshaft side of the block and should be pointing towards the front of the engine. If bearing caps have been re-bored, make sure bearing caps have numbers stamped on them.

IMPORTANT: Do not use pneumatic wrench to install main bearing cap screws, as damage may occur to threads.

7. Before tightening cap screws on main bearing caps, align upper and lower thrust flanges on main thrust bearings. Using a soft-face hammer, tap crankshaft to the rear and then to the front to line up thrust bearing flanges.
8. Tighten No.'s 1, 2, 3, 4, 6, and 7 main bearing cap screws to initial torque specifications.

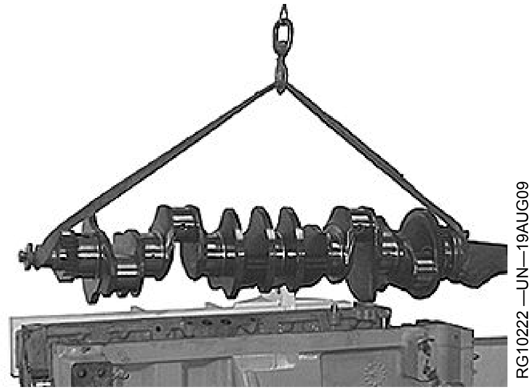
Specification

Crankshaft Main Bearing Cap Screws—Initial Torque.......... 122 N•m (90 lb-ft)

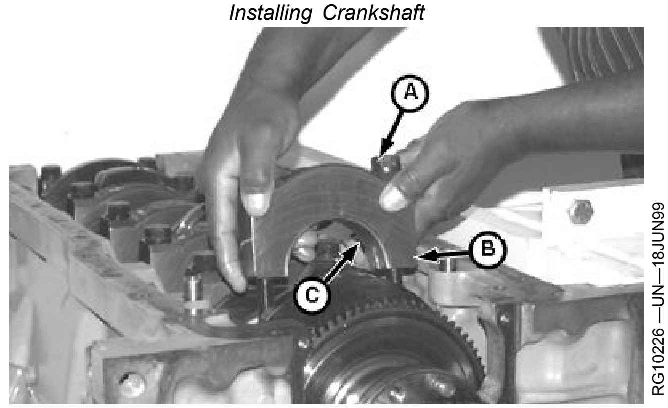
Hand-tighten No. 5 main thrust bearing cap screws.

9. Gently pry crankshaft rearward and then forward to align thrust washers on No. 5 main thrust bearing.

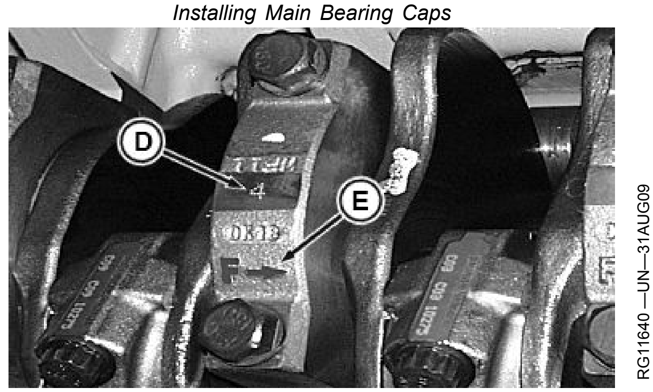
NOTE: DO NOT PRY crankshaft on No. 5 main thrust bearing.



Installing Crankshaft



Installing Main Bearing Caps



Stamped Main Bearing Cap

A—Cap Screw with Washer
B—Bearing Cap
C—Bearing
D—Stamped Cylinder Number
E—Stamped Arrow

10. Tighten No. 5 main thrust bearing cap screws to specification above.

Continued on next page

RE38635,00000CD -19-15JUN11-2/3

11. Tighten all main bearing cap screws to final torque specification.

Specification

Crankshaft Main Bearing Cap Screws—Final Torque..Additional 120° (between 1/4 - 1/2 turn)

12. Turn crankshaft by hand. If it does not turn easily, disassemble parts and determine the cause.

13. Install connecting rod bearings and connecting rods caps. See INSTALL PISTON AND CONNECTING ROD in Group 030.

14. Check crankshaft for specified end play.

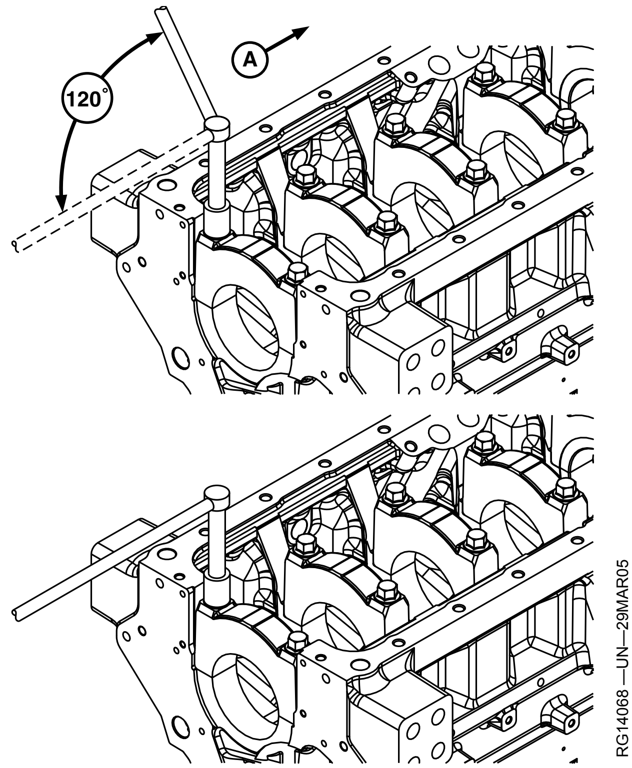
Specification

Crankshaft—End Play..............0.038—0.380 mm (0.00150—0.0150 in.)

15. Install oil pump and check drive gear-to-crankshaft clearance. See INSTALL ENGINE OIL PUMP in Group 060.

Specification

Oil Pump Drive Gear-to-Crankshaft—Backlash Clearance..0.38 mm (0.015 in.)



Torque Turn Main & Thrust Bearings

A—Front of Engine

RE38635,00000CD -19-15JUN11-3/3

Check Crankshaft Rear Oil Seal Housing Runout

IMPORTANT: On service "short block" assemblies, rear oil seal housing runout is preset at the factory. Do not remove housing from block.

1. Position magnetic base dial indicator (A) on end of crankshaft flange as shown. Preset dial indicator tip on I.D. of oil seal housing bore (B).

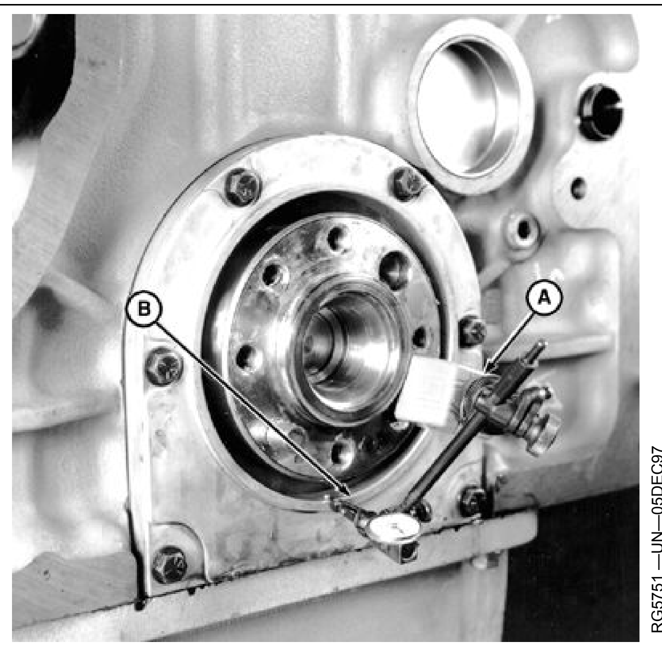
2. Zero dial indicator and rotate crankshaft one full revolution, observe full indicator movement. The maximum oil seal housing bore runout is as follows:

Specification

Crankshaft Rear Oil Seal Housing—Maximum Runout..0.152 mm (0.006 in.)

   If runout exceeds specification, loosen cap screws and adjust housing to obtain an acceptable runout while keeping bottom of seal housing flush with oil pan mating surface.

3. Recheck oil seal housing bore runout. If runout still exceeds specification, oil seal housing bore is possibly distorted and should be replaced. See INSTALL CRANKSHAFT REAR OIL SEAL HOUSING, earlier in this group.



Checking Rear Oil Housing Runout

A—Magnetic Base Dial Indicator

B—Oil Seal Housing Bore

RG,RG34710,1183 -19-23OCT97-1/1

Install Thrust Washer and Timing Gear Cover

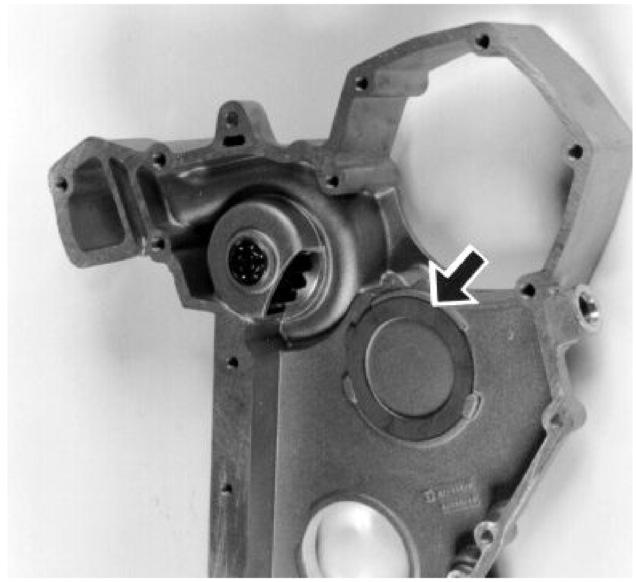
1. Lubricate thrust washer (bold arrow) with TY6333 or TY6347 High Temperature Grease and install in timing gear cover tabs.
2. Install a new gasket over dowel pins at bottom of cylinder block face. Use additional guide pins if necessary.
3. If equipped with auxiliary drive, install a new gasket with the auxiliary drive housing with gear onto the timing gear cover. See REMOVE, INSPECT AND INSTALL CRANKSHAFT GEAR-DRIVEN AUXILIARY DRIVE, earlier in this group.)

IMPORTANT: Tightening the timing gear cover cap screws in proper sequence controls the total runout of the crankshaft flange-to-oil seal bore.

If equipped with auxiliary drive, tighten auxiliary drive housing to timing gear cover and to cylinder block prior to tightening the timing gear cover to cylinder block. See REMOVE, INSPECT AND INSTALL CRANKSHAFT GEAR-DRIVEN AUXILIARY DRIVE in this group.

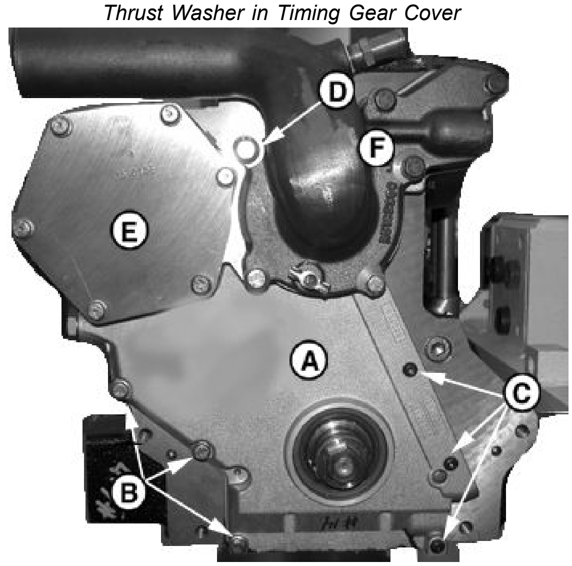
4. Install timing gear cover (A) over gasket and guide pins. Use crankshaft pilot to guide front seal. Install three M8 hex head cap screws (B), three M8 button head cap screws (C), and one M10 hex head cap screw (D).

A—Timing Gear Cover
B—M8 Hex Head Cap Screws (3)
C—M8 Button Head Cap Screws (3)
D—M10 Cap Screw (1)
E—Fuel Pump Drive Gear Cover
F—Coolant Pump Cover



RG7060 —UN—26NOV97

Thrust Washer in Timing Gear Cover



RG14748 —UN—03FEB06

Install Timing Gear over

Continued on next page

RE38635,0000066 -19-27MAR09-1/2

5. Tighten cap screws to specification in the sequence shown.

Specification

M8 Timing Gear Cover-to-Cylinder Block Cap Screws—Torque.....27 N•m (20 lb-ft)
M10 Timing Gear Cover-to-Cylinder Block Cap Screw—Torque.....41 N•m (30 lb-ft)

6. Install coolant pump, cover assembly (F), and new gasket to two dowel pins in timing gear cover face.

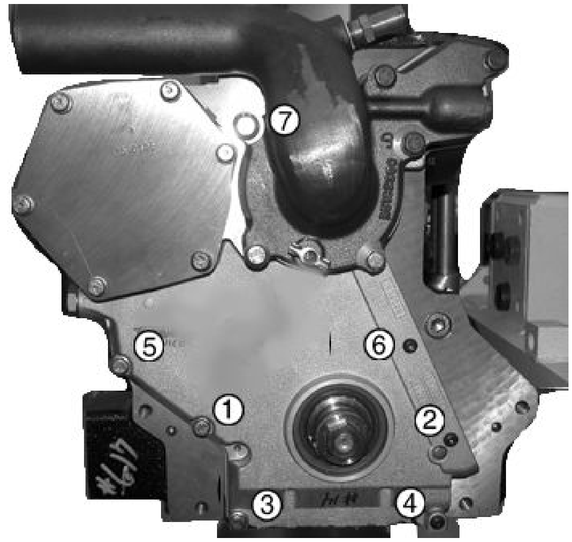
7. Install five M10 and one M8 cap screw to secure coolant pump cover. Tighten cap screws to specification.

Coolant Pump Cover-to-Timing Gear Cover—Specification

M10 Cap Screws—Torque.....47 Ṅ•m (35 lb-ft)
M8 Cap Screw—Torque.....32 Ṅ•m (24 lb-ft)

8. Check camshaft endplay. See CHECK CAMSHAFT END PLAY AND MEASURE GEAR BACKLASH earlier in this group.)

9. Install injection pump drive gear cover (E) using a new gasket and tighten cap screws to specifications.



Timing Gear Cover Torque Sequence

Specification

Injection Pump Drive Gear Cover—Torque.....31 Ṅ•m (23 lb-ft)

10. Trim timing gear cover gasket flush with oil pan gasket rail.

RE38635,0000066 -19-27MAR09-2/2

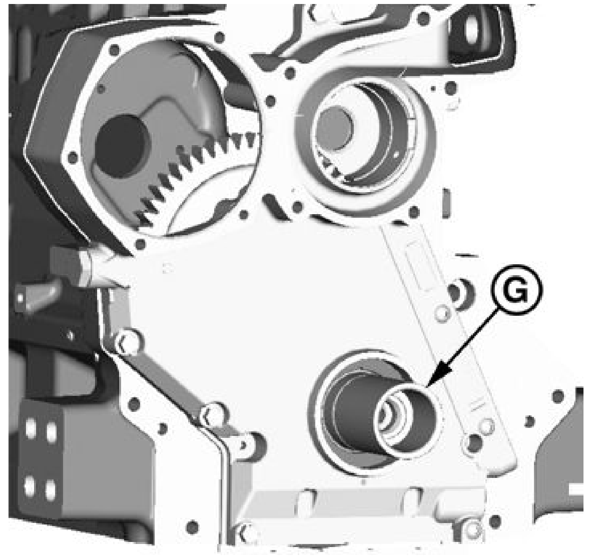
Install Unitized Front Crankshaft Oil Seal

IMPORTANT: It is important to note which type of seal is being replaced on the engine. Older engines used a two piece seal which included a wear sleeve. For service of those engines, the spacer provided in the kit MUST BE installed with the seal. The spacer fills space previously taken by the wear sleeve.

On newer engines where the new unitized seal was installed at the factory, this spacer is not required.

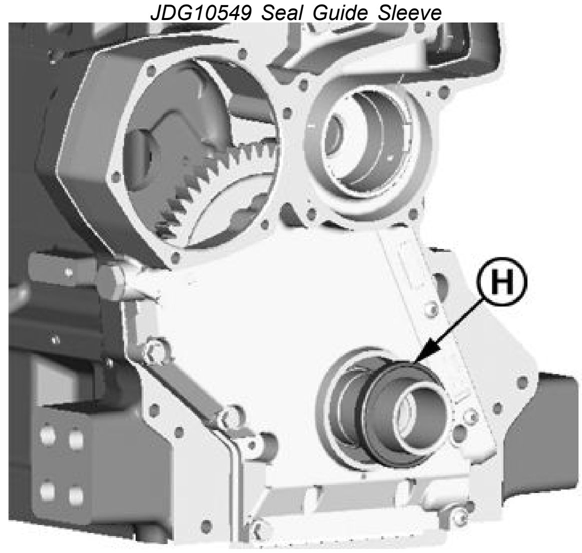
1. Place JDG10549 seal guide sleeve (G) over crankshaft nose.
2. Install unitized front crankshaft oil seal (H) over guide sleeve.
3. Install JDG10549 seal press tool (I) over guide sleeve and tighten forcing screw until tool bottoms out on guide sleeve.
4. Remove seal press tool and guide sleeve.

G—JDG10549 Seal Guide Sleeve
H—Unitized Front Oil Seal
I— JDG10549 Seal Press and Forcing Screw



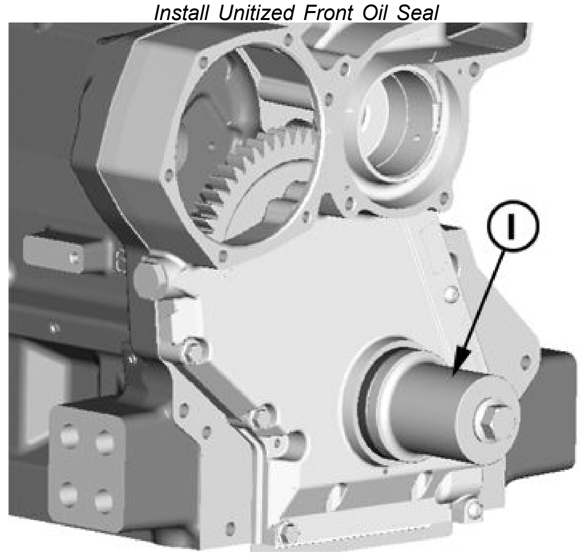
RG15403 —UN—29JUN07

JDG10549 Seal Guide Sleeve



RG15433 —UN—19JUL07

Install Unitized Front Oil Seal



RG15434 —UN—19JUL07

JDG10549 Seal Press

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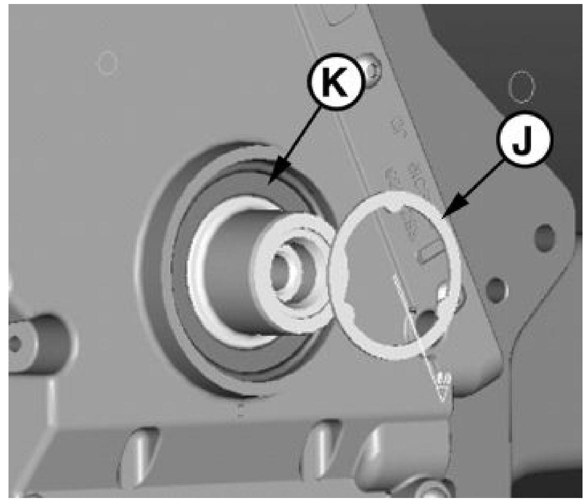
AS58880,000004F -19-21JUL08-1/2

NOTE: If the oil seal removed from the engine has a wear sleeve, the spacer included in the kit MUST be installed AFTER installation of the seal.

IMPORTANT: When the spacer is installed over the crankshaft nose, it will stop against a shoulder on the crankshaft, 1-2 mm prior to contacting the seal.

5. Install spacer (J) over crankshaft nose and position against shoulder of crankshaft, 1-2 mm prior to contacting seal.

J— Spacer **K—Oil Seal**



RG15435 —UN—19JUL07

Unitized Front Oil Seal and Spacer

RG15436 —UN—19JUL07

Complete Assembly

AS58880,000004F -19-21JUL08-2/2

Install Vibration Damper

NOTE: On engines with dual dampers, ALWAYS replace both dampers as a matched set.

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

1. Install crankshaft Woodruff key with tab facing toward front of engine and key firmly seated in keyway. Position damper (B) onto crankshaft.

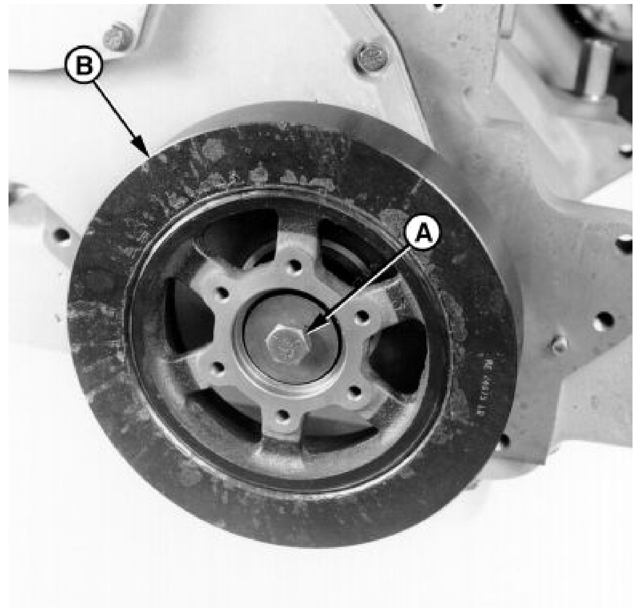
IMPORTANT: Always use new cap screws when installing damper to crankshaft and fan pulley to damper.

2. Use hardened washer (part of damper assembly) and insert a cap screw that is 25 mm (1 in.) longer than original cap screw (A). Tighten cap screw until it just bottoms out.
3. Remove cap screw and install original cap screw with same hardened washer.
4. Tighten cap screw to specifications.

Specification	
Vibration Damper-to-Crankshaft Cap Screws—Torque	230 N·m (170 lb-ft)

5. Install crankshaft pulley (if equipped) to damper. Tighten cap screws to specifications.

Specification	
Crankshaft Pulley-to-Damper Cap Screws (Single Dampers for Gen-Set Applications)—Torque	61 N·m (45 lb-ft)
Crankshaft Pulley-to-Damper Cap Screws (All Other Applications)—Torque	70 N·m (52 lb-ft)



Installing Vibration Damper

A—Cap Screw **B—Damper**

RE38635,0000086 -19-18MAR05-1/1

Install SAE 2 and 3 Flywheel Housing

On SAE 1 and all aluminum flywheel housings, the flywheel housing is installed AFTER the flywheel.

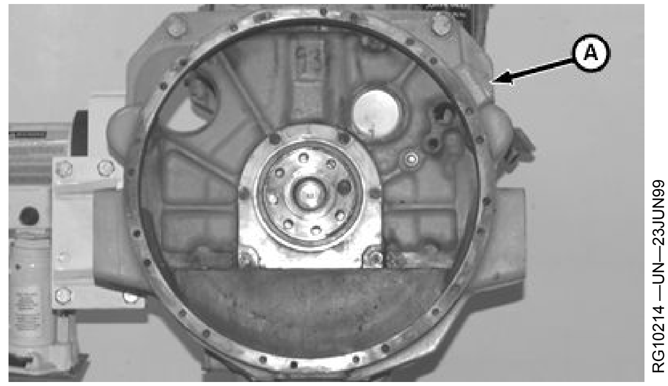
CAUTION: Flywheel housing (A) is heavy. Plan a handling procedure to avoid personal injuries.

NOTE: See Oil Pan — Installation for using sealant on the T-joints on front and rear of cylinder block, timing gear cover, and flywheel housing joints.

1. Inspect cylinder block and flywheel housing gasket surfaces to see that they are clean. Scrape off all old gasket material.
2. Position flywheel housing gasket over the two dowel pins in rear cylinder block face.
3. Install flywheel housing on cylinder block.

NOTE: Use new cap screws when installing flywheel housing.

4. Dip threads of cap screw in engine oil before installing. Install and tighten cap screws to specifications.



Installing SAE 3 Flywheel Housing

A—Flywheel Housing

Specification

SAE 2 and 3 Flywheel Housing-to-Cylinder Block Cap Screws—Torque....365 N•m (269 lb-ft)
SAE 3 Flywheel Housing-to-Oil Pan 12 mm. Cap Screws—Torque....129 N•m (95 lb-ft)
SAE 3 Flywheel Housing-to-Oil Pan 10 mm. Cap Screws—Torque....47 N•m (35 lb-ft)
SAE 2 Flywheel Housing-to-Cylinder Block 19 mm. Cap Screws (With Rear PTO)—Torque....325 N•m (240 lb-ft)
SAE 2 Flywheel Housing-to-Cylinder Block 15 mm. Cap Screws (With Rear PTO)—Torque....275 N•m (203 lb-ft)

RE38635,00000CF -19-15JUN11-1/1

Install Flywheel

Two guide studs may be used at cap screw locations (A) opposite each other to aid in flywheel installation.

CAUTION: Flywheel is heavy. Plan a handling procedure to avoid personal injuries.

NOTE: ALWAYS use new cap screws when installing flywheel. DO NOT use plated cap screws.

IMPORTANT: Flywheel must be clean and free of oil before installing. Clean threaded holes in crankshaft carefully. DO NOT blow them out with compressed air. These are through holes and debris could be blown into the engine crankcase.

1. **On engines without rear PTO**, coat threads of flywheel attaching cap screws with LOCTITE® 242 or its equivalent.
2. Position flywheel over dowel pin and install drive hub (if equipped). Start four cap screws. Remove guide studs and install remaining cap screws.
3. Install remaining flywheel attaching cap screws.
4. Tighten flywheel attaching cap screws to specifications.

Specification

Drive Hub-to-Flywheel Cap Screws—Torque..115 N·m (85 lb-ft)

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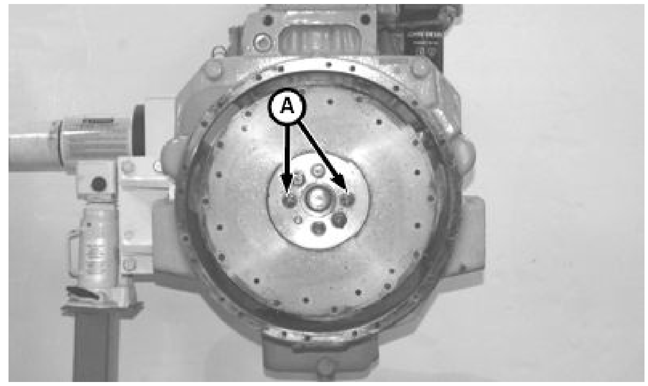


Installing Flywheel

A—Locations for Guide Studs

Flywheel-to-Crankshaft Cap Screws (With Rear PTO)—Torque.. 162 N·m (120 b-ft)
Flywheel-to-Crankshaft Cap Screws (All Other Applications)—Torque...115 N·m (85 lb-ft)

RG,RG34710,1191 -19-10JUN99-1/1

Install SAE 1 Flywheel Housing

CAUTION: Flywheel housing is heavy. Plan a handling procedure to avoid personal injuries.

On SAE 2 and 3 cast-iron flywheel housings, the housing MUST be installed BEFORE installing flywheel.

1. Be sure flywheel housing mounting surface is clean and dry and free of any debris.
2. Install flywheel housing on cylinder block.

NOTE: ALWAYS use new cap screws when installing flywheel housing.

3. Dip threads of cap screw in engine oil before installing. Install and tighten cap screws to specifications.

Specification

SAE 1 Flywheel Housing-to-Cylinder Block Cap Screws—Torque...365 N•m (269 lb-ft)

RE38635,00000CE -19-15JUN11-1/1

Complete Final Assembly

1. Install oil pump assembly and oil pan. Fill engine with clean engine oil.
2. Fill cooling system with proper coolant after engine installation and perform engine break-in. See PERFORM ENGINE BREAK-INat end of Group 021.

RG,RG34710,1193 -19-02SEP08-1/1

Check Camshaft End Play and Measure Gear Backlash

NOTE: Camshaft end play must be measured before removing timing gear cover, as thrust washer in back side of timing gear cover limits camshaft end play.

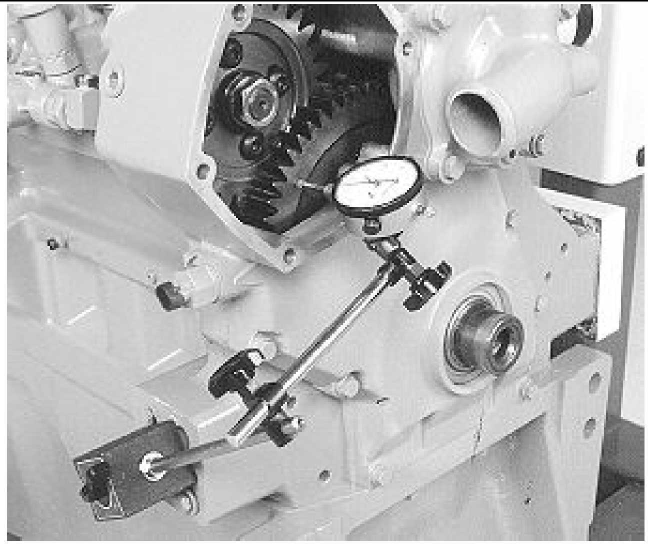
1. Remove injection pump drive gear cover (shown removed).
2. Install magnetic base dial indicator on front face of cylinder block and position dial indicator tip on front face of camshaft gear, as shown. Set dial indicator to zero.
3. Move camshaft gear back and forth and observe end play reading. Compare reading with specification given below.

Specification

Camshaft—End Play............0.010—0.600 mm (0.0004—0.024 in.) new
Wear Limit .... 0.65 mm (0.0260 in.) maximum allowable

If end play is excessive, remove timing gear cover and crankshaft and measure thickness of thrust washers.

4. Position indicator plunger tip against camshaft gear tooth with a preload.
5. Measure backlash between camshaft drive gear and crankshaft gear in three (3) different positions around the camshaft gear. Compare readings with specifications given below.


RG7211 —UN—28JUL94

Measuring Camshaft End Play

Specification

Camshaft Drive
Gear-to-Crankshaft
Gear—Backlash..0.076 mm (0.003 in.) min.

Replace gear if backlash does not equal or exceed specification.

RG,RG34710,1199 -19-16FEB05-1/1

Remove Vibration Damper and Timing Gear Cover

1. Drain oil and engine coolant (if not previously done).
2. Remove oil pan.
3. Remove cap screw and washer on damper pulley. Install JDG787 Thread Protector in nose of crankshaft.

IMPORTANT: DO NOT use a jaw-type puller to remove vibration damper. Damage could result to the damper. Never apply thrust on outer ring of damper. Do not drop damper or strike with a hammer.

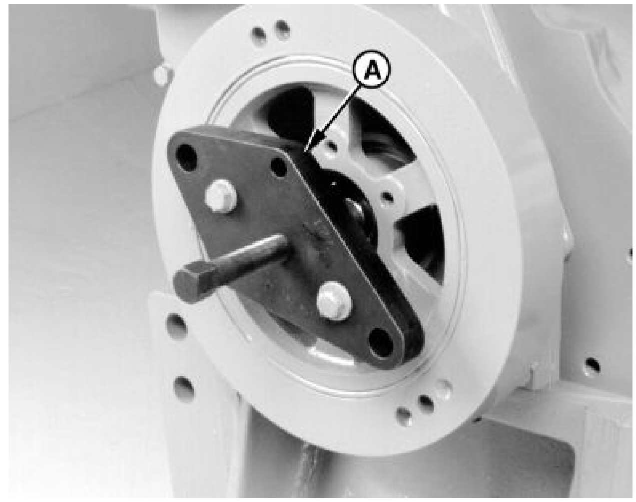
4. Remove damper from crankshaft using JDG721 Hub Puller (A).

NOTE: D01207AA (OTC518) Puller Set (not shown) may also be used to remove damper.

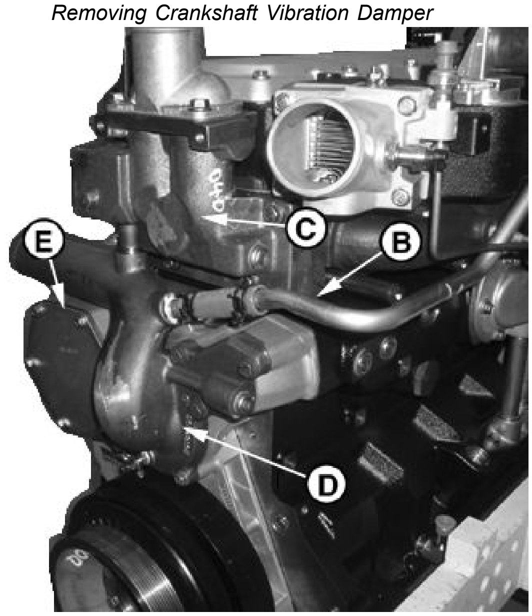
5. Disconnect Exhaust Gas Recirculator (EGR) coolant return line (B).
6. Remove injection pump drive gear cover (E).
7. Check camshaft end play. See CHECK CAMSHAFT END PLAY AND MEASURE GEAR BACKLASH earlier in this group.

IMPORTANT: Whenever timing gear cover is removed, ALWAYS install a new front oil seal and wear sleeve.

8. Remove thermostat cover & thermostat housing (C).
9. If equipped, remove crankshaft gear-driven auxiliary drive. See REMOVE, INSPECT AND INSTALL CRANKSHAFT GEAR-DRIVEN AUXILIARY DRIVE later in this group.
10. Remove coolant pump cover (D).
11. Remove all remaining cap screws and remove timing gear cover.
12. Remove front oil seal from timing gear cover. Install a new seal after timing gear cover is installed. See INSTALL CRANKSHAFT FRONT OIL SEAL in Group 040.
13. Remove crankshaft front wear sleeve. See REMOVE CRANKSHAFT FRONT OIL SEAL AND WEAR SLEEVE in Group 040.



Removing Crankshaft Vibration Damper



Removing Timing Gear Cover

A—JDG721 Hub Puller
B—EGR Coolant Return Line
C—Thermostat Cover & Housing
D—Coolant Pump Cover
E—Injection Pump Drive Gear Cover

RE38635,0000020 -19-07MAR07-1/1

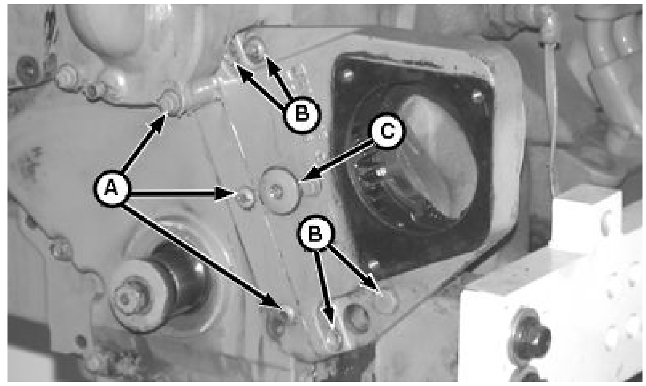
Remove, Inspect, and Install Crankshaft Gear-Driven Auxiliary Drive—If Equipped

NOTE: Auxiliary drive hardware will remain English on the 6090 engine.

NOTE: Various auxiliary drive options are available; removal and installation of all options are similar. The auxiliary drive is integrated into the engine front timing gear cover. Refer to CTM67-OEM Engine Accessories for removal of auxiliary drive accessories and repair of auxiliary drive components.

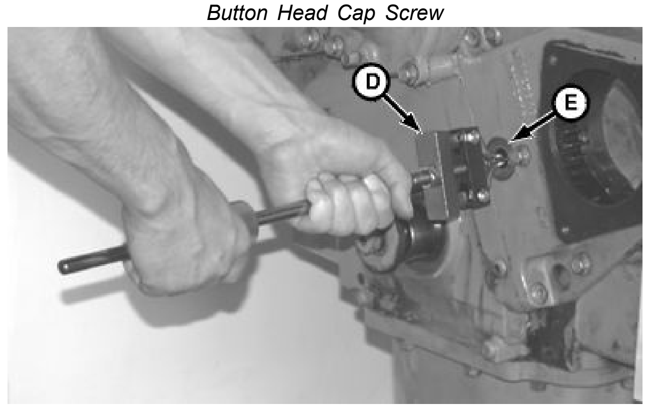
1. If equipped, remove auxiliary drive accessory (air compressor, hydraulic pump, etc.) (shown removed).
2. Remove vibration damper (shown removed).
3. Loosen idler housing cap screws (B) and timing gear cover cap screws (A).
4. Remove button head cap screw (C).
5. Remove idler gear bushing/spacer (E) from timing gear cover using D01209AA Slide Hammer and Attachment (D) and discard bushing/spacer.

A—Timing Gear Cover Cap Screws
B—Idler Housing Cap Screws
C—Button Head Cap Screw
D—D01209AA Puller
E—Idler Gear Bushing/Spacer



RG10055 —UN—23JUN99

Button Head Cap Screw



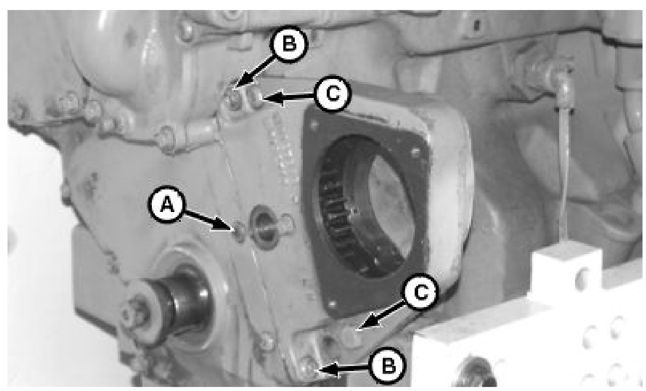
RG10056 —UN—23JUN99

Auxiliary Drive Idler Bushing/Spacer

RE38635,0000061 -19-21FEB05-1/6

6. Remove cap screws (A—C) and remove idler housing and gear.
7. Remove idler housing-to-timing gear housing face seal and O-ring. Face seal may be reused if not damaged.
8. Clean and inspect auxiliary drive assembly for cracked housing, worn or damaged bearings and damaged gear or spline. Replace components as required.

A—Timing Gear Cover-to-Cylinder Block Cap Screw
B—Idler Housing-to-Timing Gear Cover Cap Screws
C—Idler Housing-to-Cylinder Block Cap Screws



RG10057 —UN—23JUN99

Remove Auxiliary Drive Assembly

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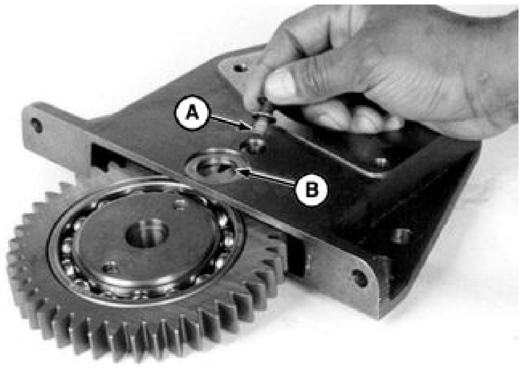
RE38635,0000061 -19-21FEB05-2/6

9. Grease and install O-ring in housing bore (B).

NOTE: Inner idler bearing support has one threaded hole, and is installed toward block side of housing.

10. If removed, install idler gear into idler housing. Install cap screw with seal (A) to hold idler gear in place.

A—Cap Screw **B—Housing Bore**



Idler Gear

RE38635,0000061 -19-21FEB05-3/6

11. Insert idler shaft through idler housing and idler gear until flush with block side of housing.

IMPORTANT: White dot on one end of shaft must face out toward front of engine.

12. Grease O-ring groove (A) in back side of idler housing. Insert O-ring.

A—O-Ring Groove

O-Ring Groove

RE38635,0000061 -19-21FEB05-4/6

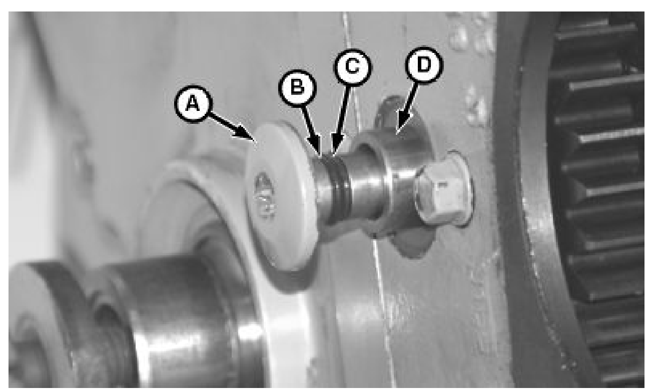
NOTE: Face seal may be reused if it is not cut, nicked, or damaged.

13. Using a short guide stud, place face seal on timing gear cover opening. Gauge hole in seal must be positioned toward bottom of opening.

IMPORTANT: Be careful not to damage face seal or displace O-ring on back side of idler housing during assembly.

14. Carefully insert idler gear into opening of timing gear cover until idler gear meshes with crankshaft gear, and housing is seated against face seal. Push idler bushing/spacer (D) into block.

15. Check condition of O-rings (B) and (C) on large button head cap screw (A). Grease O-rings and install cap screw through idler shaft. Thread into block until finger tight.



Button Head Cap Screw

A—Button Head Cap Screw
B—Large O-Ring
C—Small O-Ring
D—Idler Bushing/Spacer

Continued on next page

RE38635,0000061 -19-21FEB05-5/6

NOTE: Center timing gear cover-to-cylinder block cap screw must have a seal.

16. Remove guide stud. Install timing gear cover cap screws (E), idler housing cap screws (A and B) and cap screw (D) finger tight.

17. Tighten cap screws to specifications in the following sequence:

- Idler housing-to-timing gear cover (A):

Specification

Auxiliary Drive Idler Housing-to-Timing Gear Cover (3/8 inch.)—Torque................41 N•m (30 lb-ft)

- Idler housing-to-cylinder block (B) 10 mm cap screws:

Specification

Auxiliary Drive Idler Housing-to-Cylinder Block (3/8 inch.)—Torque................41 N•m (30 lb-ft)

- Idler housing-to-cylinder block (D) 12 mm cap screws:

Specification

Auxiliary Drive Idler Housing-to-Cylinder Block (1/2 inch.)—Torque................127 N•m (94 lb-ft)

- Idler bushing/spacer button head cap screw (F):

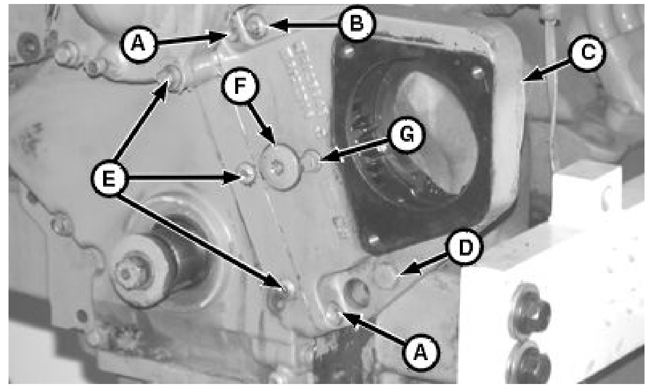
Specification

Auxiliary Drive Idler Shaft Button Head Cap Screw—Torque................150 Ṅ•m (110 lb-ft)

- Timing gear cover-to-cylinder block (E):

Specification

Timing Gear Cover-to-Cylinder Block Cap Screws (5/16 inch.)—Torque................27 N•m (20 lb-ft)



RG10236 —UN—30JUN99

Install Auxiliary Drive Assembly

A—Idler Housing-to-Timing Gear Cover Cap Screws
B—Idler Housing-to-Cylinder Block Cap Screw
C—Idler Housing
D—Idler Housing-to-Cylinder Block Cap Screw
E—Timing Gear Cover-to-Cylinder Block Cap Screws
F—Idler Bushing Button Head Cap Screw
G—Idler Housing-to-Idler Bearing Cap Screw

- Idler housing-to-idler bearing (G):

Specification

Auxiliary Drive Idler Housing-to-Idler Bearing (5/16 inch.)—Torque................27 N•m (20 lb-ft)

18. Check idler gear-to-crankshaft gear backlash. Backlash must be as follows:

Specification

Auxiliary Drive Idler Gear-to-Crankshaft Gear—Backlash................0.11—0.7 mm (0.004—0.028 in.)

19. Install vibration damper.

RE38635,0000061 -19-21FEB05-6/6

Remove Camshaft

NOTE: It is not necessary to remove cylinder head from engine for camshaft removal. If push rods are bent or show excessive scuffing, it may be necessary to remove cylinder head for inspection of block, head, cam lobes and cam followers.

1. Drain engine oil and coolant, if not previously done. Remove timing gear cover as detailed earlier in this group. See <u>REMOVE VIBRATION DAMPER AND TIMING GEAR COVER</u> in this group.
2. Rotate engine flywheel with JDE81-1 or JDG820 Flywheel Rotation Tool and lock engine at No. 1 cylinder's “TDC-Compression” stroke with JDE81-4 Timing Pin. Timing marks (A) on camshaft gear and crankshaft gear should be aligned.

   If timing marks are not aligned, remove timing pin and continue to rotate engine until marks align. Timing pin should enter hole in flywheel. Engine will be locked at No. 1 “TDC-Compression” stroke.
3. Remove rocker arm assembly and push rods. See <u>REMOVE CYLINDER HEAD</u> in Group 020.

RG6614 —UN—05DEC97

Timing Marks—Camshaft and Crankshaft Gears

A—Timing Marks

4. When removing camshaft with engine on rollover stand, roll engine to a position where followers fall away from camshaft lobes (oil pan side up).

RG,RG34710,1202 -19-23OCT97-1/3

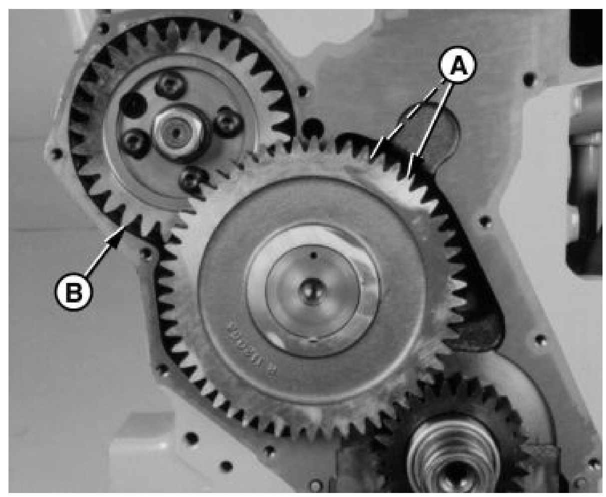
5. Examine both camshaft gears (A) and injection pump drive gear (B) for worn or damaged gear teeth. Gears should have a minimum backlash as follows:

Specification

Camshaft Gear-to-Injection Pump Drive Gear Backlash—Backlash............................ 0.051 mm (0.0020 in.) minimum

NOTE: Timing marks on crankshaft and camshaft gear should be aligned and No. 1 cylinder locked at “TDC Compression” stroke when removing camshaft.

A—Camshaft Gear **B—Injection Pump Drive Gear**



RG7215 —UN—26NOV97

Camshaft Gears

Continued on next page

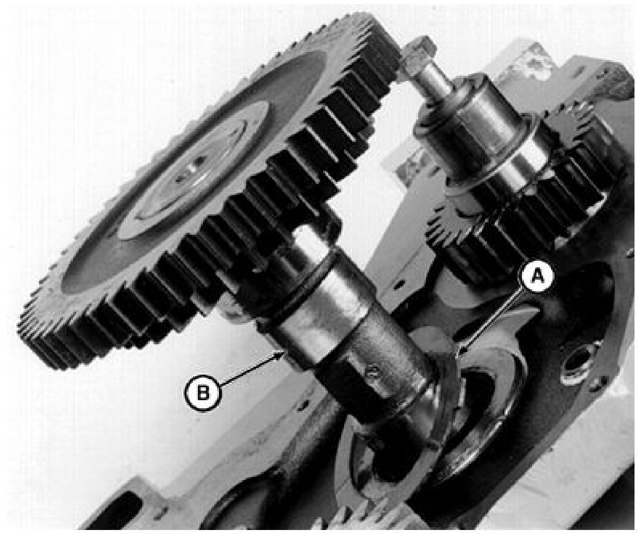
RG,RG34710,1202 -19-23OCT97-2/3

6. Carefully remove camshaft (B) from cylinder block so that camshaft lobes do not drag in bores.

NOTE: Rotate camshaft carefully to aid in removing.

7. Remove thrust washer (A) from behind cam gears.
8. Remove cam followers from cylinder block.

A—Thrust Washer **B—Camshaft**



RG7057 —UN—05DEC97

Removing Camshaft

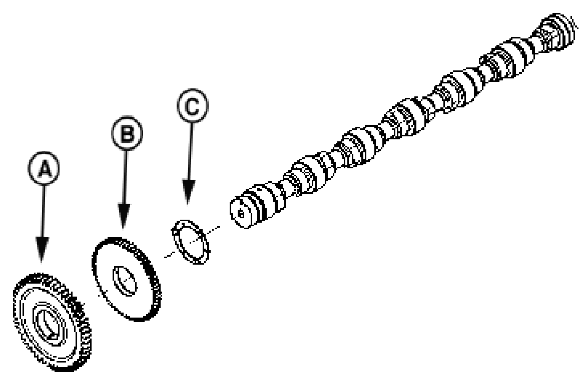
RG,RG34710,1202 -19-23OCT97-3/3

Remove Camshaft Gears

IMPORTANT: Prevent camshaft from striking floor when pushing camshaft nose out of gear. Camshaft may be damaged if it is allowed to fall to the floor.

NOTE: Camshaft gears are pressed onto the camshaft. Removal of gears from camshaft will require approximately a 10-ton press.

1. Support outer camshaft gear (A) in a press.
2. Remove outer gear from camshaft.
3. Support inner camshaft gear (B) in a press.
4. Remove inner gear from camshaft.
5. Clean camshaft and gears in solvent. Dry with compressed air.



RG13969 —UN—16FEB05

Removing Camshaft Gears

A—Outer Camshaft Gear
B—Inner Camshaft Gear
C—Thrust Washer

RE38635,0000062 -19-16FEB05-1/1

Measure Thrust Washer Thickness

1. After removal of camshaft, check the two thrust washers individually for proper thickness.

Specification

Thrust Washer—Thickness..2.24—2.34 mm (0.088—0.092 in.)

2. Replace washers if worn or damaged.

RG5775 —UN—05DEC97

Measuring Camshaft Thrust Washers

RG,RG34710,1204 -19-23OCT97-1/1

Inspect and Measure Camshaft Followers

1. Inspect camshaft roller followers for uneven wear or damage. Also inspect corresponding camshaft lobe for wear or damage. Replace as necessary.
2. Measure follower O.D. and follower bore I.D. in cylinder block.

Specification

Camshaft Follower—OD.........28.495—28.521 mm (1.122—1.123 in.)

Camshaft Follower Bore in Block—ID.........28.550—28.600 mm (1.124—1.126 in.)

Replace cam followers that are not within specification. Replace cylinder block if any one follower bore is not within specification.

RG13978 —UN—19FEB05

Inspect Roller Follower

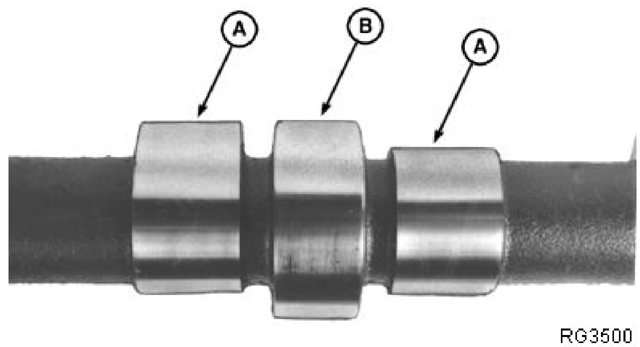
RE38635,0000063 -19-16FEB05-1/1

Visually Inspect Camshaft

1. Clean camshaft in solvent. Dry with compressed air.
2. Inspect all camshaft lobes (A) and journals (B) for wear or damage. Replace camshaft as necessary. New camshaft followers can be used with old camshaft (if camshaft is serviceable). DO NOT reuse old camshaft followers with a new camshaft.

NOTE: Very light score marks may be found but are acceptable if valve lift is within specification. Pitting or galling dictates replacement.

A—Camshaft Lobes **B—Journals**



RG3500 —UN—03NOV97

Inspecting Camshaft

RE38635,0000064 -19-16FEB05-1/1

Measure Camshaft Journal O.D. and Bushing I.D.

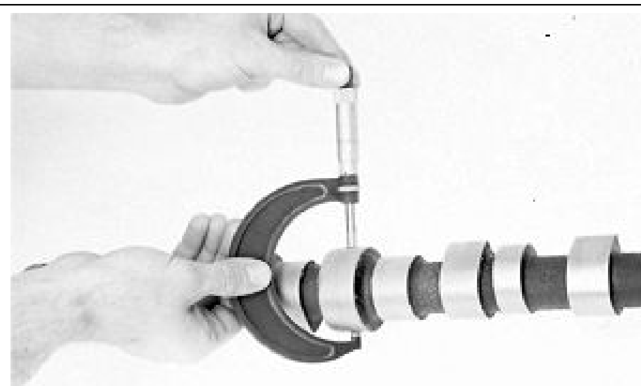
1. Measure each camshaft journal O.D. If camshaft journal O.D. is not within specification, install a new camshaft.
2. Measure each camshaft bushing I.D. when installed in cylinder block.

Compare measurements with specs given below. Replace camshaft and bushings as needed.

Specification

Camshaft Journal—OD.........66.987—67.013 mm (2.6373—2.6383 in.) new

Camshaft Bushing—I.D.........67.076—67.102 mm (2.6408—2.6418 in.) new

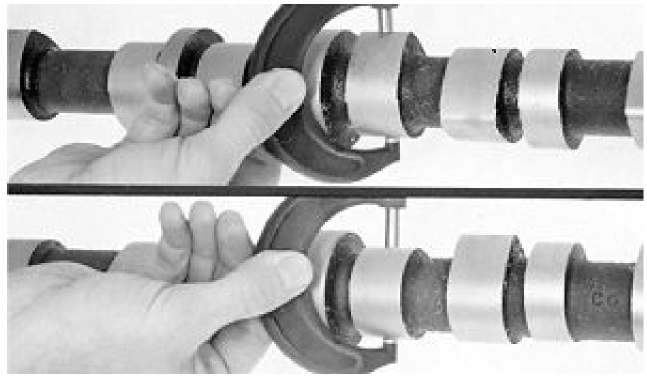


T81260 —UN—07NOV88

Measuring Camshaft Journals

RG,RG34710,1207 -19-23OCT97-1/1

Measure Camshaft Lobe Lift



Measuring Camshaft Lobes

Measure each camshaft lobe at its highest point and at its narrowest point. Subtract narrowest dimension from highest dimension to find camshaft lobe lift.

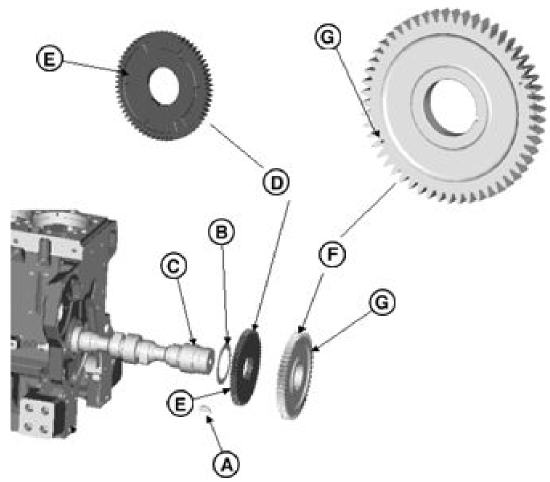
If camshaft lobe lift is not within the wear specification on any one lobe, install a new camshaft.

Specification

Intake Camshaft
Lobe—Lift..7.69—7.79 mm (0.303—0.307 in.)
Wear Limit ....7.19 mm (0.283 in.)
Exhaust Camshaft
Lobe—Lift..8.25—8.35 mm (0.325—0.329 in.)
Wear Limit ....7.75 mm (0.305 in.)

RG,RG34710,1208 -19-23OCT97-1/1

Camshaft Gears — Installation



Camshaft Gear Assembly

A—Woodruff Key
B—Thrust Washer
C—Camshaft Nose
D—Fuel Pump rive Gear
E—Fuel Pump Gear Orientation
F—Camshaft Drive Gear
G—Camshaft Gear Timing Marks

1. Support camshaft under first bearing journal in a hydraulic press.
2. Install Woodruff key (A). Lubricate camshaft nose with LOCTITE® 51048 Moly Paste.
3. Coat both sides of camshaft thrust washer (B) with high temperature grease and assemble to inside (with ribs) thrust surface of pump gear, as shown.
4. Coat gear seat diameters with high temperature grease.
5. Set fuel pump drive gear (D) on camshaft nose (C) with thrust washer surface and cast ribs (E) to the inside - toward the camshaft. Align woodruff key and keyway.
6. Install gear onto nose of camshaft. Push inner (fuel pump) gear on until tight against the camshaft bearing journal.
7. Set outer (drive) gear (F) on camshaft with **V** timing mark (G) facing away from the camshaft nose. Align woodruff key with keyway of drive gear.
8. Push drive gear onto camshaft nose until tight against inner (pump) gear.

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RG,RG34710,1209 -19-27JUL09-1/1

Service Camshaft Bushings Using JDG602 Adapter Set

NOTE: JDG602 was developed and can be used to service camshaft bushings when the engine has been removed from the vehicle and is on an engine stand. JDG606 was developed for servicing camshaft bushings while the engine is still in the vehicle and thus clearances are less.

1. Inspect camshaft journals and bushings for wear or damage. Measure cam journals and bushings to determine if proper oil clearance exists. Replace camshaft and/or bushings as necessary.

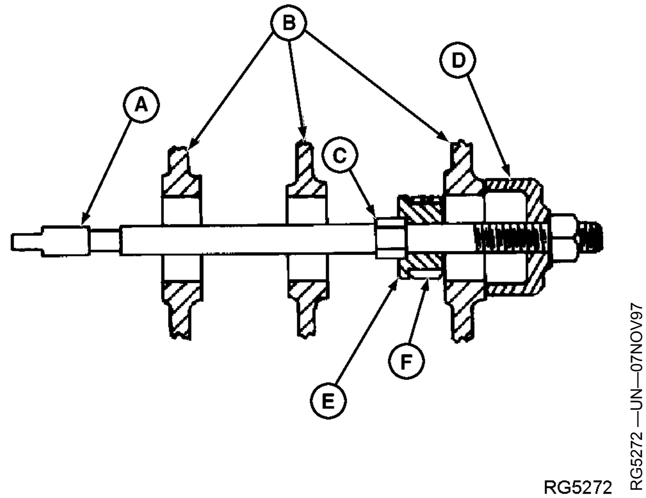
Specification

Camshaft Bushing—ID..67.076—67.102 mm (2.6408—2.6418 in.)
Bore in Block ....69.987—70.013 mm (2.7554—2.7564 in.)
Camshaft Bore—Runout...................................... 0.038 mm (0.0015 in.) maximum
Camshaft Journal—OD..66.987—67.013 mm (2.6373—2.6383 in.)
Camshaft Bushing-to-Journal—Oil Clearance..0.063—0.115 mm (0.0025—0.0045 in.)

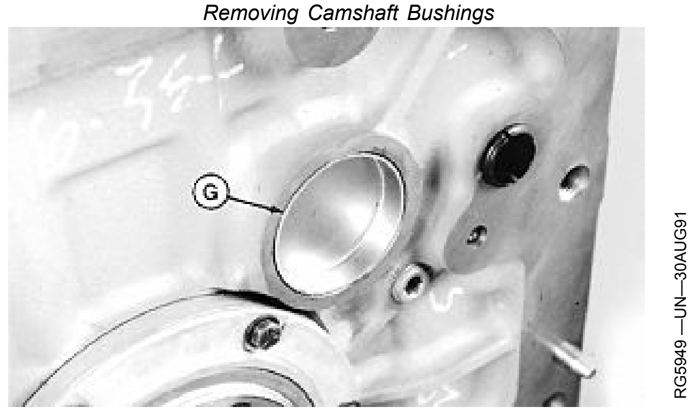
NOTE: The front bushings can be reached from the front of the engine. The flywheel and rear camshaft bore plug (G) must be removed to reach the rear bushings.

2. Remove camshaft bushings (F) using JDG603 Bushing Driver (E) and JDG604 Receiver Cup (D) along with the components shown from JDE6 Camshaft Bushing Replacement Set (A and C).

3. Tighten nut on end of bushing screw until bushing is pulled out of camshaft bushing bore. Inspect and measure camshaft bushing bore in block (B). Follow same procedure for remaining bushings to be replaced.



Removing Camshaft Bushings



Camshaft Rear Bore Plug

A—Bushing Screw (JDE6-1)
B—Cylinder Block Web
C—Lock Bushing (No. 25916)
D—Receiver Cup (JDG604)
E—Bushing Driver (JDG603)
F—Camshaft Bushing
G—Camshaft Bore Plug

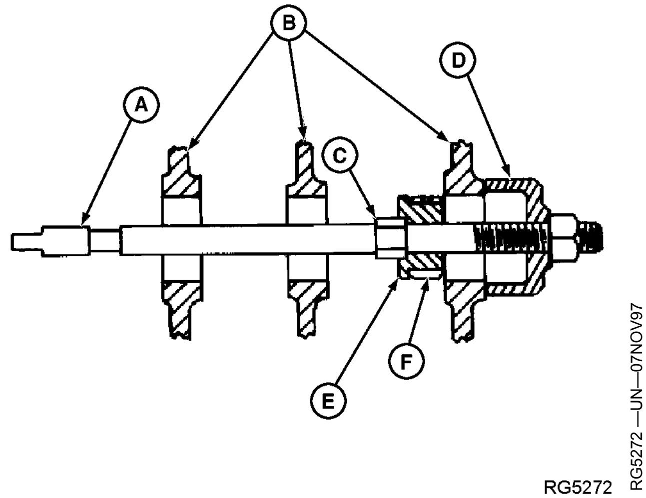
Continued on next page

RE38635,0000065 -19-16FEB05-1/2

IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation or oil starvation will occur. The elongated hole in bushing must be toward the top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.

4. Slide a new camshaft bushing (F) onto JDG603 Bushing Driver (E). Assemble driver and JDGF604 Receiver Cup (D) along with components shown from JDE6 Camshaft Bushing Replacement Set (A and C).
5. Be sure bushing is started square in bore and oil holes are aligned with holes in block. Tighten nut to pull bushing in until it is properly positioned in bore.
6. Check bushing-to-cylinder block oil hole alignment using a small mirror with extension.

A—Bushing Screw (JDE6-1)
B—Cylinder Block Web
C—Lock Bushing (No. 25916)
D—Receiver Cup (JDG604)
E—Bushing Driver (JDG603)
F—Camshaft Bushing



Installing Camshaft Bushings

RE38635,0000065 -19-16FEB05-2/2

Service Camshaft Bushings Using JDG606 Adapter Set

NOTE: JDG602 was developed and can be used to service camshaft bushings when the engine has been removed from the vehicle and is on an engine stand. JDG606 was developed for servicing camshaft bushings while the engine is still in the vehicle and thus clearances are less

1. Inspect camshaft journals and bushings for wear or damage. Measure cam journals and bushings to determine if proper oil clearance exists. Replace camshaft and/or bushings as necessary.

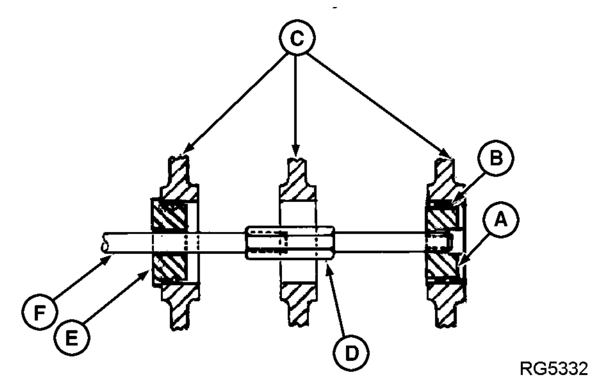
Specification	
Camshaft Bushing—ID	67.076—67.102 mm (2.6408—2.6418 in.)
Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
Camshaft Bore—Runout	0.038 mm (0.0015 in.) maximum
Camshaft Journal—OD	66.987—67.013 mm (2.6373—2.6383 in.)
Camshaft Bushing-to-Journal—Oil Clearance	0.063—0.115 mm (0.0025—0.0045 in.)

NOTE: The front camshaft bushings can be reached from the front to the engine. The flywheel and rear camshaft bore plug (G) must be removed to reach the rear camshaft bushings.

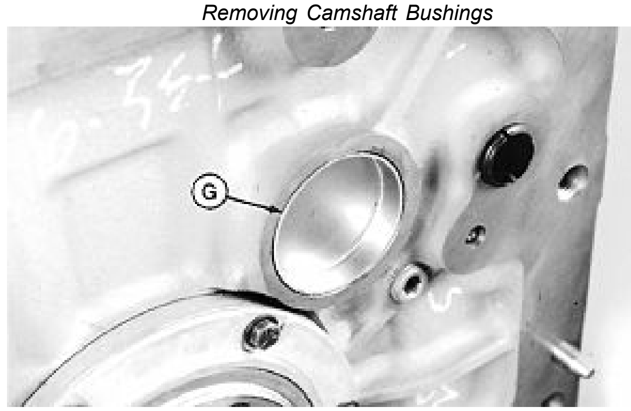
Lubricate O-ring on JDG608 Bushing Pilot with clean engine oil before installing in cylinder block web (C).

2. Remove camshaft bushings (B) using JDG607 Bushing Driver (A) and JDG408 Slide Hammer Adapter (D) (from JDG405 camshaft Bushing Service Set). Also use JDG608 Bushing Pilot (E), and D01299AA Slide Hammer (F).

NOTE: End bushing at front and rear of cylinder block may be removed with just JDG607 Bushing Driver and D01299AA Slide Hammer.



Removing Camshaft Bushings



Camshaft Rear Bore Plug

A—Bushing Driver (JDG607)
B—Camshaft Bushing
C—Cylinder Block Web
D—Slide Hammer Adapter (JDG408)
E—Bushing Pilot (JDG608)
F—Slide Hammer (D01299AA)
G—Camshaft Bore Plug

3. Inspect and measure each camshaft bushing bore in block as bushings are removed.

Continued on next page

DPSG,OUOE003,30 -19-18DEC98-1/2

IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation. The elongated hole in bushing must be toward the top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.

4. Slide a new camshaft bushing (B) onto JDG603 Bushing Driver (A). With JDG608 Bushing Pilot installed in outside cylinder block web (C), assemble D01299AA Slide Hammer (E) and JDG408 Slide Hammer Adapter (D) with bushing driver as shown.
5. Be sure bushing is started square in bore and oil holes are aligned with holes in block. Pull bushing into bore with slide hammer until properly positioned.
6. Check bushing-to-cylinder block oil hole alignment using a small mirror with extension.
7. Apply PERMATEX® AVIATION (Form-A-Gasket No. 3) to new camshaft bore steel cap plug and install plug in bore. Plug edge must be seated below edge of bore.

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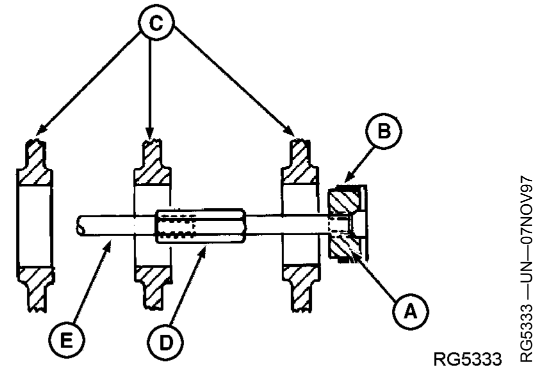
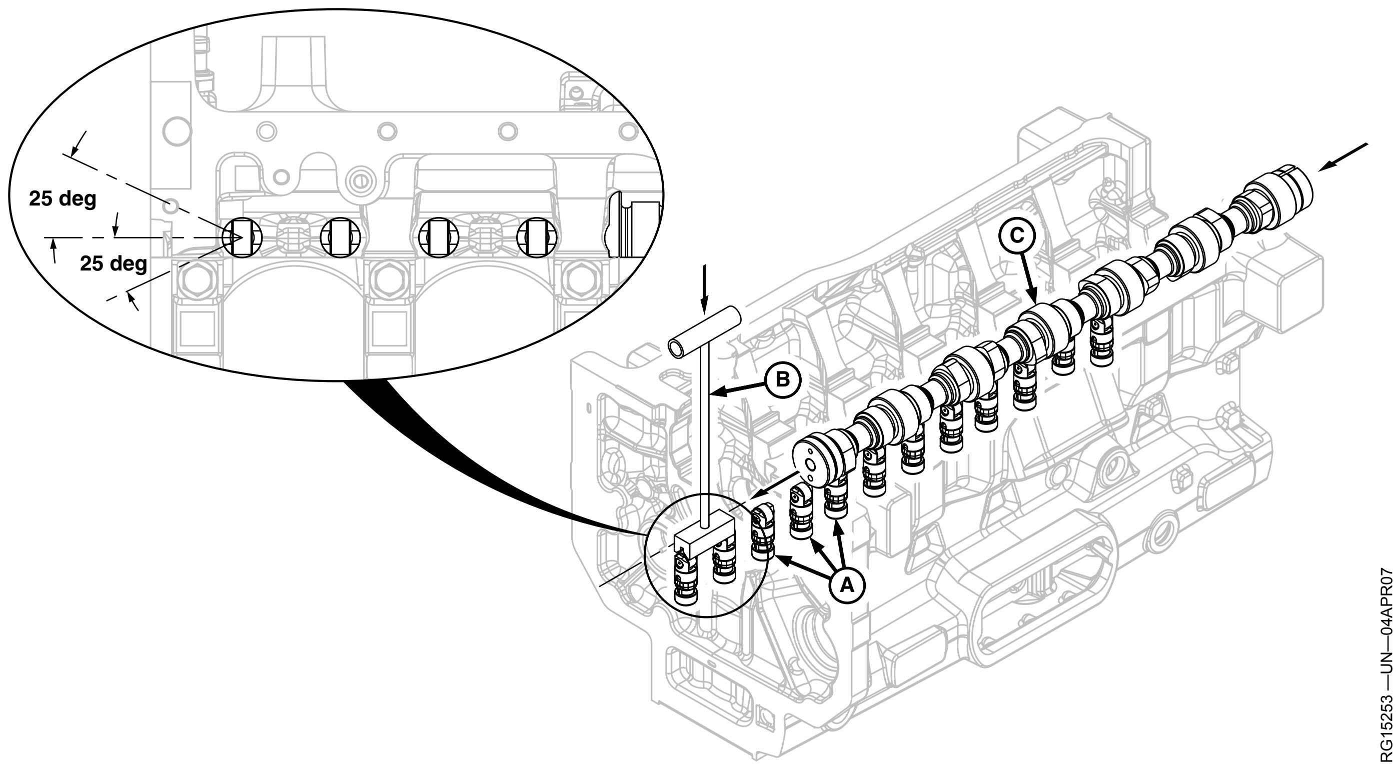


Installing Camshaft Bushings

A—Bushing Driver (JDG607)
B—Camshaft Bushing
C—Cylinder Block Web
D—Slide Hammer Adapter (JDG408)
E—Slide Hammer (D01299AA)

DPSG,OUOE003,30 -19-18DEC98-2/2

Camshaft Roller Followers — Install



Install Camshaft Roller Follower

A—Roller Followers **B—JDG1962 Special Tool** **C—Camshaft**

IMPORTANT: JDG1962 camshaft roller follower installation tool (B) locates on rollers of two adjacent followers within a cylinder to control alignment to each other and to camshaft axis. If roller follower is within this tolerance, camshaft rotation will properly align roller perpendicular to camshaft axis.

1. Install 12 camshaft roller followers (A) into cylinder block to bottom of follower bore. This will allow installation of camshaft (C).
2. Use JDG1962 special alignment tool to seat roller followers to bottom of bore, and to orient roller follower axis parallel to camshaft bore axis within +/-25° of horizontal.

RE38635,000004C -19-27JUL09-1/1

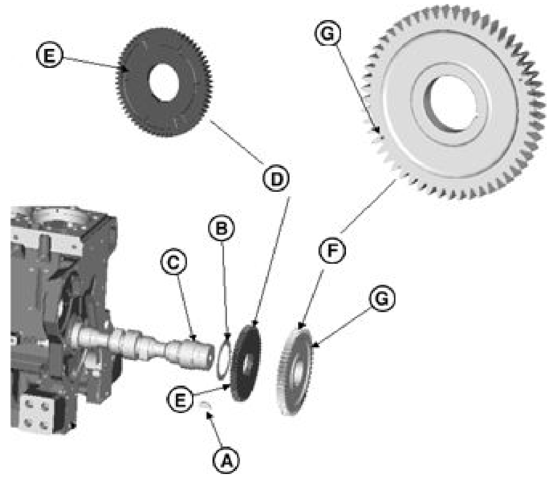
Install Camshaft

IMPORTANT: Set engine at TDC of No. 1 piston's compression stroke before installing camshaft so timing marks on camshaft and crankshaft gears will be aligned. Align the “V” marks on camshaft and crankshaft gears. Align the “2” marks on the camshaft and fuel pump gears.

1. If camshaft followers were removed with engine on a rollover stand, reinstall followers but do not obstruct camshaft bore.

NOTE: Double check to be sure camshaft thrust washer has been installed on inside of fuel pump (inner) gear).

2. Lubricate camshaft lobes with TY6333 or TY6347 High Temperature Grease and bearing journals with clean engine oil.
3. Carefully install camshaft in cylinder block so that camshaft lobes do not drag in bores. Rotate camshaft during installation to avoid obstruction in any bore.



RG14337 —UN—30JUN05

Camshaft Gear Assembly

A—Woodruff Key
B—Thrust Washer
C—Camshaft Nose
D—Fuel Pump rive Gear
E—Fuel Pump Gear Orientation
F—Camshaft Drive Gear
G—Camshaft Gear Timing Marks

RE38635,0000067 -19-18FEB05-1/2

4. With No. 1 piston on “TDC” compression, align timing marks (A) on camshaft and crankshaft gears. Check injection pump timing.

IMPORTANT: BE CERTAIN to remove the large cap screw and washer from the block face when installing timing gear cover.

5. Use a correctly sized cap screw and a large washer to secure the camshaft in the block (B). Not doing so risks the camshaft being damaged by falling out of the block.

A—Timing Marks
B—Secure Camshaft in Block

RG6614 —UN—05DEC97

Timing Marks—Camshaft and Crankshaft Gears

RG13976 —UN—19FEB05

Secure Camshaft

RE38635,0000067 -19-18FEB05-2/2

Install Thrust Washer and Timing Gear Cover

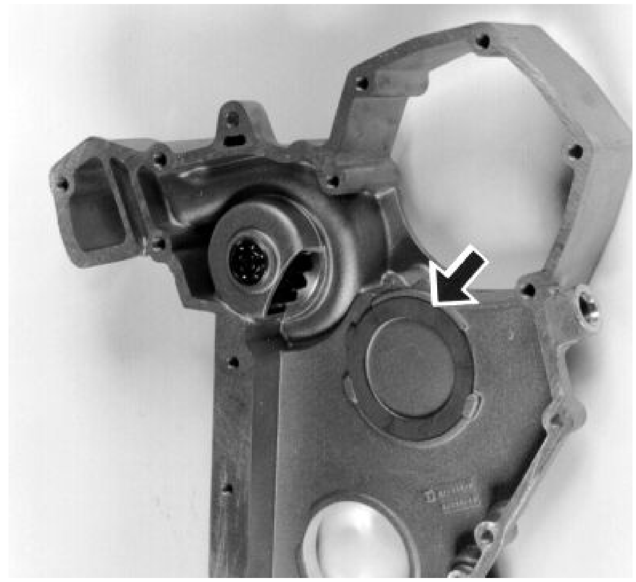
1. Lubricate thrust washer (bold arrow) with TY6333 or TY6347 High Temperature Grease and install in timing gear cover (A) tabs.
2. Install a new gasket over dowel pins at bottom of cylinder block face. Use additional guide pins if necessary.
3. If equipped with auxiliary drive, install a new gasket with the auxiliary drive housing with gear onto the timing gear cover. See <u>REMOVE, INSPECT AND INSTALL CRANKSHAFT GEAR-DRIVEN AUXILIARY DRIVE</u>, earlier in this group.)

IMPORTANT: Tightening the timing gear cover cap screws in proper sequence controls the total runout of the crankshaft flange-to-oil seal bore.

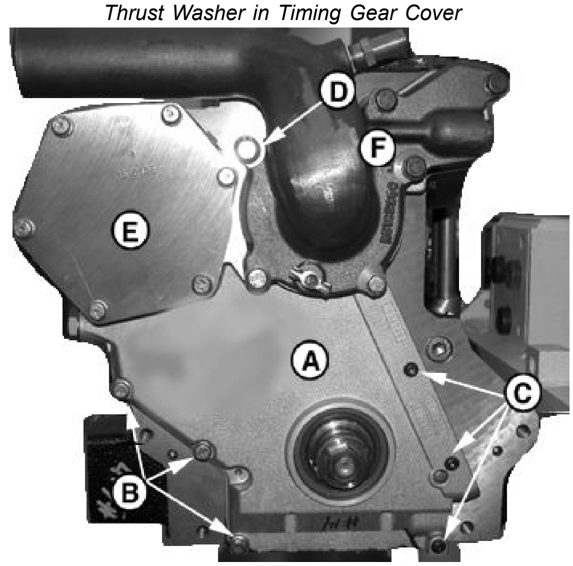
If equipped with auxiliary drive, tighten auxiliary drive housing to timing gear cover and to cylinder block prior to tightening the timing gear cover to cylinder block. See <u>REMOVE, INSPECT AND INSTALL CRANKSHAFT GEAR-DRIVEN AUXILIARY DRIVE</u> earlier in this group.

4. Install timing gear cover (A) over gasket and guide pins. Use crankshaft pilot to guide front seal. Install three M8 hex head cap screws (B), three M8 button head cap screws (C), and one M10 hex head cap screw (D).

A—Timing Gear Cover
B—M8 Hex Head Cap Screws (3)
C—M8 Button Head Cap Screws (3)
D—M10 Cap Screw (1)
E—Fuel Pump Drive Gear Cover
F—Coolant Pump Cover



Thrust Washer in Timing Gear Cover



Install Timing Gear Cover

Continued on next page

RE38635,0000066 -19-19JUN07-1/2

5. Tighten cap screws to specification in the sequence shown.

Specification

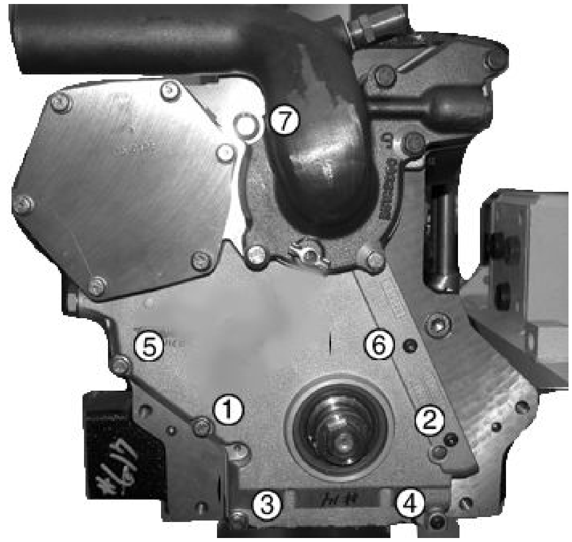
M8 Timing Gear Cover-to-Cylinder Block Cap Screws—Torque.....27 N•m (20 lb-ft)
M10 Timing Gear Cover-to-Cylinder Block Cap Screw—Torque.....41 N•m (30 lb-ft)

6. Install coolant pump, cover assembly (F), and new gasket to two dowel pins in timing gear cover face.
7. Install five M10 and one M8 cap screw to secure coolant pump cover. Tighten cap screws to specification.

Coolant Pump Cover-to-Timing Gear Cover—Specification

M10 Cap Screws—Torque.....47 Ṅ•m (35 lb-ft)
M8 Cap Screw—Torque.....32 Ṅ•m (24 lb-ft)

8. Check camshaft endplay. See CHECK CAMSHAFT END PLAY AND MEASURE GEAR BACKLASH earlier in this group.)
9. Install injection pump drive gear cover (E) using a new gasket and tighten cap screws to specifications.



Timing Gear Cover Torque Sequence

Specification

Injection Pump Drive Gear Cover—Torque.....31 Ṅ•m (23 lb-ft)

10. Trim timing gear cover gasket flush with oil pan gasket rail.

RE38635,0000066 -19-19JUN07-2/2

Complete Final Assembly

1. Install a new crankshaft front wear sleeve and oil seal. See INSTALL CRANKSHAFT FRONT OIL SEAL in Group 040.
2. Connect the magnetic speed sensor wiring lead.
3. Install crankshaft vibration damper. See INSTALL VIBRATION DAMPER in Group 040.
4. Install valve train and rocker arm assembly. See INSTALL CYLINDER HEAD AND CAP SCREWS SERIAL NUMBER in Group 021.
5. Install oil pan using a new gasket or install engine into vehicle if equipped with a structural oil pan. See INSTALL ENGINE OIL PAN in Group 060. Fill engine with clean engine oil.
6. Perform engine break-in as required. SeePERFORM ENGINE BREAK-IN in Group 021.

RG,RG34710,1212 -19-02SEP08-1/1

Diagnosing Lubrication System Malfunctions

Engine oil pressure (with engine warm) should be as follows:

Specification

Engine—Oil Pressure
(Engine Warm).. 280—400 kPa (2.8—4.0 bar)
(40—58 psi) @ 1800-2000 rpm

Low Oil Pressure:

- Low oil level.
- Clogged cooler or filter.
- Excessive oil temperature.
- Incorrect oil.
- Oil pressure regulating valve failure.
- Excessive main or rod bearing clearance.
- Clogged oil pump screen.
- Excessive clearance between oil pump gears and cover.
- Piston cooling orifice not installed.

High Oil Pressure:

- Improper oil classification.
- Clogged oil lines.
- Crimped or clogged ventilator outlet hose and adapter on rocker arm cover.
- Oil pressure regulating valve failure.

Oil Sludge and Dilution:

- Improper operation and servicing.
- Coolant leakage into lubrication system.
- Incomplete combustion.
- Excessive oil consumption.
- Defective injection pump (failed internal O-ring seals).

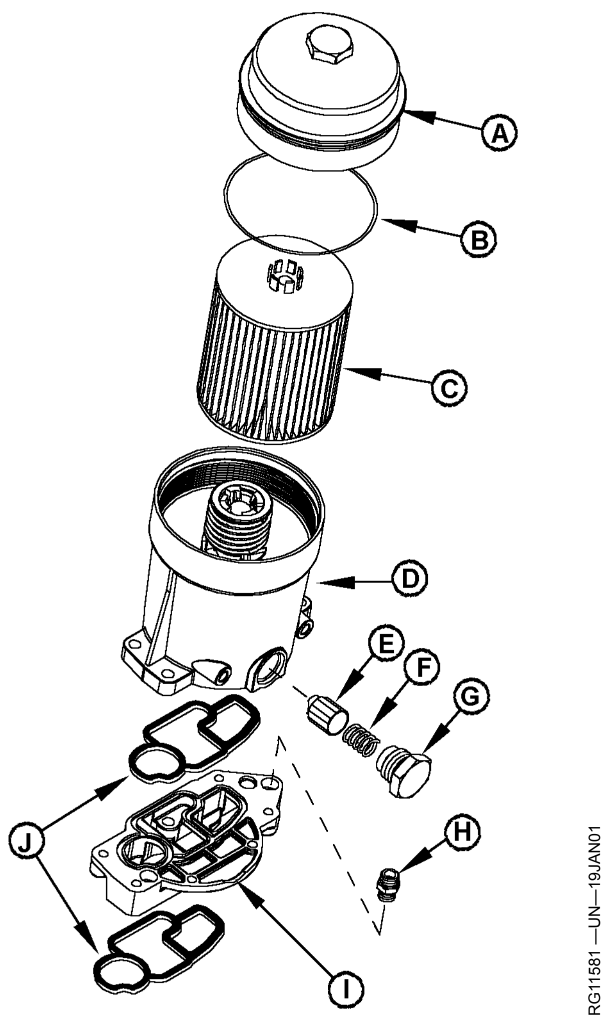
Low Oil Pressure at Slow Idle:

- Bypass oil check valve failure.

RG,RG34710,1215 -19-27APR99-1/1

Top-Load Oil Filter Assembly

A—Screw Cap
B—O-ring
C—Filter Element
D—Oil Filter Housing
E—Pressure Regulating Valve
F—Spring
G—Plug
H—Flex Fitting
I— Adapter Plate Assembly
J— Seal



Top-Load Oil Filter Assembly

RE38635,0000058 -19-12FEB05-1/1

Top Load Oil Filter - Theory of Operation

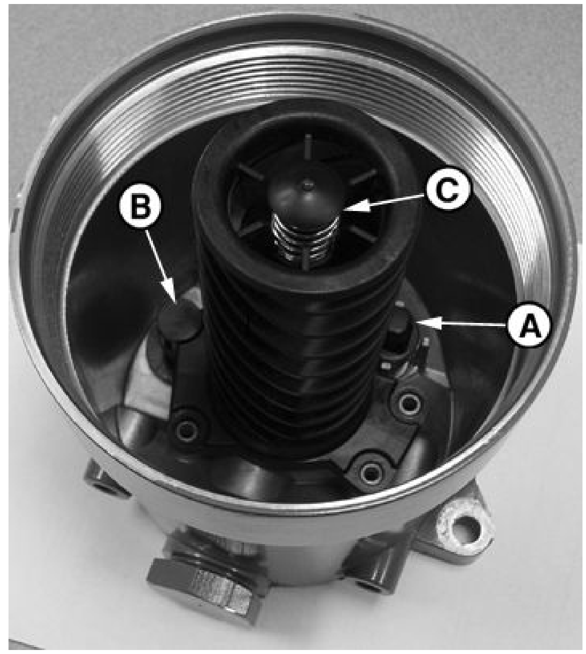
The top load oil filter assembly derives its name from the way the filter element "top loads" into the filter canister. The design is such that the filter element can be changed without the typical oil spill resulting from removal of the filter canister from the filter base. With the top load design, the filter canister remains on the filter base. Valves inside the filter canister regulate oil flow into the filter canister, pressure, and dump to sump when the filter element is changed.

When the filter element is in place and the system thus "closed", the pressure of the filter element keeps the return to sump valve (A) pressed downward, and thus closed. This prevents pressurized oil from being dumped back to sump prior to being filtered. If this valve is missing or not closed, low oil pressure will result.

Pressurized oil from the oil pump opens the inlet valve (B). This allows dirty, unfiltered oil from the sump to fill the canister and flow through the filter element. When the engine is turned off, this valve closes due to pressure from the oil within the canister, thus keeping the filter full of oil for the next start.

The bypass valve (C) protects the engine when the filter element becomes plugged, allowing unfiltered oil to reach engine components via the oil galley until the filter element can be changed.

When the oil filter element is removed for service replacement, pressure on the dump valve (A) is released, allowing oil in the canister to drain back to sump.



RG13823 —UN—16NOV04

Filter Canister Valve Operation

A—Return to Sump Valve
B—Inlet Valve
C—Bypass Valve

RE38635,0000059 -19-12FEB05-1/1

Install Oil Filter Assembly

1. Assure cleanliness by wiping mating surfaces on both the cylinder block mounting pad (A) and oil filter housing adapter (B).
2. Install oil filter housing adapter by starting 3 socket head cap screws (C) through adapter into cylinder block. Tighten to initial torque specification in the sequence shown to seat adapter evenly.

Specification

Oil Filter Housing Adapter to Cylinder Block - Initial Torque—Torque.. 5 N•m Maximum (3-4 lb-ft)

3. Final tighten socket head cap screws to specification, again in the sequence shown.

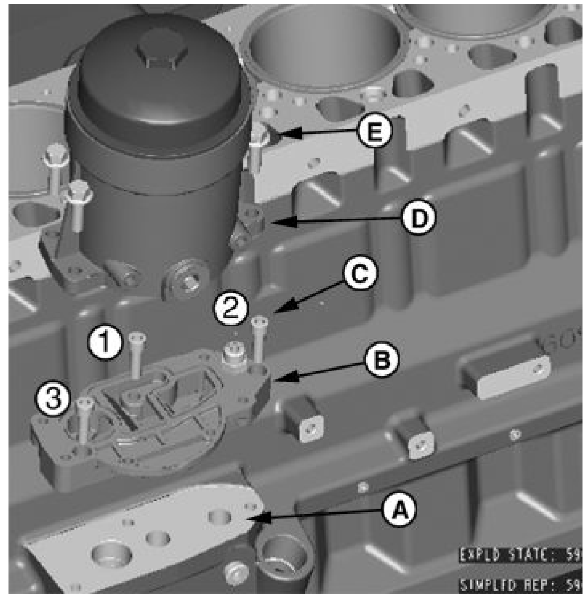
Specification

Oil Filter Housing Adapter to Cylinder Block - Final Torque—Torque.. 36 N•m (27 lb-ft)

4. Install oil filter assembly (D) by starting 4 hex flange head cap screws through oil filter assembly into oil filter adapter. Tighten to specification.

Specification

Oil Filter Assembly to Oil Filter Adapter—Torque.. 36 N•m (27 lb-ft)



RG14527 —UN—06OCT05

Oil Filter Assembly

A—Cylinder Block Mounting Pad
B—Oil Filter Housing Adapter
C—Socket Head Cap Screws (3) - Adapter to Cylinder Block
D—Oil Filter Assembly
E—Flange Head Cap Screws (4)- Oil Filter to Adapter

RE38635,0000082 -19-06OCT05-1/1

Changing Top-Load Oil Filter

1. Use a wrench to unscrew cap (A). Wait 30 seconds to allow oil filter housing to drain. Remove cap and filter assembly.
2. While holding on to screw cap, strike filter element against a solid surface as shown to disconnect filter from cap. Discard used filter.
3. Remove o-ring seal and replace with new o-ring provided with new filter element.
4. Press new filter into cap until it snaps into place.
5. Insert cap and filter assembly into oil filter housing. Screw cap in place.
6. Use wrench to tighten cap to specification.

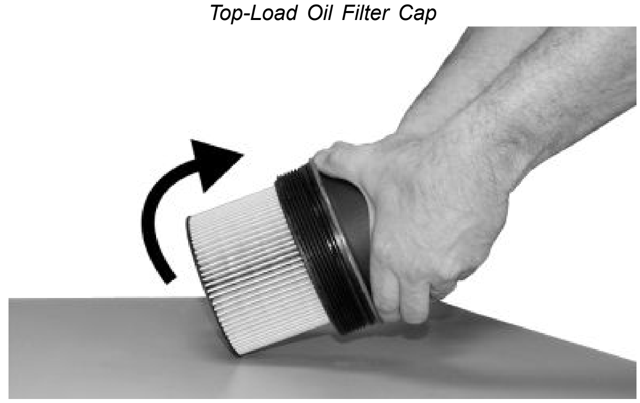
Specification

Top-Load Oil Filter Cap—Torque... 40—50 N·m (30—37 lb-ft)

A—Cap

RG11629A —UN—20DEC00

Top-Load Oil Filter Cap

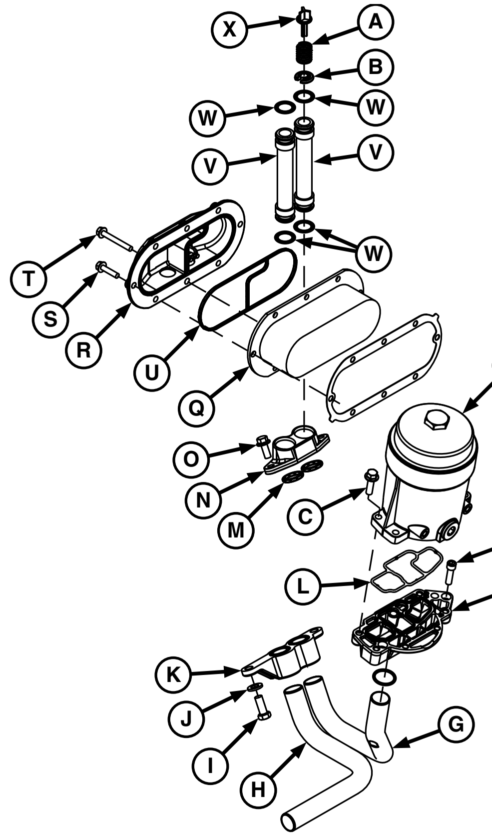


RG11628 —UN—01FEB01

Strike on Surface to Remove Filter

RG41165,0000034 -19-20DEC00-1/1

Engine Oil Cooler Assembly



Oil Cooler Assembly

A—Bypass Valve Spring
B—Spring Retainer
C—M10 x 35 Cap Screw
D—Oil Filter
E—Cap Screw
F—Adapter - Oil Filter to Block
G—Oil Tube
H—Oil Tube
I— M12 x 30 Cap Screw
J— Washer
K—Adapter - Oil Tubes to Block
L—Adapter Seal
M—Adapter Seal
N—Adapter - Oil Cooler Tubes
O—10 x 25 Cap Screw
Q—Oil Cooler
R—Oil Cooler Cover
S—M8 x 35 Cap Screw
T—M8 x 65 Cap Screw
U—Seal - Oil Cooler Cover to Oil Cooler
V—Oil Cooler Tubes -2-
W—O-Rings -2-
X—Bypass Valve

RE38635,0000077 -19-19SEP05-1/1

Remove, Inspect, and Install Engine Oil Cooler

See ENGINE OIL COOLER ASSEMBLY, earlier in this group for exploded view of engine oil cooler assembly.

Remove Oil Cooler Assembly:

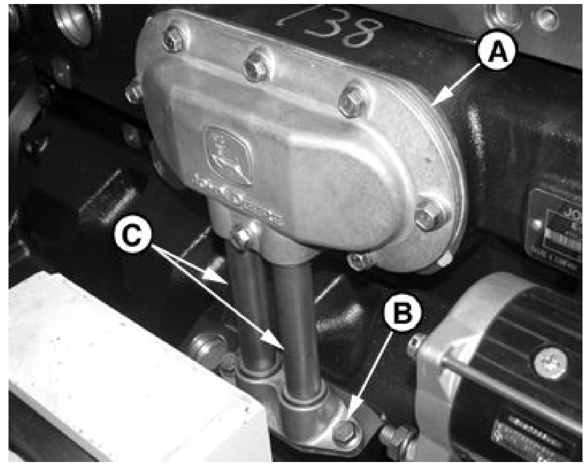
1. Remove eight cap screws securing oil cooler cover (A).
2. Remove two cap screws securing oil cooler tube adapter (B). Remove cover, tubes (C), and adapter as an assembly.
3. Remove oil cooler (D) from block bore. Clean all gasket material from mating surfaces.

Inspect Oil Cooler Assembly:

1. Inspect oil cooler for physical damage, plugging, or leakage which may allow mixing of oil and coolant.
2. Back flush oil cooler to clean all debris from core.
3. Pressure test oil cooler in liquid and compressed air if mixing of oil and coolant is suspected.

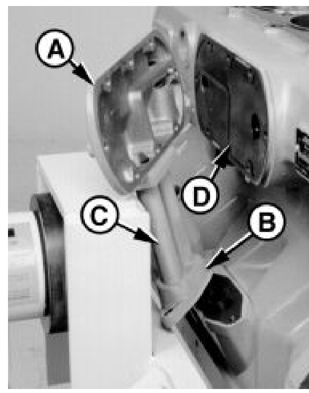
   Oil cooler should show no leakage when 140-170 kPa (1.4—1.7 bar) (20—25 psi) air pressure is applied for a minimum of 30 seconds.
4. Inspect all remaining parts of oil cooler assembly.

   Replace parts as needed. DO NOT attempt to repair oil cooler.



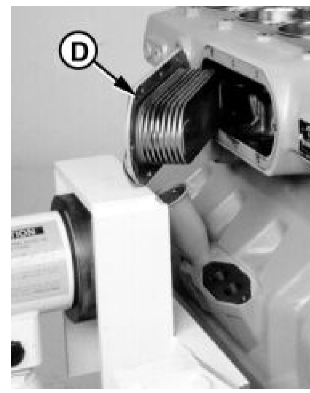
RG13962 —UN—12FEB05

Oil Cooler



RG7218 —UN—26NOV97

Removing Oil Cooler



RG7219 —UN—28NOV97

Oil Cooler Removed

A—Oil Cooler Cover/Bypass Valve Housing
B—Oil Cooler Tube Adapter
C—Oil Cooler Tubes
D—Oil Cooler

RE38635,000005A -19-12FEB05-1/2

Install Oil Cooler Assembly:

1. Install oil cooler using a new gasket on each side of cooler. Be sure gaskets are properly aligned with cap screw holes.

NOTE: If cover, tubes, and adapter were disassembled, lubricate new O-rings with clean engine oil.

2. Install a new gasket on cylinder block and install oil cooler cover, tubes, and adapter as an assembly. Tighten adapter cap screws to specifications.

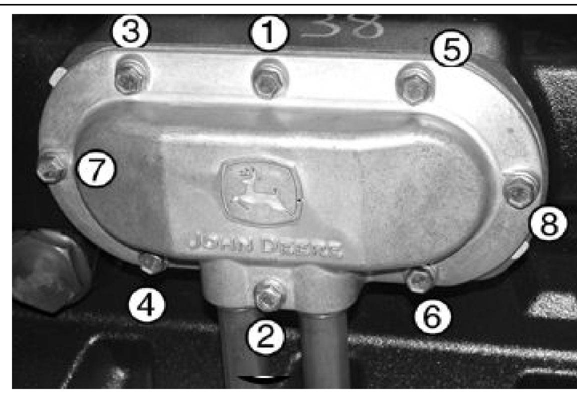
Specification

Oil Cooler Adapter Cap Screws—Torque... 47 N·m (35 lb-ft)

3. Tighten oil cooler cover (A) cap screws in sequence shown (1-8). Apply initial torque as follows:

Specification

Oil Cooler Cover-to-Cylinder Block Cap Screws—Initial Torque.. 20 N•m (15 lb-ft)



RG13955 —UN—12FEB05

Oil Cooler Cover Torque Sequence

Then retighten in same sequence to final torque specification.

Specification

Oil Cooler Cover-to-Cylinder Block—Final Torque... 37 N·m (27 lb-ft)

RE38635,000005A -19-12FEB05-2/2

Remove Engine from Tractors for Access to Engine Oil Pump

6090HRW Engines used in Tractors are equipped with a front frame/oil sump which is also a structural member of the vehicle. For access to the engine oil pump, the engine must be removed from the vehicle. Refer to the tractor Technical Manual for engine removal instructions.

RE38635,000005B -19-12FEB05-1/1

Remove Oil Pan

Removing oil pan will allow access to engine oil pump.

1. Drain engine oil.
2. Remove oil pan and discard gasket.
3. Remove all gasket material from oil pan rail and cylinder block mounting surfaces.

RE38635,0000055 -19-08FEB05-1/1

Check Crankshaft Gear-to-Oil Pump Drive Gear Backlash

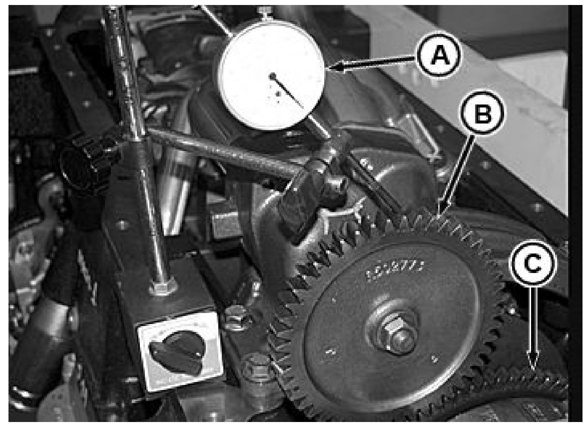
IMPORTANT: Backlash must be at least 0.10 mm (0.004 in.) for spur gear. If backlash is less than specification, replace the oil pump drive gear.

Before removing oil pump, determine if there is adequate backlash between oil pump and crankshaft drive gears.

Mount dial indicator (A) and measure backlash between pump drive gear (B) and crankshaft gear (C).

Specification

Crankshaft Spur Gear-to-Oil Pump Drive Gear—Backlash	0.10 mm (0.004 in.) minimum



RG13956 —UN—03SEP09

Oil Pump Drive Gear Backlash

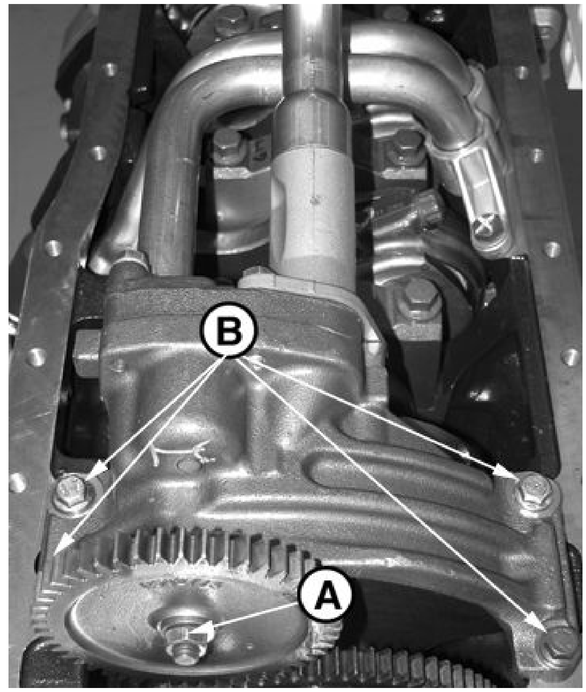
A—Dial Indicator
B—Oil Pump Drive Gear
C—Crankshaft Gear

RE38635,000005C -19-12FEB05-1/1

Remove Engine Oil Pump

1. Loosen drive gear retaining nut (A) one full turn.
2. Remove four oil pump housing cap screws with washers (B).
3. Lift up on oil pump assembly and wiggle assembly left-to-right to disengage housing from mounting dowels.

A—Drive Gear Retaining Nut
B—Oil Pump Housing Cap Screws



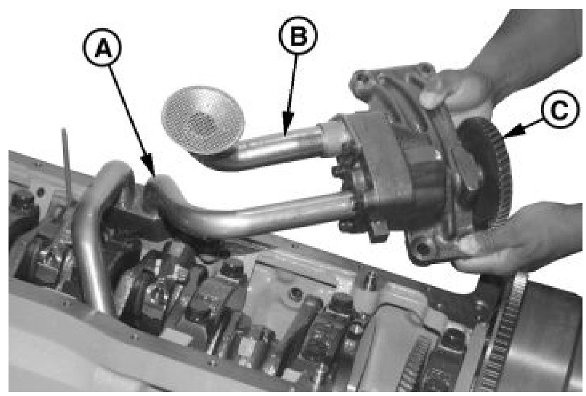
RG13961 —UN—12FEB05

Remove Oil Pump

RE38635,000005D -19-12FEB05-1/2

4. Once pump assembly is free from dowels, swing assembly to the right (as viewed from flywheel end) and disengage outlet tube (A) from pump housing.
5. Remove oil pump drive gear (C) and oil pickup tube (B) from pump.

A—Outlet Tube
B—Pickup Tube
C—Oil Pump Drive Gear



RG9046 —UN—28APR99

Remove Oil Pump

RE38635,000005D -19-12FEB05-2/2

Inspect and Clean Oil Pump

1. Visually inspect oil pump for wear or damage.

IMPORTANT: DO NOT disassemble engine oil pump for flushing, inspection, or performing wear checks. Individual components of oil pump are not available through service parts. Replace pump as a complete assembly.

Never hammer directly on oil pump housing as it could cause binding of gears.

2. Flush pump assembly internally with clean solvent to remove oil. Spin pump gears to help remove solvent. *Pump gears should move freely*.
3. Place oil pump on a work bench with pump-to-cylinder block mounting surface facing upward (same as when mounted on engine).

IMPORTANT: To help insure accurate wear measurements, be sure the oil pump is clean and faces the same way as when mounted on the cylinder block.

NOTE: Leave pump drive gear installed when making checks.

RG,RG34710,1225 -19-23OCT97-1/1

Check Drive Shaft End Play

1. Mount dial indicator with indicator plunger resting against end of pump drive shaft.
2. Move shaft toward and away from indicator.

   If end play exceeds specification, there is excessive wear on pump cover and/or wear on end of pump drive gear.

Specification

Oil Pump Drive Shaft—Maximum End Play.. 0.15 mm (0.006 in.)

Replace oil pump if end play exceeds specification.

RG5916 —UN—05DEC97

Checking Pump Shaft End Play

RG,RG34710,1226 -19-23OCT97-1/1

Check Drive Shaft Side Movement

1. Mount dial indicator with indicator plunger resting on one of the hex nut flats.
2. Move shaft from side-to-side.

   If shaft side movement exceeds specification, there is excessive wear in drive shaft bushing and/or drive shaft.

Specification

Oil Pump Drive Shaft—Maximum Side Movement.. 0.17 mm (0.0065 in.)

Replace oil pump if shaft side movement exceeds specification.

RG5917 —UN—05DEC97

Checking Pump Shaft Side Movement

RG,RG34710,1227 -19-23OCT97-1/1

Check Pumping Gear Backlash

1. Mount dial indicator with plunger resting against side of gear tooth.
2. Hold idler gear stationary. Slowly rotate drive gear back and forth until contact with idler gear is left.

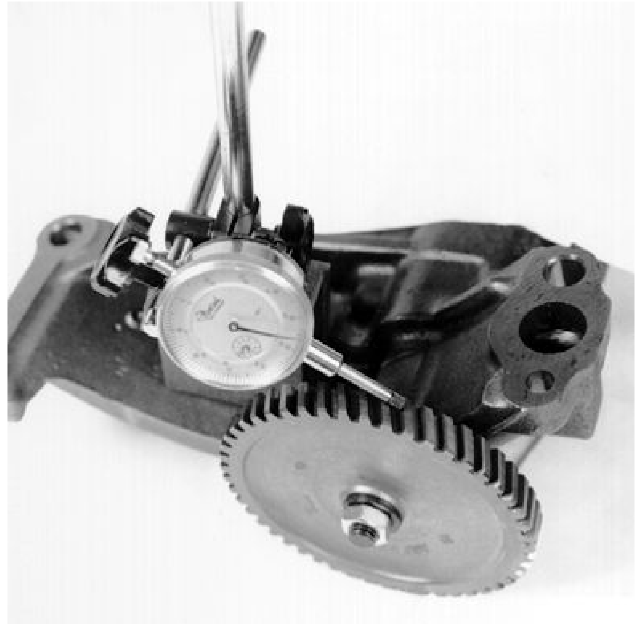
   If backlash is not within specification, there is excessive pumping gear wear and/or idler shaft and gear bushing wear.

Specification

Oil Pump Drive
Gear—Backlash.................................0.33—2.00 mm (0.013—0.079 in.)

   If there is less than 0.33 mm (0.013 in.) backlash, re-clean gears and check backlash again.

3. Replace oil pump if pumping gear backlash exceeds 2.00 mm (0.079 in.).



RG5918 —UN—05DEC97

Checking Backlash of Pumping Gear

RG,RG34710,1228 -19-23OCT97-1/1

Inspect Oil Pump Drive Gear

NOTE: Oil pump does not need to be removed from engine, when inspecting drive gear.

Inspect drive gear teeth for chips, cracks, or wear. Replace as necessary.

RG6435 —UN—05DEC97

Inspecting Pump Drive Gear

RG,RG34710,1229 -19-23OCT97-1/1

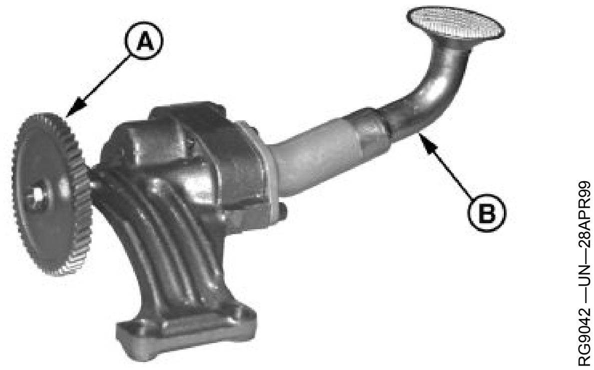
Install Engine Oil Pump

1. Install gear (A) onto pump and tighten snug using nut and washer. Final torque will be accomplished after installing pump.
2. Using a new gasket, install oil pickup tube (B) onto oil pump and tighten cap screws to specifications.

Specification

Oil Pump Intake (Pickup) Tube-to-Cover—Torque	41 N•m (30 lb-ft)

A—Oil Pump Drive Gear **B—Oil Pickup Tube**



Install Oil Pump Gear and Pickup

AS58880,000000E -19-04FEB08-1/2

3. Install new O-ring in groove of oil pump housing and lubricate with clean engine oil. Install oil pump outlet tube into oil pump housing.
4. Swing oil pump assembly over locating dowels and carefully position assembly onto dowels without applying pressure to or causing binding of outlet tube.

IMPORTANT: Do not hammer directly on pump housing as it could cause binding of gears.

5. Seat pump onto dowels using a hard rubber hammer on outer edge of housing near mounting holes (as shown). Make sure drive gear (A) is properly meshed with crankshaft gear and oil pump outlet tubes (B) are properly positioned (with no binding) in O-ring bores.
6. Install and tighten oil pump housing-to-cylinder block cap screws to specifications.

Specification

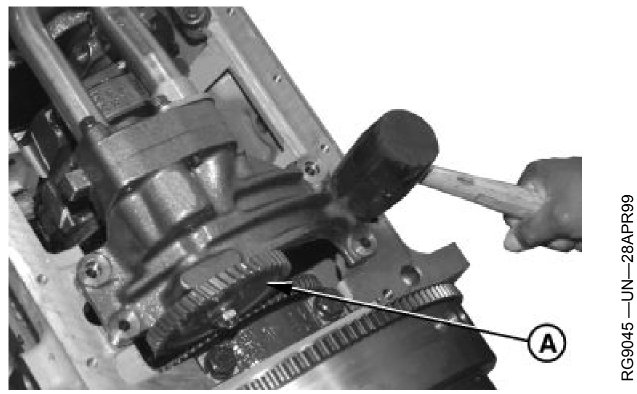
Oil Pump Housing-To-Cylinder Block—Torque	63 N•m (46 lb-ft)

7. Tighten oil pump drive gear retaining nut to specifications.

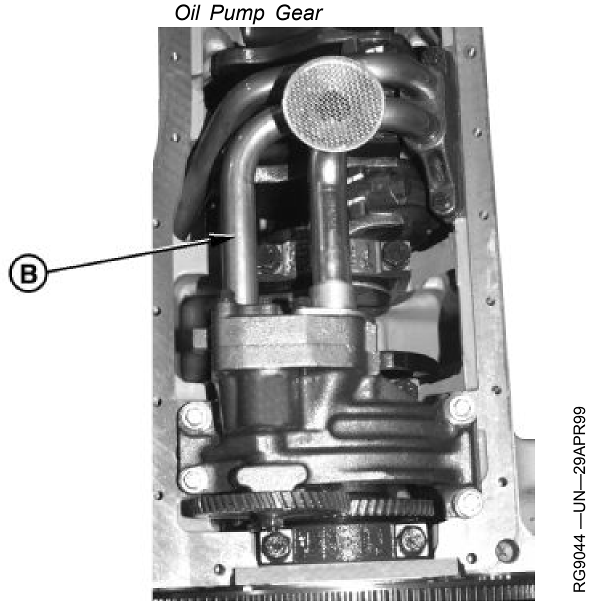
Specification

Oil Pump Drive Gear Retaining Nut—Torque	54 N•m (40 lb-ft)

A—Oil Pump Drive Gear **B—Oil Pump Outlet Tube**



Oil Pump Gear

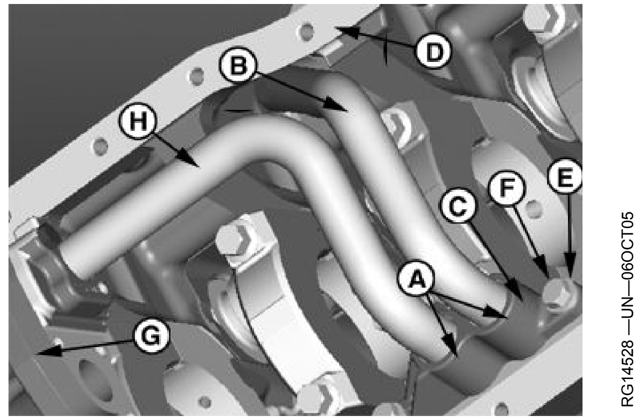


Install Oil Pump Outlet Tube

AS58880,000000E -19-04FEB08-2/2

Install Oil Bypass & Oil Pump Tubes & Oil Pump Adapter

1. Apply SAE 10W30 oil to both o-rings in oil pump adapter (A).
2. Apply AMOJELL snow white grease to both ends of oil bypass tube (B).
3. Install short end of oil bypass tube into oil pump adapter (C).
4. Insert free end of oil bypass tube into cylinder block (D).
5. Assemble 2 washers (E) to the 2 oil pump adapter cap screws (F).
6. Apply thread lock to threads of cap screws and hand start through oil pump adapter into cylinder block. Do not tighten.
7. Apply SAE 10W30 engine oil to o-ring in oil pump assembly (G).
8. Apply AMOJELL snow white grease to end of oil pump tube (H) which installs in oil pump adapter (C).
9. Install oil pump tube into oil pump adapter, as shown.
10. Tighten oil pump adapter to cylinder block cap screws to specification.



Oil Bypass & Oil Pump Tubes & Oil Pump Adapter

A—Oil Pump Adapter O-Rings
B—Oil Bypass Tube
C—Oil Pump Adapter
D—Cylinder Block
E—Oil Pump Adapter - Cylinder Block Washer
F—Oil Pump Adapter- Cylinder Block Cap Screw
G—Oil Pump Adapter
H—Oil Pump Tube

Specification

Oil Pump Adapter to Cylinder Block—Torque...54 N•m (40 lb-ft)

RE38635,0000083 -19-06NOV08-1/1

Remove, Inspect, and Install Oil Pump Pickup Tube

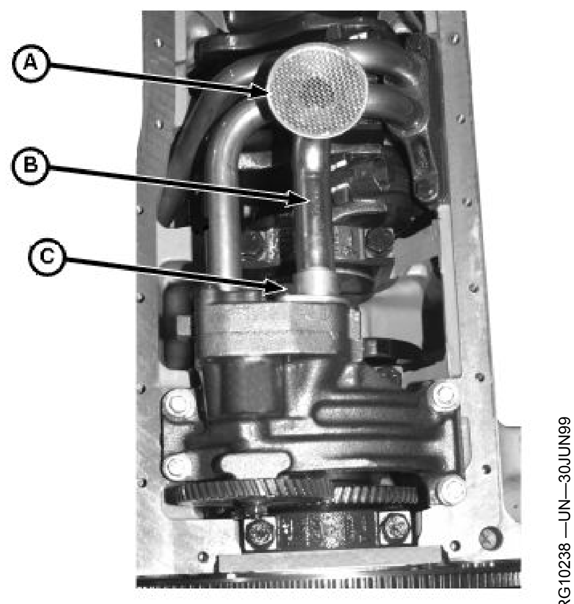
1. Remove oil pan. See REMOVE OIL PAN earlier in this group.
2. Remove cap screws (C) and remove oil pickup tube assembly (B) and gasket.
3. Clean and flush tube and pickup screen (A).
4. Inspect tube for cracks or restrictions. Replace as required.
5. Install pickup tube assembly with new gasket and tighten cap screws to specifications.

Specification

Oil Pump Pickup Tube Cap Screws—Torque... 41 N·m (30 lb-ft)

6. Install oil pan. See INSTALL ENGINE OIL PAN later in this group.

A—Screen
B—Oil Pickup Tube
C—Cap Screws (3 used)



Oil Pickup Tube

DPSG,OUO1004,914 -19-29JUN99-1/1

Install Engine Oil Pan

All oil pan and cylinder block (including timing gear cover and rear seal housing) gasket sealing surfaces MUST BE free of gasket material or oil, and dry.

1. Apply a thin layer of Sealing Compound DT5041LOCTITE 30516 (PM37559)® Aviation (Form-A-Gasket No. 3) at timing gear cover-to-cylinder block mating surfaces.
2. Apply a thin layer of Sealing Compound DT5041 LOCTITE 30516 (PM37559)® Aviation (Form-A-Gasket No. 3) at rear oil seal housing-to-cylinder block mating surfaces.
3. Position new oil pan gasket (A) on cylinder block.

NOTE: Locate rear of oil pan flush to ± 0.05 mm (0.002 in.) with rear face of cylinder block.

4. Carefully install oil pan (B) on cylinder block and install finger tight M10 (D) & M12 (E) oil pan-to-cylinder block cap screws.
   a. First tighten M12 cap screws (E) to the following specification.

Specification

Oil Pan M12 Cap Screws—Torque.......... 130 N•m (96 lb-ft)

   b. Next tighten M10 cap screws (D) to specifications.

Specification

Oil Pan M10 Cap Screws—Torque.......... 73 N•m (54 lb-ft)

5. Trim oil pan gasket flush at rear surface of cylinder block and oil pan.
6. Install pan drain plug (if provided) using a new O-ring and tighten to specifications.

Specification

Oil Pan Drain Plug Aluminum Pans—Torque.......... 101 N·m (75 lb-ft)

NOTE: Check that the washer moves freely. If not, replace the assembly. Check the o-ring for any damage.

7. Install drain valve assembly finger tight (C).

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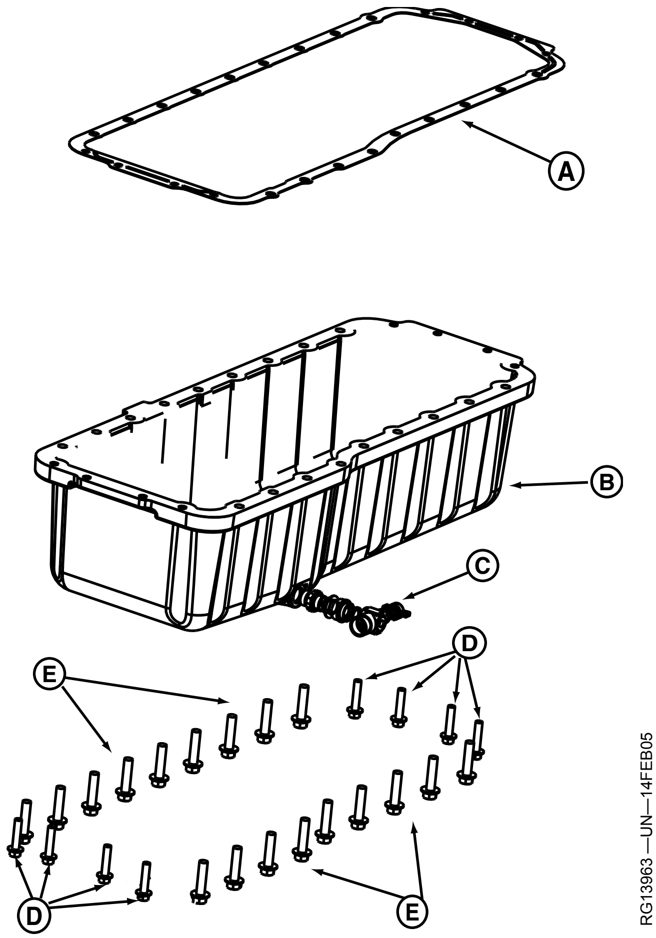


9 L Oil Pan Assembly

A—Oil Pan Gasket
B—Oil Pan
C—Drain Plug Assembly
D—M10 Cap Screws (8)
E—M12 Cap Screws (18)

8. Position adjustable fitting, unscrewing the fitting no more than one turn. Point oil pan side drain valve toward rear of engine.
9. Tighten oil pan drain valve assembly to specification.

Specification

Oil Pan Elbow Lock Nut—Torque.......... 81 N•m (60 lb-ft)

DPSG,OUO1004,824 -19-10NOV08-1/1

Tighten Cap Screws on Front Frame/Oil Sump - Tractors

NOTE: Refer to illustration on following page.

1. Be sure sump-to-block locating dowels are in place.

IMPORTANT: DO NOT apply gasket sealant to gasket, front frame/oil sump, trimmed edges of timing gear cover gasket, oil seal housing gasket, or cylinder block mating surfaces. Before installing engine, be sure mating surfaces of engine and front frame/oil sump are clean and dry.

2. Install front frame/oil sump-to-cylinder block gasket.
3. Carefully lower engine block onto front frame/oil sump locating dowels.
4. Install all M10 and M12 cap screws in their appropriate locations as shown.
5. Tighten all M12 cap screws to specifications.

Specification

Front Frame/Oil Sump M12 Cap Screws—Torque .... 133 N•m (98 lb-ft)

Tighten all 3/8 in. cap screws to specifications.

Specification

Front Frame/Oil Sump M10 Cap Screws—Torque .... 58 N•m (43 lb-ft)

6. Retighten all M10 cap screws to specifications.

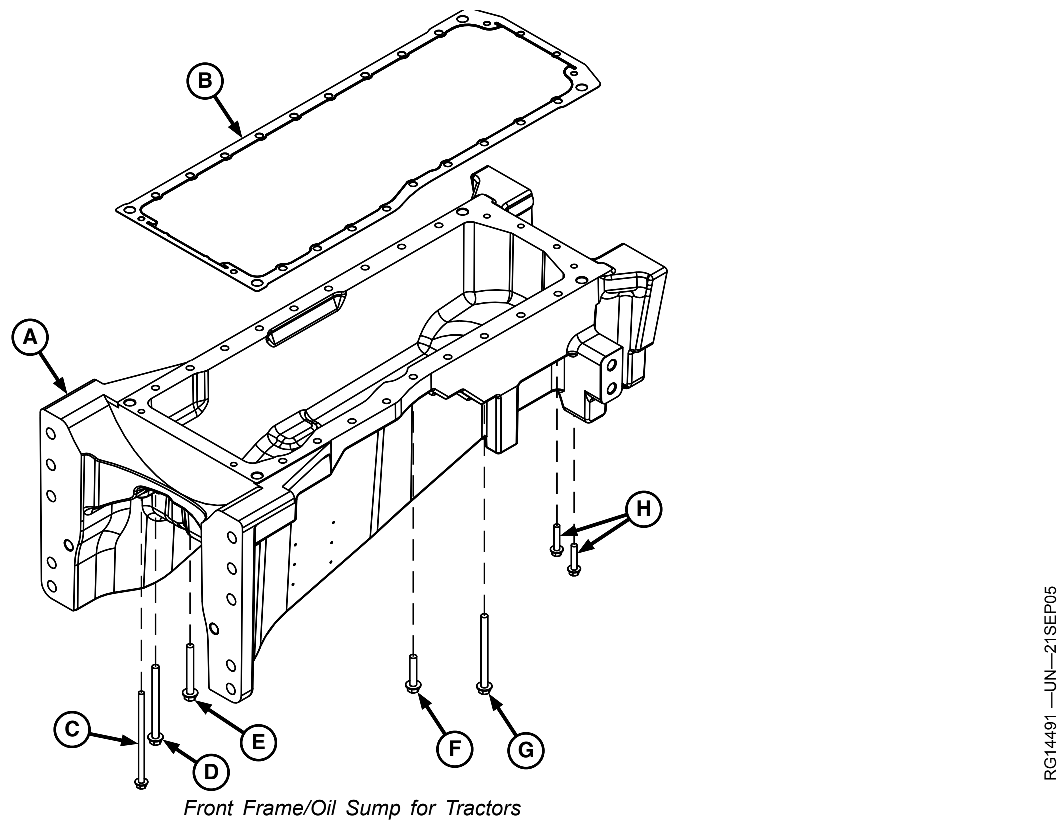
   Retighten all M12 cap screws to specifications.

7. Apply clean engine oil to new O-ring for bottom drain plug and install drain plug, if removed. Tighten plug to specifications.

Specification

Oil Pan Drain Plug Cast Iron Pans (Sumps)—Torque .... 47 N•m (35 lb-ft)

NOTE: Refer to tractor Technical Manual for engine installation instructions after servicing engine oil pump assembly.

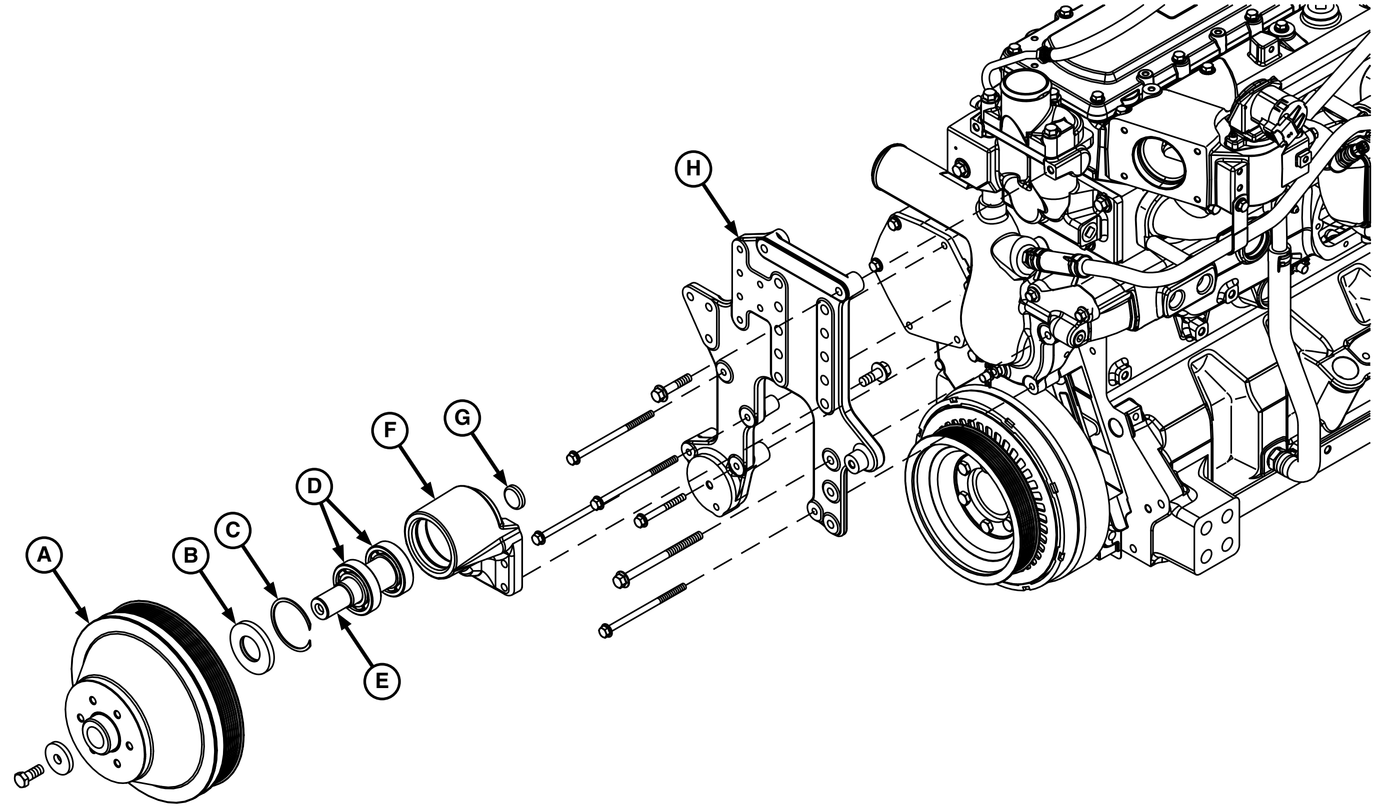


Front Frame/Oil Sump for Tractors

A—Oil Pan
B—Oil Pan Gasket
C—M10 x 190 Cap Screw -2-
D—M12 x 150 Cap Screw -8-
E—M12 x 100 Cap Screw -4-
F—M12 x 60 Cap Screw -6-
G—M12 x 150 (same as D)
H—M10 x 45 Cap Screw -2-

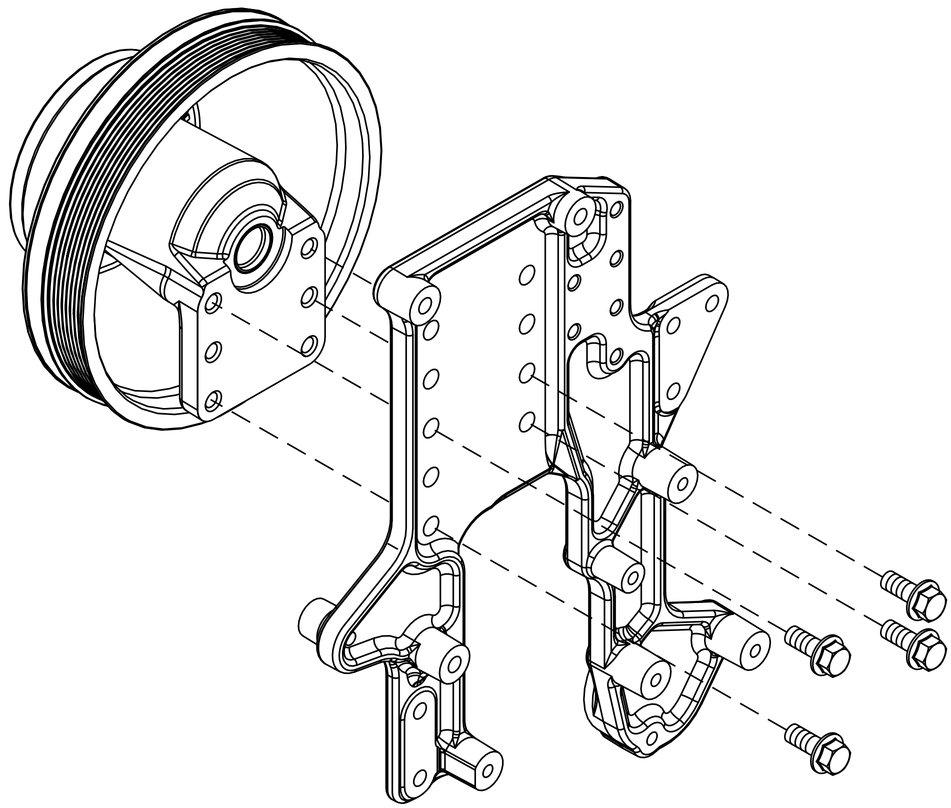
RE38635,000005F -19-12FEB05-1/1

Inspect Fan Hub & Replace Bearings in Heavy-Duty, Adjustable Fan Drive Assembly



RG14051 —UN—27MAY05

Heavy Duty Adjustable Fan Drive Assembly



RG14050 —UN—31MAY05

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A—Fan Hub/Pulley
B—Grease Seal
C—Snap Ring
D—Ball Bearing Assemblies (2)
E—Bearing Shaft
F—Bearing Housing
G—Cup Plug
H—Support Plate
I— Fan Bearing Housing Assembly
J— Fan Bearing Housing to Support Plate Hardware

To Disassemble Fan Drive:

1. Remove belts and remove fan. Remove fan drive assembly from engine.
2. Check run-out of fan hub using a dial indicator on outer face of hub. If run-out exceeds specification, replace fan drive assembly.

Specification

Fan Drive Hub—Radial Runout .... 0.038 mm (0.0015 in.)

3. Clamp fan hub/pulley (A) in a soft-jawed vise. Support fan hub (so it does not fall to floor), and remove cap screw securing hub to shaft (E). Remove fan hub.
4. Remove pipe plug from fan housing, grease seal, and snap ring (C). Discard seal and snap ring.
5. Remove shaft (E) with bearings (D) by lightly tapping with a rubber mallet or brass hammer.
6. Remove bearings from shaft using a press and discard bearings.
7. Thoroughly clean and inspect shaft and bearing housing (F) for cracks or any other damage. Measure parts and compare with specifications given below.

Specification

Adjustable Fan Drive Housing—ID .... 71.999—72.025 mm (2.8346—2.8356 in.)
Adjustable Fan Drive Shaft—OD .... 35.001—35.017 mm (1.3780—1.3786 in.)
Adjustable Fan Drive Bearing—ID .... 34.987—35.013 mm (1.3774—1.3785 in.)
OD .... 71.987—72.013 mm (2.8341—2.8351 in.)

Replace parts that are cracked or not within specification.

To Assemble Fan Drive:

1. Pack inner and outer bearings with TY6333 or TY6347 High Temperature Grease. Apply clean engine oil to bearing I.D. and shaft O.D.
2. Support end of shaft (E) and install bearings against shoulder. *Apply force to bearing inner race only*.
3. Support bearing housing (F) on a firm flat surface with bearing bore in the upward position.
4. Install bearing and shaft assembly into housing. Small end of shaft should extend through housing.
5. Determine proper snap ring (C) thickness needed to obtain specified end play.

Specification

Adjustable Fan Drive Shaft—End Play .... 0.10 mm (0.004 in.)

6. Install snap ring in housing groove. Visually inspect snap ring installation for proper seating in housing groove.
7. Apply a thin coat of clean engine oil to O.D. of oil seal casing and to seal lips. Install seal in housing bore until metal casing is to specified depth below housing face.

Specification

Adjustable Fan Drive Housing Seal—Depth .... Flush-to-0.50 mm (0.020 in.) below housing face

8. Apply clean engine oil to I.D. of fan hub/pulley (A). Support end of shaft through pipe plug hole in bearing housing and push onto other end of shaft until it bottoms against shoulder.

NOTE: If engine is equipped with a fan/hub pulley-to-fan spacer, tighten hub/pulley-to-spacer cap screws to the following specification.

Specification

Fan/Hub Pulley-to-Fan Spacer Cap Screws—Torque .... 60 N·m (45 lb-ft)

9. Install washer and cap screw. Tighten cap screw to specifications.

Specification

Fan Hub/Pulley-to-Fan Shaft—Torque .... 80 N·m (60 lb-ft)

10. Apply LOCTITE® 592 Pipe Sealant to threads of pipe plug. Install and tighten plug in bearing housing.
11. Install fan drive assembly (I) onto support plate in the specified height position.
12. Install 4 fan support plate to fan bearing housing cap screws (J) from the backside of the plate, as shown. Tighten cap screws to specification.

Specification

Fan Drive Assembly to Support Plate—Torque .... 101 N•m (75 lb-ft)

13. Install support plate assembly onto engine and tighten cap screws to the following specifications.

Fan Drive Support Plate-to-Engine—Specification

8 mm. Mounting Cap Screws (5 total)—Torque .... 40 Ṅ•m (18 lb-ft)
10 mm. Mounting Cap Screws (2 total)—Torque .... 60 Ṅ•m (45 lb-ft)

Continued on next page

RE38635,000008A -19-22MAR05-2/3

14. Install fan and belts and adjust tension. See REPLACING FAN/ALTERNATOR V-BELT in operator's manual.

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RE38635,000008A -19-22MAR05-3/3

Replace Bearings in Coolant Manifold-Mounted, Fixed Fan Drive Assembly

To Disassemble Fan Drive:

1. Remove thermostat housing-to-cylinder head cap screws. Remove thermostat housing (A) and fan pulley (C) assembly from cylinder head and lift to dislodge coolant bypass pipe.
2. Support front face of coolant manifold and use a press to push bearing and pulley out of housing.
3. Support front face of fan pulley and push bearing out of pulley, and fan spacer (if equipped). Discard bearing.
4. Thoroughly inspect thermostat housing and pulley for cracks or damage. Measure parts and compare readings with specifications shown. Replace parts as necessary.

IMPORTANT: Support fan pulley on a flat, firm surface and press only on bearing outer race to prevent damage to the bearing.

5. Install new bearing into pulley until outer race bottoms in bore of pulley. End of shaft will extend through bearing stop.

Thermostat Housing-Mounted Fixed Fan Drive Specifications

Thermostat Housing-Mounted Fixed Fan Drive Specifications—Specification

Fixed Fan Drive Shaft—OD....................25.387—25.400 mm (0.9995—1.0000 in.)

Fixed Fan Drive Bearing—OD....................47.612—47.625 mm (1.8745—1.8750 in.)

Fixed Fan Drive Pulley (Bearing End)—ID....................47.576—47.612 mm (1.8731—1.8745 in.)

[2]Fixed Fan Drive Pulley (Fan Spacer End) —ID....................49.485—49.518 mm (1.9482—1.9495 in.)

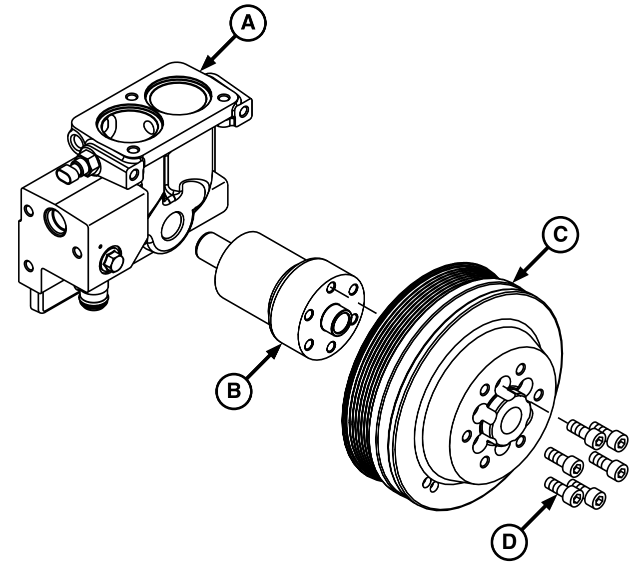
[3]Fan Spacer —O.D....................49.457—49.483 mm (1.9471—1.9481 in.)

Fixed Fan Drive Manifold—I.D....................25.336—25.362 mm (0.9975—0.9985 in.)

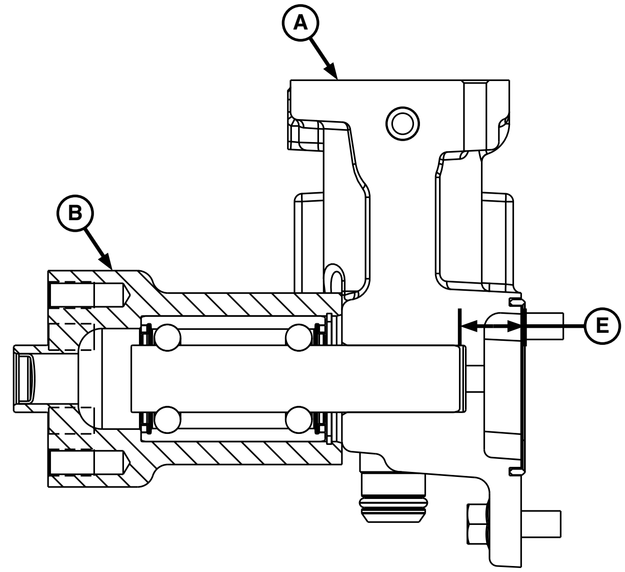
Fixed Fan Drive Shaft (Installed)—Dimension From Manifold Mounting Face to End of Shaft....................25.51—25.77 mm (1.004—1.015 in.)

To Assemble Fan Drive:

IMPORTANT: Support thermostat housing on machined surface and press only on inner shaft to prevent damage to bearing.



Fixed Fan Drive Assembly



A—Thermostat Housing
B—[1]Bearing Shaft & Fan Spacer Hub
C—Fan Pulley
D—Fan Pulley to Spacer Hub Cap Screws
E—Bearing Shaft Installed Dimension

1. On units with a press-fit fan spacer, press spacer into pulley to the following depth.

Specification

Adjustable Fan Drive Housing Seal—Depth....................Flush-to-0.50 mm (0.020 in.) below housing face

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RE38635,00000B4 -19-11APR05-1/2

2. Press bearing shaft (B) into thermostat housing (A) to the following specification.

Specification

Fixed Fan Drive Bearing
Shaft—Depth...25.51—25.77 mm (1.004—1.015 in.) below manifold mounting surface

Hold thermostat housing firmly and turn fan pulley by hand to be sure bearings rotate freely.

3. Install a new gasket and O-rings. Insert coolant bypass pipe in coolant pump cover and install assembly in front face of cylinder head. Tighten cap screws to specifications.

Specification

Fixed Fan Drive (Coolant Manifold Mounted) Cap
Screws—Torque.. 60 N·m 45 (lb-ft)

4. Install fan and belts. Refer to appropriate operator's manual for proper belt tensioning.

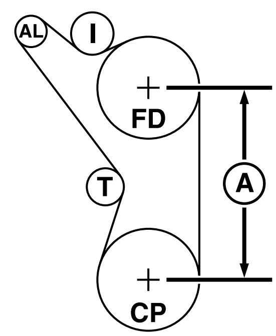
[1] In some applications, bearing is pressed into hub. The fan spacer and pulley are then bolted to hub. In some applications, the fan spacer is press-fit into the pulley. Dimension (E) is the same for all applications.
[2] Units with press-fit fan spacer only.
[3] Units with press-fit fan spacer only.

RE38635,00000B4 -19-11APR05-2/2

Fan Drive Assembly

Use the following tables to determine proper fan drive height.

Adjustable Fan Drives (A)		
Fan Belt Option	Fan Drive Option	Fan Height
2418, 2419	23BL	354 mm (13.9 in.)
2416, 2417, 2428	23AL	317 mm (12.5 in.)
2412, 2426, 2427, 2429	23CL	391 mm (15.4 in.)

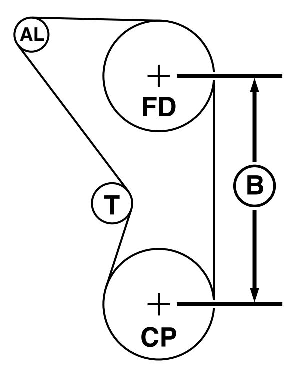


RG11666 —UN—03SEP09

A—Fan Drive Height
AL—Alternator
I— Idler
FD—Fan Drive
T—Tensioner
CP—Crank Pulley

RG41165,000006D -19-25AUG09-1/9

Adjustable Fan Drives (B)		
Fan Belt Option	Fan Drive Option	Fan Height
2404, 2410, 2414	23DL	425 mm (16.7 in.)
2415, 2420, 2422	23DL	425 mm (16.7 in.)
2409	23EL	462 mm (18.2 in.)
2424	23FL	499 mm (19.6 in.)



RG11667 —UN—03SEP09

B—Fan Drive Height
AL—Alternator
FD—Fan Drive
T—Tensioner
CP—Crank Pulley

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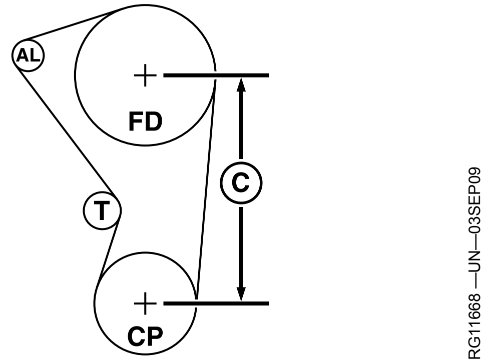
RG41165,000006D -19-25AUG09-2/9

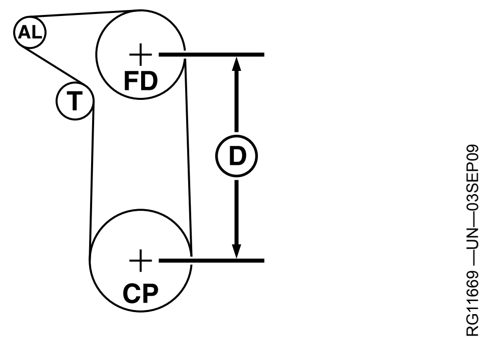
Adjustable Fan Drives (C)		
Fan Belt Option	Fan Drive Option	Fan Height
2411	23FC	499 mm (19.6 in.)
2413	23CC	391 mm (15.4in.)
2495, 2499	23DC	425 mm (16.7 in.)
2425	23EC	499 mm (19.6 in.)



C—Fan Drive Height
AL—Alternator
FD—Fan Drive
T—Tensioner
CP—Crank Pulley

RG41165,000006D -19-25AUG09-3/9

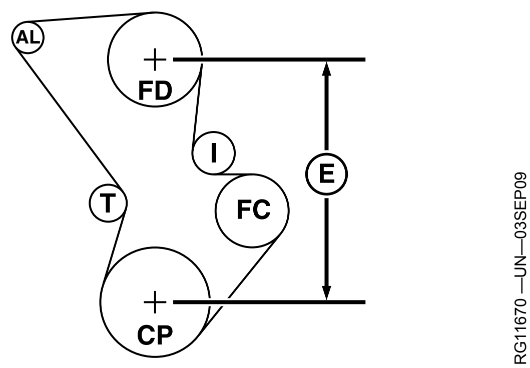
Fixed Fan Drives (D)		
Fan Belt Option	Fan Drive Option	Fan Height
2408	236A	425 mm (16.7 in.)



D—Fan Drive Height
AL—Alternator
FD—Fan Drive
T—Tensioner
CP—Crank Pulley

RG41165,000006D -19-25AUG09-4/9

Adjustable Fan Drives (E)		
Fan Belt Option	Fan Drive Option	Fan Height
2404, 2410, 2414, 2415, 2420, 2422	23DL	425 mm (16.7 in.)
2424	23FL	499 mm (19.6 in.)
2409	23EL	462 mm (18.2 in.)



E—Fan Drive Height
AL—Alternator
I— Idler
FD—Fan Drive
T—Tensioner
CP—Crank Pulley

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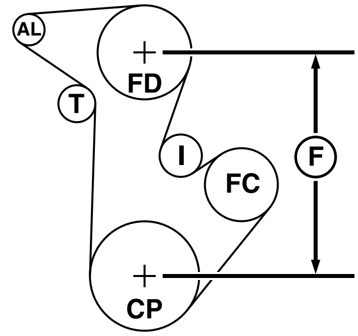
RG41165,000006D -19-25AUG09-5/9

Fixed Fan Drives (F)		
Fan Belt Option	Fan Drive Option	Fan Height
2408	236A	425 mm (16.7 in.)

F—Fan Drive Height
AL—Alternator
I— Idler
FD—Fan Drive
T—Tensioner
CP—Crank Pulley



RG11671 —UN—03SEP09

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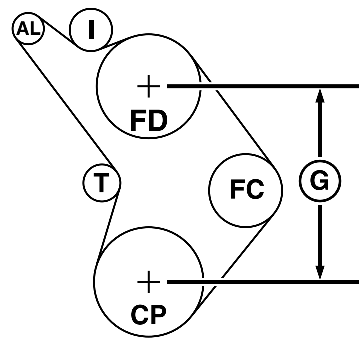
Adjustable Fan Drives (G)		
Fan Belt Option	Fan Drive Option	Fan Height
2416, 2417, 2428	23AL	317 mm (12.5 in.)
2418, 2419	23BL	354 mm (13.9 in.)
2412, 2426, 2427, 2428	23CL	391 mm (15.4 in.)

G—Fan Drive Height
AL—Alternator
I— Idler
FD—Fan Drive
T—Tensioner
CP—Crank Pulley
FC—Freon Compressor



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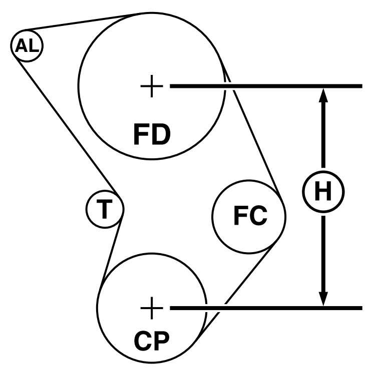
RG41165,000006D -19-25AUG09-7/9

Adjustable Fan Drives (H)		
Fan Belt Option	Fan Drive Option	Fan Height
2413	23CC	391 mm (15.4 in.)
2495, 2499	23DC	425 mm (16.7 in.)
2425	23EC	462 mm (18.2 in.)
2411	23FC	499 mm (19.6 in.)

H—Fan Drive Height
AL—Alternator
FD—Fan Drive
T—Tensioner
CP—Crank Pulley
FC—Freon Compressor

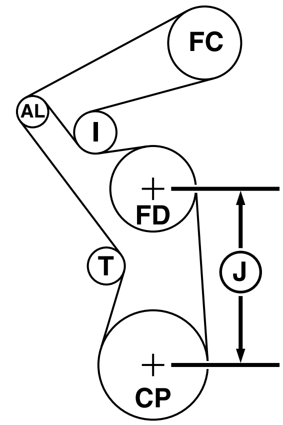


RG11673 —UN—03SEP09

Continued on next page

RG41165,000006D -19-25AUG09-8/9

Adjustable Fan Drives (J)		
Fan Belt Option	Fan Drive Option	Fan Height
2416, 2417, 2421, 2428	23AL, 23AM	317 mm (12.5 in.)
2418, 2419	23BL	354 mm (13.9 in.)
2412, 2426, 2427, 2429	23CL	391 mm (15.4 in.)
2404, 2410, 2414, 2415, 2420, 2422	23DL	425 mm (146.7 in.)
2495, 2499	23CF	391 mm (15.4 in.)



RG11674 —UN—03SEP09

J— Fan Drive Height
AL—Alternator
I— Idler
FD—Fan Drive
T— Tensioner
CP—Crank Pulley
FC—Freon Compressor

RG41165,000006D -19-25AUG09-9/9

Checking Belt Tensioner Spring Tension and Belt Wear

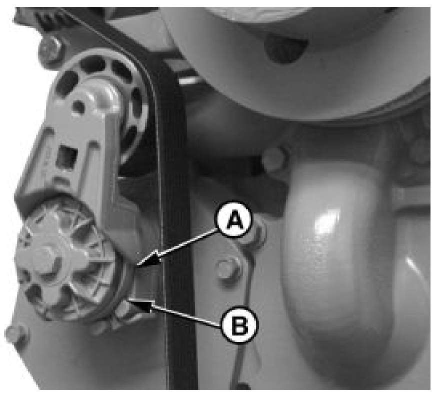
Belt drive systems equipped with automatic (spring) belt tensioners cannot be adjusted or repaired. The automatic belt tensioner is designed to maintain proper belt tension over the life of the belt. If tensioner spring tension is not within specification, replace tensioner assembly.

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 are used.

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

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 operator's manual).



RG7380 —UN—28NOV97

Belt Tensioner

A—Cast Stop
B—Cast Stop

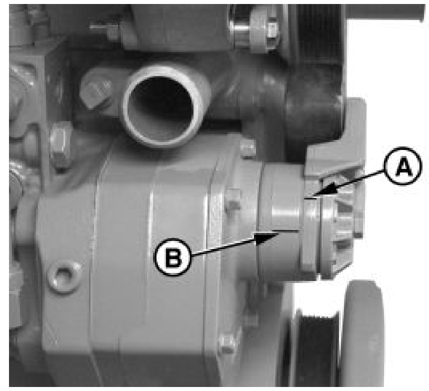
Continued on next page

RG,RG34710,1241 -19-23OCT97-1/3

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 long-handle 1/2-in. breaker bar in 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.



RG7382 —UN—28NOV97

Checking Belt Tensioner

A—Mark on Swing **B—Mark on Tensioner Mounting Base**

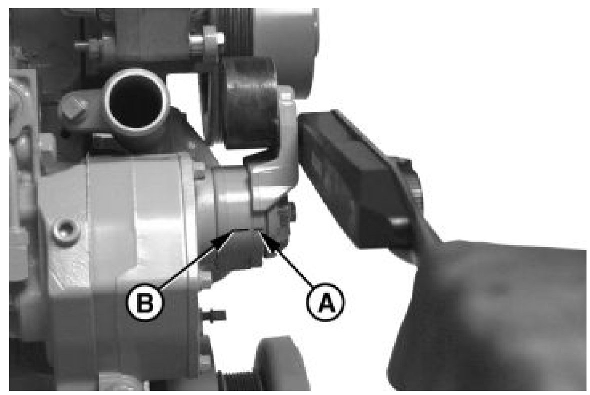
RG,RG34710,1241 -19-23OCT97-2/3

5. 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

Belt Tensioner
Spring—Tension..24-28 N·m (17-21 lb-ft)

A—Mark **B—Mark**



RG7381 —UN—28NOV97

Measuring Belt Tensioner

RG,RG34710,1241 -19-23OCT97-3/3

Inspect and Install Fan Assembly

Several fan drive ratios are available, allowing a closer matching of fan speed to application.

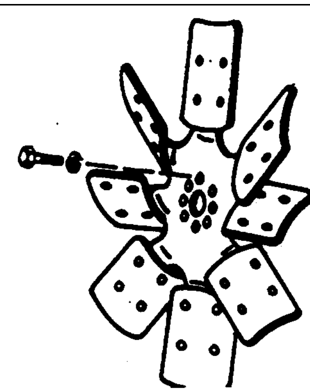
1. Inspect fan blades for bent or damaged condition. Bent blades reduce cooling system efficiency and throw the fan out of balance. Replace fan if blades are bent or damaged.

NOTE: Engines may be equipped with either suction-type fan or a blower-type fan, depending on application.

2. Install fan on pulley or pulley spacer hub. Tighten cap screws (with lock washers) to specifications.

Specification

Fan-to-Fan
Hub/Pulley—Torque.. 47 N·m (35 lb-ft)


RG4797 —UN—14DEC88

Fan Assembly

RG,RG34710,1242 -19-23OCT97-1/1

Visually Inspect Coolant Pump

Inspect Weep Hole:

When accessible, clean any debris or obstruction from the weep hole area of coolant pump, being careful not to disturb the seal.

Inspect coolant pump weep hole (A) in timing gear cover for oil or coolant leakage.

Oil leakage indicates a possible damaged rear seal.

Coolant leakage indicates a possible damaged front seal.

If no leakage of coolant is observed during normal operating conditions, the coolant pump should not be replaced.

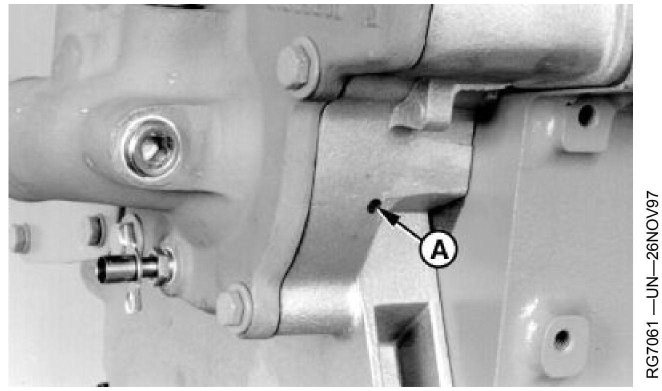
Chemical streak trails, or coolant “weeping”, or “seeping” are normal. ”Weeping” can be defined as a passing of liquid across a sealed surface of about 1-5 drops per day of use. “Seepage” is defined as a coolant loss equal to more than 5 drops per day of use. A “leak” is defined as a near constant dripping of coolant.

If coolant loss out the weep hole dictates coolant pump repair, a complete coolant pump assembly replacement is necessary. Individual repair parts are not available.

Reference DTAC solution 61186 for additional information.

Inspect for Impeller Contact with Cover:

1. Remove radiator-to-coolant pump hose from coolant pump inlet elbow.



Coolant Pump Weep Hole

A—Weep Hole

2. Using a flashlight, inspect I.D. of coolant pump cover for internal impeller contact.

   Impeller contact with cover usually indicates that impeller has moved on shaft or there is a damaged bearing.

   Replace coolant pump assembly and cover as necessary if impeller contact is detected.

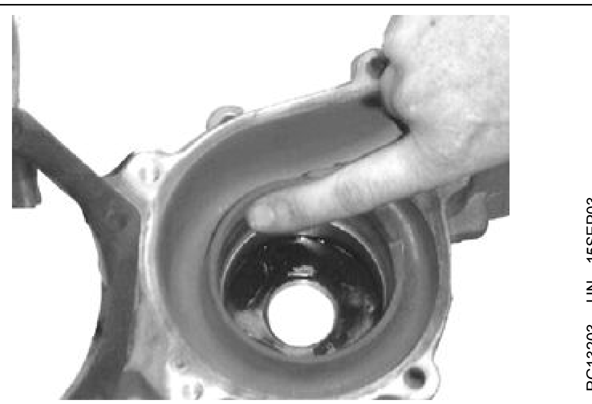
RE38635,0000130 -19-31JAN08-1/2

Inspect Timing Gear Cover for Cavitation

1. Any time repair of the coolant pump is necessary, check the timing gear cover for erosion, or cavitation.
2. Cavitation has the appearance of small holes, or “pock marks” on any surface where coolant flow exists. John Deere Coolants have cavitation preventatives added, but aluminum can still be susceptible to cavitation.
3. Cavitation can also occur from a leaking radiator cap or coolant system.. A leak can lower the boiling point of the coolant and accelerate the erosion of aluminum components.

IMPORTANT: Always change coolant when the coolant pump is replaced, since the cavitation preventatives in the coolant have been depleted.

IMPORTANT: Always change engine oil when coolant pump is replaced due to failure.



Timing Gear Cover

RE38635,0000130 -19-31JAN08-2/2

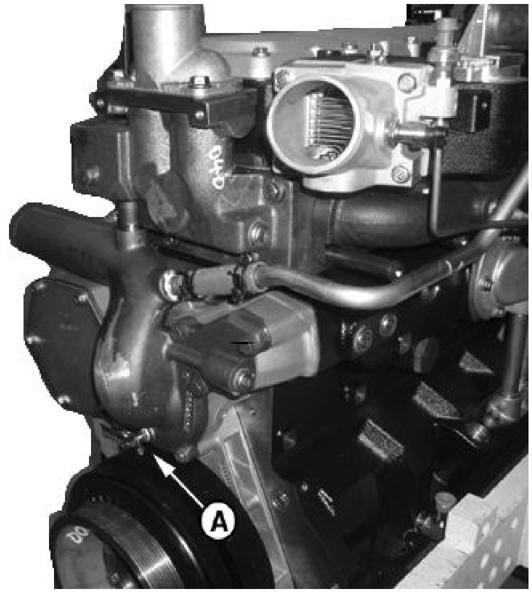
Remove Coolant Pump Assembly

The coolant pump should be removed from the timing gear cover for replacement purpose only. There are no service parts available to repair coolant pump, replace as a complete assembly.

CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Wait until engine coolant is cool enough to touch with bare hands before draining. Slowly loosen radiator cap to first stop to relieve pressure.

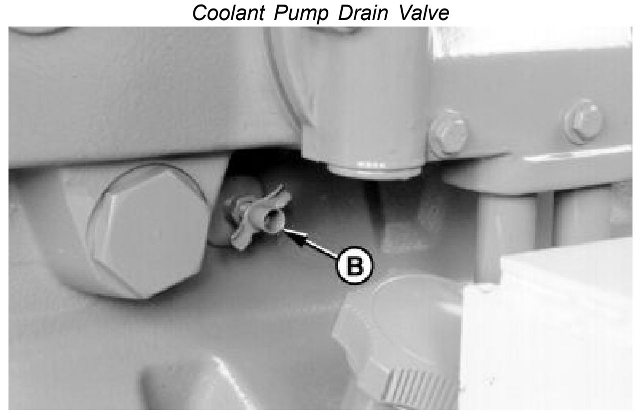
1. Open coolant pump drain valve (A) and cylinder block drain valve (B) to drain coolant from engine.

A—Coolant Pump Drain Valve B—Cylinder Block Drain Valve



RG14158 —UN—12APR05

Coolant Pump Drain Valve



RG7143 —UN—26NOV97

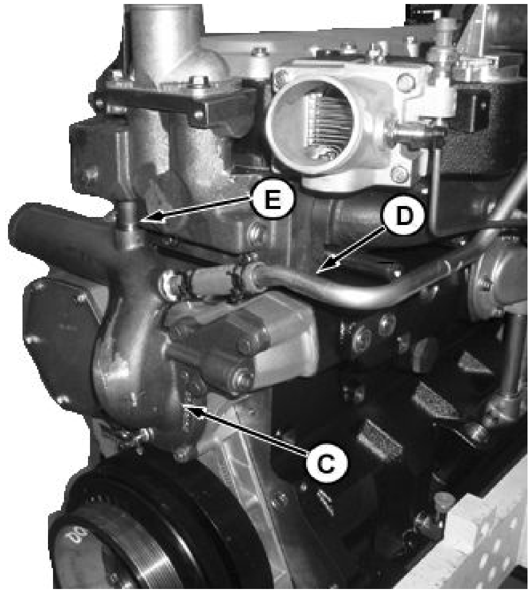
Cylinder Block Drain Valve

Continued on next page RE38635,00000DD -19-05AUG11-1/4

2. Remove radiator hose from coolant pump cover inlet elbow, shown removed.
3. Loosen hose clamps and remove EGR coolant return hose (D) from coolant pump port.

IMPORTANT: For some applications, it will be easier to remove the coolant pump assembly if the thermostat housing and bypass tube are removed prior to the coolant pump. Removing the bypass tube and thermostat housing first prevents damage to the bypass tube o-rings during reassembly.

4. Remove six cap screws securing coolant pump cover (C) to timing gear cover and remove coolant pump cover. Bypass tube (E) will remain attached to thermostat housing.
5. Remove gasket from timing gear cover and discard.



RG17701 —UN—08OCT09

Removing Coolant Pump Cover

C—Coolant Pump Cover
D—EGR Coolant Return Line
E—Bypass Tube

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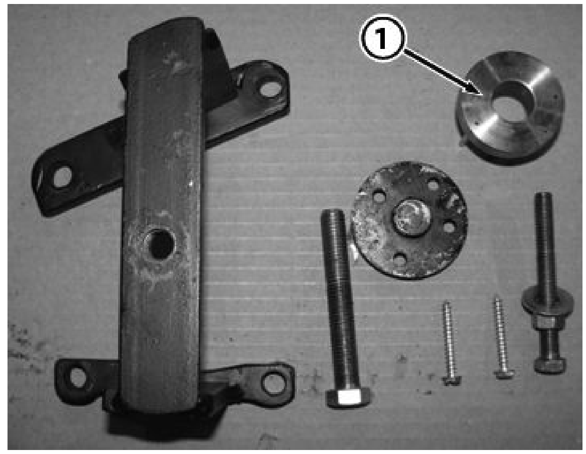
RE38635,00000DD -19-05AUG11-2/4

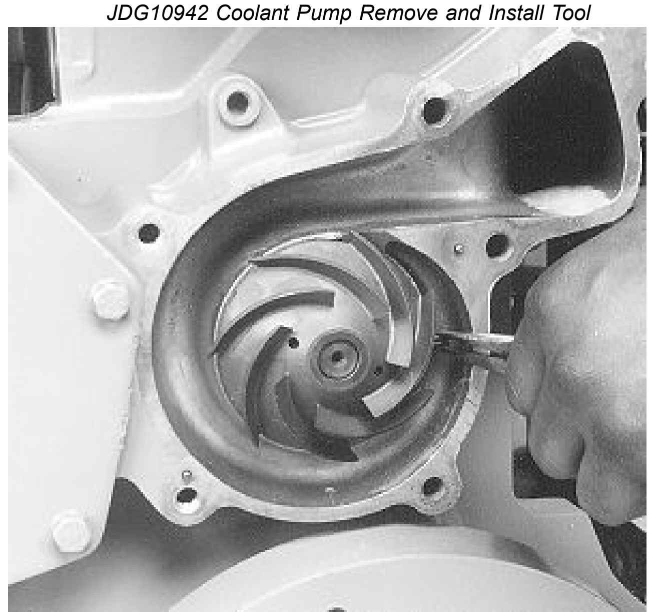
NOTE: Note components of JDG10942 tool to be used for the Tier 3 9.0 L engine. There is a base plate used on IT4 engines, but this plate is not used on Tier 3 or Tier 2 8.1 L. **The component labeled #1 is not a part of the tool set. It is used for pump installation and is included in coolant pump service kit.**

6. Remove snap ring from coolant pump assembly.



RG20721 —UN—05AUG11

JDG10942 Coolant Pump Remove and Install Tool



RG7062 —UN—07SEP94

Remove Snap Ring

Continued on next page RE38635,00000DD -19-05AUG11-3/4

NOTE: This tool was designed to also remove coolant pumps from Tier-2 8.1L and IT-4 9L Screw through holes are marked.

NOTE: Puller plate (B) is reversible and is used for both removal and installation of pump. For removing pump use the threaded portion of center hole in plate to mate with forcing screw.

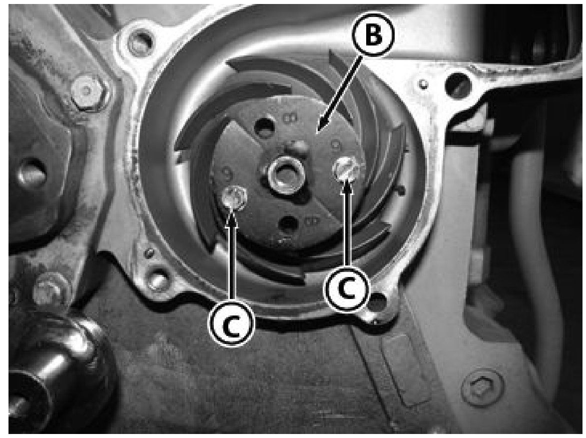
NOTE: If engine has a number of hours on it, the pump can be more difficult to pull. JDG11253 L-shaped Puller Screws can be ordered and used for difficult to remove pumps.

7. Position JDG10942P3 Plate (B) to coolant pump nose. Install 2 number 12 x 1.5 in long drill and tap screws (C) provided with tool through plate holes marked 9 and into coolant pump impeller face. Tighten screws snugly.
8. Install JDG10942P1 bridge (D) in the orientation shown. Secure with 3 cap screws (.375 in. OD x .750 in. L) through bridge into timing gear cover.
9. Install forcing screw with nut and washer (E) through bridge and thread into JDG10942P3 puller plate (B).

IMPORTANT: Be certain puller screws are lined up and square with the coolant pump face. The puller screws will not be in plate holes directly across from each other. They will be slightly above puller plate centerline.

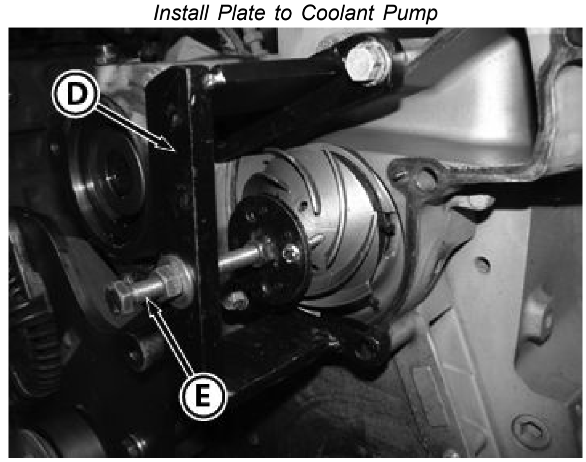
10. Turn forcing nut clockwise to pull pump (F) from timing gear cover face.
11. Remove forcing screws and puller plate from coolant pump.
12. Remove remainder of JDG10942 tool from timing gear cover face.

B—JDG10942P3 Plate
C—Tap Screws -2-
D—JDG10942P1 Bridge
E—Forcing Screw with Nut and Washer
F—Coolant Pump



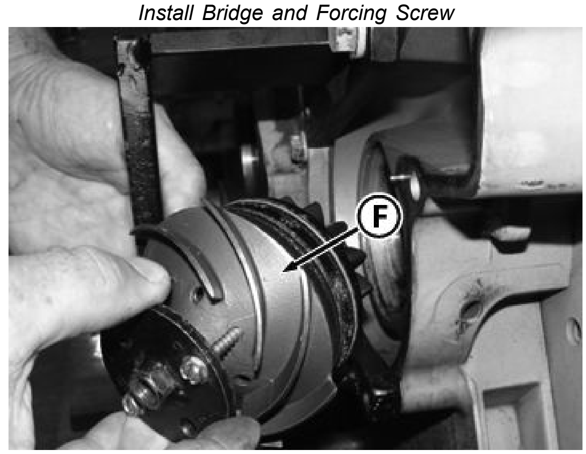
RG20722 —UN—05AUG11

Install Plate to Coolant Pump



RG20723 —UN—05AUG11

Install Bridge and Forcing Screw



RG20724 —UN—05AUG11

Removed Coolant Pump

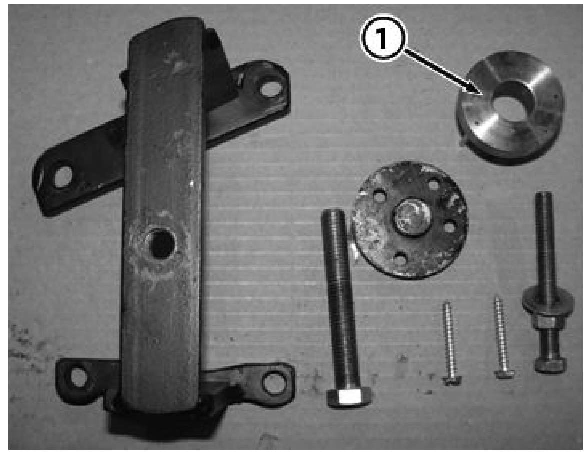
RE38635,00000DD -19-05AUG11-4/4

Install Coolant Pump Assembly

IMPORTANT: If coolant pump is replaced because of failure, always change engine oil and filter as a part of the repair procedure.

NOTE: Coolant pump is supplied with an installation tool. **The component labeled #1 is not a part of the JDG10942 tool set. It is used for pump installation and is included in coolant pump service kit.**

1— Coolant Pump Assembly Tool



JDG10942 Coolant Pump Installation and Removal Tool

RE38635,00000DE -19-08AUG11-1/3

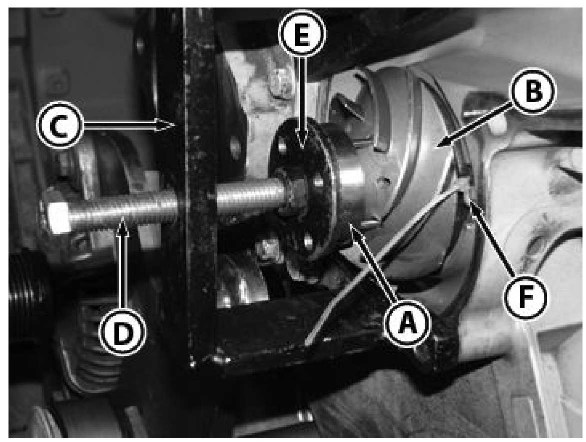
1. Apply O-ring lubricant to coolant pump O-rings.

IMPORTANT: When installing coolant pump, DO NOT push on pump shaft. Damage to seals and bearing will occur. Be cautious during installation so O-rings to not roll.

2. Install coolant pump assembly tool (A) supplied with pump kit to holes in face of coolant pump (B) and install pump into timing gear cover.
3. Install JDG10942P1 Bridge (C) in the orientation shown. Secure with 3 cap screws (.375 in. OD x .750 in. L) through bridge into timing gear cover.

NOTE: JDG10942P3 plate (E) is reversible and is used for both removal and installation of pump. For installing pump use the flat side of center boss in plate to provide location for end of forcing screw.

4. Install forcing screw (0.500 in. OD x 3.5 in. L) (D) through bridge.
5. Position JDG10942P3 small forcing plate (E) against face of coolant pump assembly tool (A) as shown. Align forcing screw with center boss on back side of plate.
6. Clip and remove the tie band (F) securing the pump snap ring.



Install Coolant Pump

A—Pump Assembly Tool
B—Coolant Pump
C—JDG10942P Bridge
D—Forcing Screw—0.500 inch OD x 3.5 inch L
E—JDG10942P3 Forcing Plate
F—Non-Metallic Tie Band

7. Turn forcing screw clockwise to install coolant pump to proper position. Turn forcing screw until tool bottoms out.

Continued on next page

RE38635,00000DE -19-08AUG11-2/3

8. Install five M10 cap screws and one M8 cap screw (H) through coolant pump cover into timing gear cover finger tight.
9. Torque cap screws to specification.

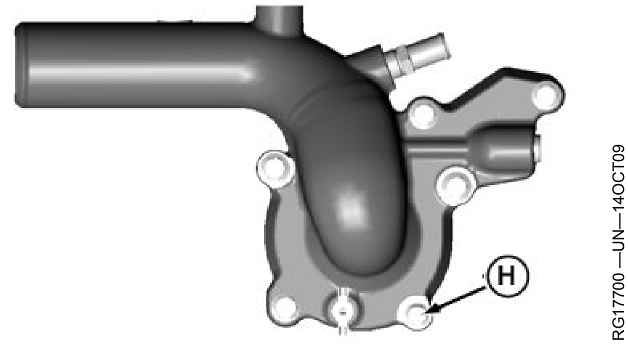
Specification

Coolant Pump Cover to Timing Gear Cover — M8—Torque .... 32 N•m (24 lb-ft)

Specification

Coolant Pump Cover to Timing Gear Cover — M10—Torque .... 47 N•m (35 lb-ft)

10. If previously removed, replace thermostat housing and coolant bypass tube assembly.
11. Install radiator hose.
12. Refill engine coolant.



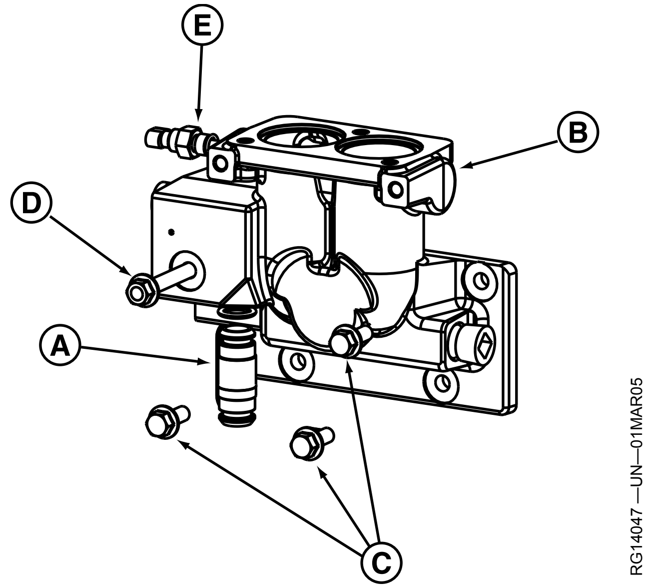
Install Coolant Pump Cover

H—Cap Screws

RE38635,00000DE -19-08AUG11-3/3

Replace Bypass Tube & O-Rings in Thermostat Housing

1. Drain cooling system.
2. Loosen one long (D) and three short (C) cap screws and remove thermostat housing (B) with bypass tube (A) from cylinder head and coolant pump cover. Discard gasket.
3. Carefully clamp cover in a soft-jawed vise and remove bypass tube from thermostat housing. Be careful not to damage machined gasket surface of housing.
4. Remove o-rings from bypass tube.
5. Install two new o-rings to bypass tube.
6. Apply Amogell (or equivalent) grease to both o-rings and drive bypass tube into thermostat housing by hand until seated.
7. Remove cover from vise and inspect bypass tube installation and also machined gasket surfaces.



Thermostat Housing Assembly

A—Bypass Tube with O-Rings
B—Thermostat Housing
C—Short Flange Head Cap Screws
D—Long Flange Head Cap Screw
E—Coolant Temperature Sensor

RE38635,000008D -19-28MAR05-1/1

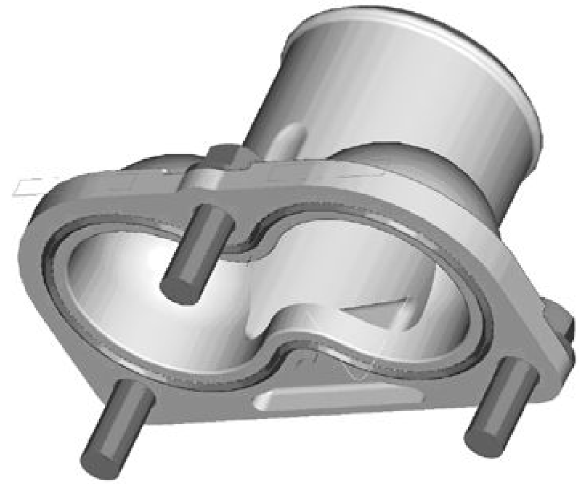
Remove and Test Thermostats

CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Do not drain coolant until coolant temperature is below operating temperature. Always loosen cooling system filler cap, radiator cap, or drain valve slowly to relieve pressure.

1. Visually inspect the area around the coolant manifold for leaks. Partially drain coolant from the cooling system.
2. Remove thermostat cover with gasket.
3. Remove thermostats.
4. Inspect thermostats for debris or damage, and test each thermostat using an approved testing procedure. Thermostats should start to open within the range specified below.

Specification

Thermostat 82°C (180°F)—Opening Temperature..80—84°C (175—182°F)



Thermostat Housing Cover

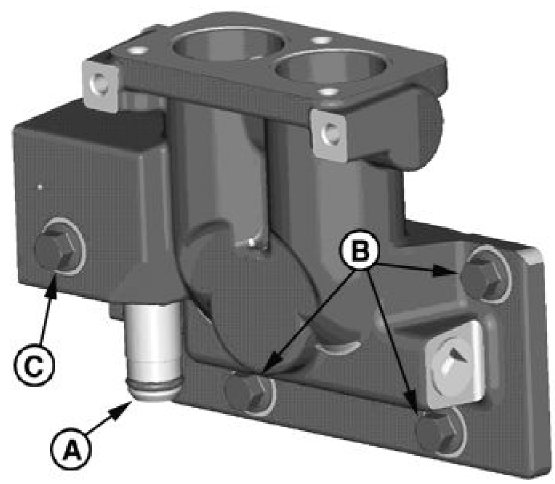
If either thermostat fails to open within this range, replace both thermostats as a set.

RE38635,000008E -19-28MAR05-1/1

Remove Thermostat Housing

1. Drain coolant and remove thermostat cover and thermostats (shown removed).
2. Remove one long (C) and three short (B) thermostat housing-to-cylinder head cap screws, remove housing and dislodge coolant bypass tube (A) from coolant pump cover as housing is removed.
3. Remove and discard thermostat housing gasket.

A—Coolant Bypass Tube
B—Short Cap Screws
C—Long Cap Screw



Thermostat Housing

RE38635,000008F -19-28MAR05-1/1

Install Thermostats

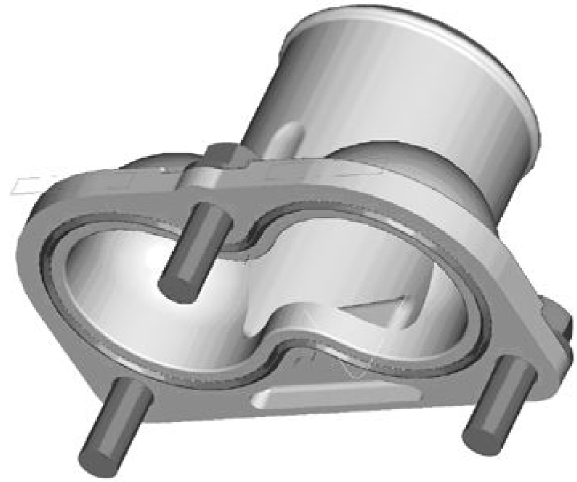
NOTE: Install thermostats in groove in housing first. Then install gasket after thermostat is properly seated in grooves.

1. Install thermostats. Install a new gasket in cover, as applicable.
2. Install cover and tighten cap screws to specifications.

Specification

Thermostat
Cover-to-Thermostat
Housing—Torque..30 N•m (22 lb-ft)

IMPORTANT: Air must be expelled from cooling system when system is refilled. Loosen temperature sensor in thermostat housing to allow air to escape when filling system. Retighten fitting when all the air has been expelled.



Thermostat Housing Cover

RE38635,0000090 -19-28MAR05-1/1

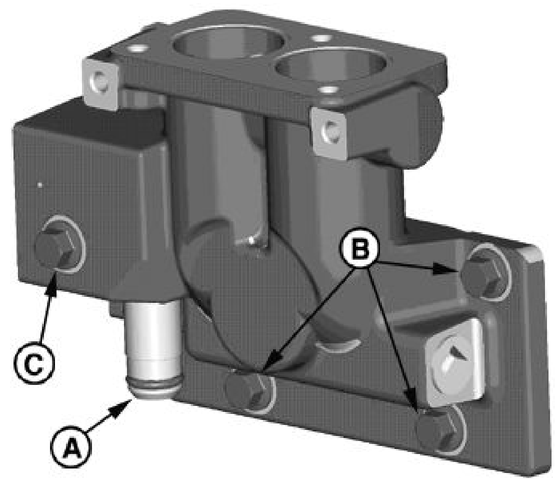
Install Thermostat Housing

1. Position thermostat housing assembly to cylinder head with new gasket. Apply grease to bypass tube O-ring and install bypass tube (A) into coolant pump cover.
2. Install three short (B) and one long (C) cap screws through thermostat housing and into cylinder head finger tight.
3. Tighten cap screws to specifications.

Specification

Thermostat Housing-
to-Cylinder Head Cap
Screws—Torque..61 N•m (45 lb-ft)

4. Install thermostats and cover. See <u>INSTALL THERMOSTATS</u>, earlier in this group.



Thermostat Housing

A—Coolant Bypass Tube
B—Short Cap Screws
C—Long Cap Screw

RE38635,0000091 -19-03DEC08-1/1

Remove and Install Coolant Temperature Sensor

1. Disconnect wiring and remove sensor.
2. Coat threads of switch with TY9375 Pipe Sealant with TEFLON®.
3. Install sensor and tighten to the following specifications.

Specification

Coolant Temperature
Sensor—Torque..40 N•m (35 lb-ft)

TEFLON is a registered trademark of Du Pont Co.

RE38635,0000092 -19-28MAR05-1/1

Servicing of Engine Coolant Heater

Refer to CTM67, Engine Accessories, Group 25, for service of the block-type engine coolant heater. See REMOVE COOLANT HEATER—BLOCK TYPE in Group 25 of CTM67.

RG,RG34710,1251 -19-23OCT97-1/1

Bleed Air from Coolant System

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

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

TS281 —UN—23AUG88

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AS58880,000021C -19-16MAR09-1/2

IMPORTANT: Use coolant as specified in Fuel, Lubricants and Coolant section.

NOTE: Bleed the air out of the system to prevent an overheat shut-down of the engine. Fill initially and then check the level after the engine's thermostat opens up which allows an estimated two gallons of coolant into the engine.

1. Remove cap from top tank (de-aeration tank) of cooling system.
2. Remove EGR cooler vent plug (A) from rear of cooler.
3. Fill high pressure coolant circuit at top tank.
4. Begin filling coolant recovery tank (if equipped).
5. When air is purged and coolant is visible coming out of vent hole on EGR cooler, reinstall EGR cooler vent plug and tighten to specification.

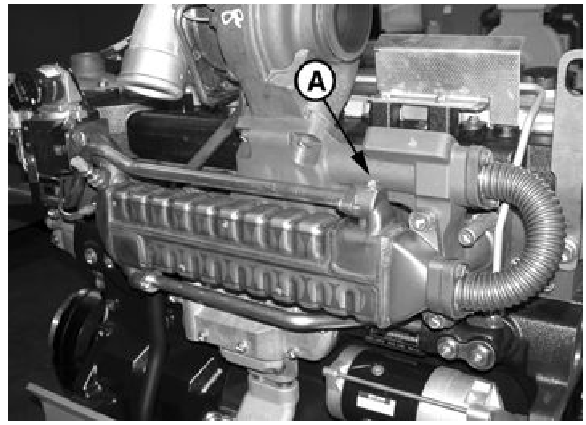
Specification	
EGR Cooler Vent Plug to Cooler—Torque	20 N•m (15 lb-ft)

.

6. Complete filling coolant recovery tank (if equipped) to **Full Hot** mark.

NOTE: Coolant level in recovery tank will drop the first few cycles unless there is a leak.

7. Install top tank (de-aeration) cap. Start engine and run at idle for 1 to 5 minutes.
8. Shut off and remove top tank cap. Fill high pressure circuit tank and reinstall cap.
9. Start engine and warm up for 15 minutes. If coolant recovery tank loses coolant to ground, repeat previous step and top off top tank until coolant loss stops. Loosing coolant to ground indicates air in high pressure system is being discharged through coolant recovery tank.



RG14831 —UN—05APR06

EGR Cooler Vent Plug

A—Plug to Bleed Air from EGR Cooler

IMPORTANT: If coolant level does not drop below Full Hot, there is a leak in cooling system. Engine damage may result.

10. Shut off engine and allow to cool. Observe coolant level dropped below **Full Hot** in recovery tank (if equipped).

NOTE: It is normal for coolant level to go down with first few cycles and then range between ***Full Hot*** *and* ***Full Cold****.*

IMPORTANT: It is normal for top (de-aeration) tank to be partially full of air when cap is removed and system completely de-aerated. When inspecting top tank, if it is at least 1/2 full, do not add additional coolant. Topping off tank may cause coolant to be expelled onto the ground and may cause coolant pump cavitation.

11. Monitor coolant recovery (if equipped) tank for two days. Refill recovery tank or top tank as required.

AS58880,000021C -19-16MAR09-2/2

Complete Final Assembly

NOTE: Consult your engine operator's manual or see Group 002 of this CTM for coolant recommendations in your area. See *DIESEL ENGINE COOLANT* *in Group 002.*

1. Fill cooling system to proper level with the proper coolant.
2. Start engine and run for several minutes to check for leaks in the cooling system.
3. After fan belts cool, check belt tension as detailed in your operator's manual.

RG,RG34710,1252 -19-04SEP08-1/1

Extending Turbocharger Life

IMPORTANT: In the event of a turbocharger failure, be certain to check the air intake system (including the charge air cooler and piping) for residual oil and, if oil is present, clean thoroughly. If this step is not done, the engine will burn the residual oil following turbocharger replacement. This will result in major engine failure.

The major causes of turbocharger failures are:

- **Lack of Lube Oil (Quick Starts and Hot Shutdowns)**
- **Oil Contamination**
- **Ingestion of Foreign Objects**
- **Restricted Oil Drainage**
- **Low Oil Level**
- **Operation on Excessive Side Slopes**
- **Abnormally High Exhaust Temperatures**
- **Oil in charge air cooler**

Lack of Lube Oil

Oil not only lubricates the turbocharger's spinning shaft and bearings, it also carries away heat. When oil flow stops or is reduced, heat is immediately transferred from the hot turbine wheel to the bearings, which are also heating up because of the increased friction due to the lack of oil. This combination causes the turbocharger shaft temperature to increase rapidly.

If oil flow does not increase and the process continues, bearings will fail. Once the bearings fail (which can happen in just seconds) seals, shaft, turbine and compressor wheels can also be damaged.

The principle causes of turbocharger bearing lubrication problems are low oil pressure, a bent, plugged or undersized oil lube supply line, plugged or restricted oil galleries in the turbocharger, or improper machine start-up and shutdown procedure.

Oil levels and pressure should always be closely monitored and all worn hoses and lines should be replaced. The turbocharger oil supply line should be checked frequently to make sure it is not kinked or bent and it should always be replaced with a line of equal size, length and strength.

The easiest way to damage a turbocharger is through improper start-up and shutdown procedures. Always idle the engine for at least 30 seconds (no load) after start-up and before shutdown. Warming the engine up before applying a load allows oil pressure to build up and lines to fill with oil.

Idling the engine before shutdown allows the engine and turbocharger to cool. “Hot” shutdowns can cause the turbocharger to fail because after high-speed operation the turbocharger will continue to rotate long after the engine has been shut off and oil pressure has dropped to zero. This will cause heat to build up and possibly damage bearings. It can also cause carbon and varnish deposits to form.

Oil Contamination

Oil contamination can be caused by a worn or damaged oil filter or not changing the lube oil at recommended intervals. Expecting the oil filter to remove dirt, sand, metal chips, etc. from the oil before they reach the engine or turbocharger can be a costly mistake because contaminated oil may completely bypass the engine oil filter if the oil filter or oil cooler is clogged, if the filter element is improperly installed, or if the oil is thick during cold weather.

Four good ways of avoiding oil contamination are:

- Always inspect the engine thoroughly during major overhaul. Look especially for any sludge or debris left in lube oil galleries.
- Change lube oil at recommended intervals. Analysis of oil samples at filter change periods can help identify potentially harmful contaminants in the oil.
- Clean the area around the oil fill cap before adding oil.
- Use a clean container when adding oil.

Ingestion of Foreign Objects

Foreign particles can be ingested and cause damage to the turbocharger on both compressor and turbine sides. This is easy to avoid.

On the compressor side, foreign objects usually take the form of dust, sand, or shreds of air cleaner element that enter through improperly installed air cleaner elements. Leaky air inlet piping (loose clamps or torn rubber joints) or torn pleats in dry-type air cleaner elements also create problems.

The result is erosion of compressor blades that can cause the delicately balanced wheel to wobble.

IMPORTANT: Whenever an internal engine failure (valve, valve seat, piston) occurs, a thorough inspection of the turbocharger MUST BE performed before returning engine to service.

Restricted Oil Drainage

The lubricating oil carries away heat generated by friction of the bearings and from the hot exhaust gases. If drainage back to the sump is impeded, the bearings will overheat with damage that will ultimately lead to failure.

There are two primary reasons for restricted drainage. A blocked drain tube, due to either damage or a buildup of sludged oil, or high crankcase pressure, which can be due to restricted crankcase breather or excessive engine blow-by.

Periodically check both turbocharger oil drain tubes (PSX Model) and engine breather tube for damage or restriction. Correction of these conditions leads to longer turbocharger life.

Continued on next page

AS58880,0000044 -19-25AUG09-1/2

Abnormally High Exhaust Temperatures

Elevated exhaust temperatures cause coking of oil which can lead to bearing failure. Extreme over-temperature operation can cause wheel burst.

There are two basic causes of over-temperature. The first is restricted air flow and the second is overpowering the engine. In either case the engine has more fuel than available air for proper combustion; this over fueled condition leads to elevated exhaust temperatures.

Causes of restricted air flow can include damaged inlet piping, clogged air filters, excessive exhaust restriction, or operation at extreme altitudes. Overpowering generally is due to improper fuel delivery or injection timing. If over temperature operation has been identified, an inspection of the air inlet and exhaust systems should be performed. Also, check the fuel delivery and timing.

Oil in Charge Air Cooler

A failed turbocharger can allow oil to enter the charge air cooler. If the charge air cooler is not cleaned out and the engine is restarted, this oil that has collected within will be ingested into the engine causing an over speed situation which will result in engine damage. Because of the proven possibility of such an over speed situation, anytime there has been a turbocharger failure, it is necessary to make certain that the charge air cooler lines or hoses have been thoroughly cleaned out. For cleaning the charge air cooler use John Deere coolant system cleaner PMCC2638 or equivalent, as per the instructions. After cleaning the charge air cooler use compressed air to completely dry the inside of the charge air cooler.

AS58880,0000044 -19-25AUG09-2/2

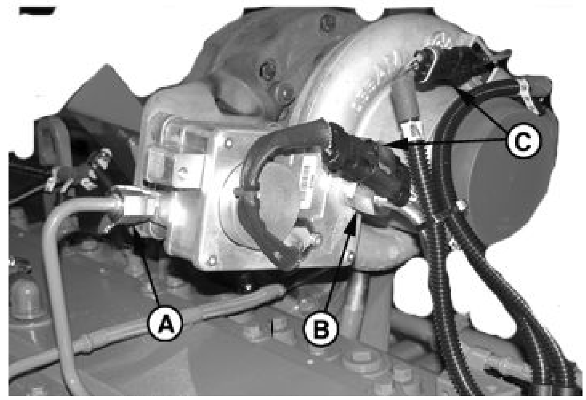
Remove Turbocharger

CAUTION: After operating engine, allow exhaust system to cool before removing turbocharger.

IMPORTANT: When cleaning turbocharger, do not spray directly into compressor cover or turbine housing. If turbocharger inspection is required, do not clean exterior prior to removal. Doing so may wash away evidence of a potential failure mode. See TURBOCHARGER INSPECTION later in this group.

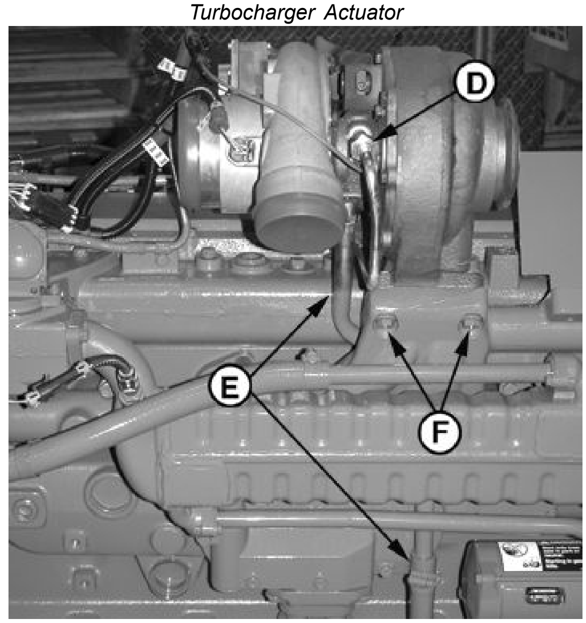
Thoroughly clean exterior of turbocharger and surrounding area to prevent entry of dirt into the air intake system during removal.

1. Disconnect air intake and exhaust piping from turbocharger (shown disconnected).
2. Disconnect turbocharger actuator coolant supply line (A).
3. Disconnect turbocharger actuator coolant drain line (B).
4. Disconnect turbocharger sensor connections (C).
5. Disconnect turbocharger oil supply line (D) at turbocharger and oil filter base. Set line aside.
6. Disconnect turbocharger oil drain line (E), removing two cap screws at flange at bottom of turbo housing and at tension clamp joint with hose as shown. Remove drain line from behind exhaust manifold, and gasket. Set drain line aside and discard gasket.
7. Remove four turbocharger mounting cap screws with washers securing turbocharger to rear exhaust manifold and remove turbocharger.
8. Cap or plug all openings on engine (exhaust and intake manifold related) and place turbocharger on a clean flat table for inspection.
9. Perform turbocharger seven-step inspection, as described later, if failure mode has not been determined. See TURBOCHARGER INSPECTION later in this group.



RG13919 —UN—31JAN05

Turbocharger Actuator



RG13921 —UN—31JAN05

Turbocharger

A—Actuator Coolant Supply Line
B—Actuator Coolant Drain Line
C—Turbocharger Sensor Connectors
D—Turbocharger Oil Supply Line
E—Turbocharger Oil Drain Line
F—Turbocharger Mounting Cap Screws

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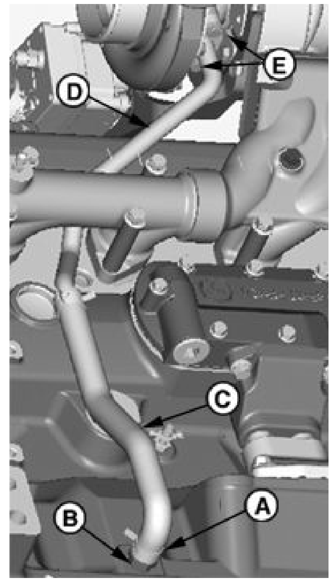
Remove Turbocharger Oil Drain Line

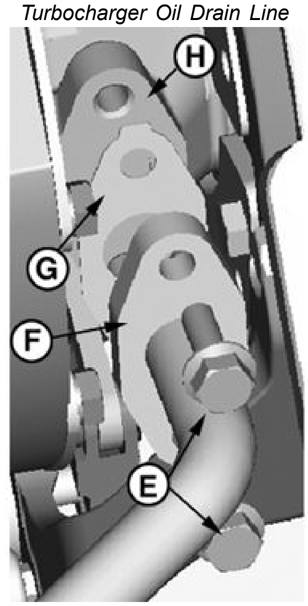
1. Loosen hose clamp (A) at cylinder block fitting (B).
2. Loosen and remove 2 cap screws (E) from flange end of line, securing drain line to turbocharger bearing housing (H).
3. Remove and discard gasket (G).
4. Remove line assembly and set aside.

A—Constant Tension Hose Clamp
B—Cylinder Block Fitting
C—Oil Drain Hose
D—Oil Drain Line
E—Cap Screws (2)
F—Drain Line Flange
G—Gasket
H—Turbocharger Bearing Housing



RG14248 —UN—01JUN05

Turbocharger Oil Drain Line



RG14238 —UN—02JUN05

Oil Drain Line - Flange End

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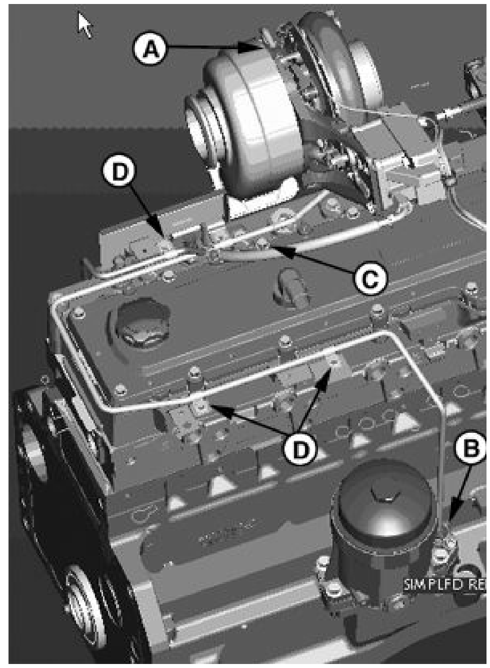
Remove Turbocharger Oil Supply Line

1. Loosen 3 cap screws securing P clamps (D) used to support oil line from oil filter adapter to turbocharger.
2. Loosen fittings at each end of oil line - turbocharger end (A) and oil filter adapter end (B).
3. Remove P Clamp Cap Screws.
4. Remove oil supply line from turbocharger and oil filter adapter and set aside.

A—Oil Line Fitting - Turbocharger
B—Oil Line Fitting - Oil Filter Adapter
C—Clearance Point
D—P Clamps (3) to Secure Line - Intake Manifold & Heat Shield



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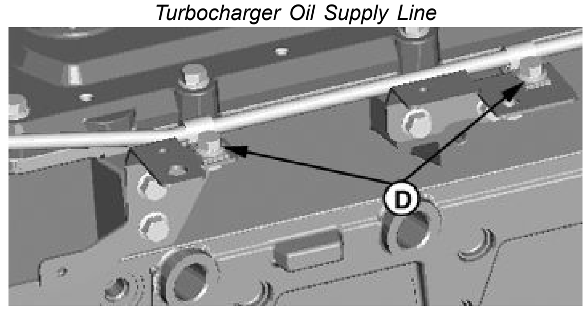
Turbocharger Oil Supply Line



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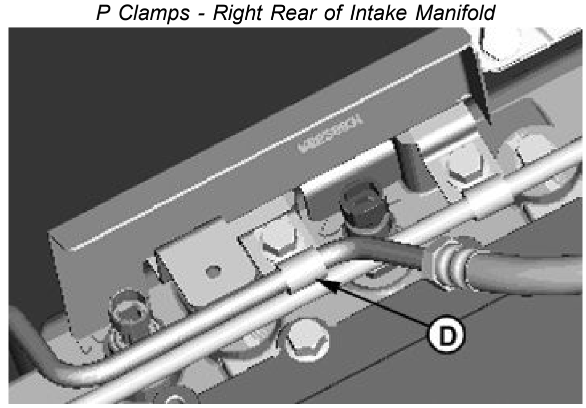
P Clamps - Right Rear of Intake Manifold



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P Clamp - Heat Shield

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Turbocharger Failure Analysis

The following is a guide for diagnosing the cause of turbocharger failures after removal from the engine.

Problem	Possible Cause	Suggested Remedy
COMPRESSOR HOUSING INLET DEFECTS		
Foreign Object Damage	Objects left in intake system.	Disassemble and inspect intake system for foreign objects (this group).
		Inspect engine for internal damage.
	Leaking and/or defective intake system.	Inspect air intake system connections including air filter; repair as required (this group).
		Inspect air intake related engine components.
Compressor Wheel Rub	Bearing failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defects.	Correct as required.
COMPRESSOR HOUSING OUTLET DEFECTS		
Oil and/or Dirt in Housing	Restricted air intake system.	Inspect and clean air cleaner.
	Prolonged periods of low rpm engine idling.	Check with operator to confirm conditions. (See Operator's Manual.)
	Defective oil seal ring.	Repair as required (this group).
	Restricted oil drain line.	Inspect and clear oil drain line as required.
TURBINE HOUSING INLET DEFECTS		
Oil in Housing	Internal engine failure.	Inspect and repair engine as **required**. **Make certain to check all oil lines/hoses for oil residue. If oil is found, it is ABSOLUTELY NECESSARY to make certain the lines and Charge Air Cooler or Heat Exchanger have been thoroughly cleaned out. Failure to do so can result in engine failure. Remove CAC and use John Deere coolant system cleaner PMCC2638, or equivalent. Dry the components with compressed air and BE CERTAIN all water is removed.**
	Oil leaking from compressor housing seal.	Verify that oil is in compressor housing and refer to “Compressor Housing Outlet Defects” as listed earlier in this chart.
Center Wall Deteriorated	Excessive operating temperature.	Check for restricted air intake.
		Check engine for overfueling.
		Check injection pump timing.
TURBINE HOUSING OUTLET DEFECTS		
Turbine Wheel Rub	Bearing failure.	Determine if engine and/or operator contributed to lack of lubrication, contaminated lubrication, excessive temperature, or debris generating engine failure in progress. Correct as required.
	Manufacturing defect.	Correct as required (this group).
Foreign Object Damage	Internal engine failure.	Inspect and repair engine as required.
	Objects left in intake system.	Disassemble and inspect air intake system (this group).

Continued on next page

AS58880,0000040 -19-04SEP08-1/2

TURBINE HOUSING OUTLET DEFECTS		
	Leaking air intake system.	Correct as required (this group).
Oil and/or Excessive Carbon	Internal engine failure.	Verified by oil in turbine housing.
	Turbine seal failure.	Inspect for excessive heat from overfueling and/or restricted air intake.
	Prolonged periods of low rpm engine idling.	Ask operator to run engine under load or at a higher rpm (See Operator's Manual).
	Restricted oil drain line.	Inspect and clear oil drain line as required.
EXTERNAL CENTER HOUSING AND JOINT DEFECTS		
Leaks from Casting	Defective casting.	Replace turbocharger (this group).
	Defective gasket.	Verify if leaks are occurring at gasket joints.
Leaks from Joints	Loose attaching screws.	Tighten to specifications in CTM (this group).
	Defective gasket.	Inspect and repair as required.
INTERNAL CENTER HOUSING DEFECTS		
Excessive Carbon Build-Up in Housing or on Shaft	Hot engine shutdown.	Review proper operation with operator as shown in operator's manual.
	Excessive operating temperature.	Restricted air intake; overfueling or mistimed engine.
	Restricted oil drain line.	Inspect and clean oil drain lines as required.
	Operating engine at high speeds and loads immediately after start-up.	Idle engine for a few minutes to allow oil to reach bearings before applying heavy loads.

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Turbocharger Inspection

The following inspection procedure is recommended for systematic failure analysis of a suspected failed turbocharger. This procedure will help to identify when a turbocharger has failed, and why it has failed so the primary cause of the failure can be corrected.

Proper diagnosis of a non-failed turbocharger is important for two reasons. First, identification of a non-failed turbocharger will lead to further investigation and repair of the cause of a performance complaint.

Second, proper diagnosis eliminates the unnecessary expense incurred when a non-failed turbocharger is replaced.

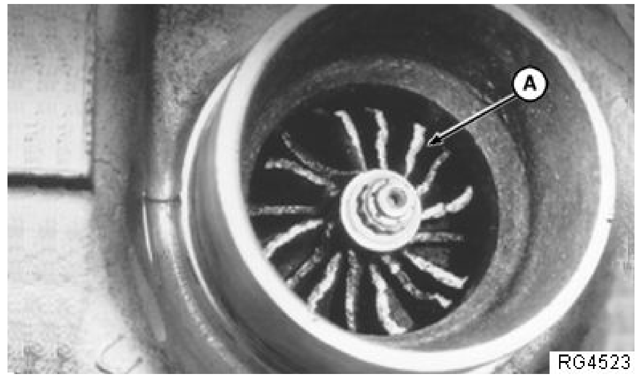
The recommended inspection steps, which are explained in detail on following pages, are:

- Compressor Housing Inlet and Compressor Wheel.
- Compressor Housing Outlet.
- Turbine Housing Inlet.
- Turbine Housing Outlet and Turbine Wheel.
- External Center Housing and Joints.
- Perform Axial End Play Test

NOTE: To enhance the turbocharger inspection, an inspection sheet (Form No. DF-2280 available from Distribution Service Center—English only) can be used that lists the inspection steps in the proper order and shows potential failure modes for each step. Check off each step as you complete the inspection and record any details or problems obtained during inspection. Retain this with the work order for future reference.

Compressor Housing Inlet and Compressor Wheel

1. Check compressor inlet and compressor wheel (A) for foreign object damage.



RG4523 —UN—03NOV97

Checking Inlet and Compressor Wheel

A—Compressor Wheel

NOTE: Foreign object damage may be extensive or minor. In either case, the source of the foreign object must be found and corrected to eliminate further damage.

2. Mark findings on your checklist and continue the inspection.

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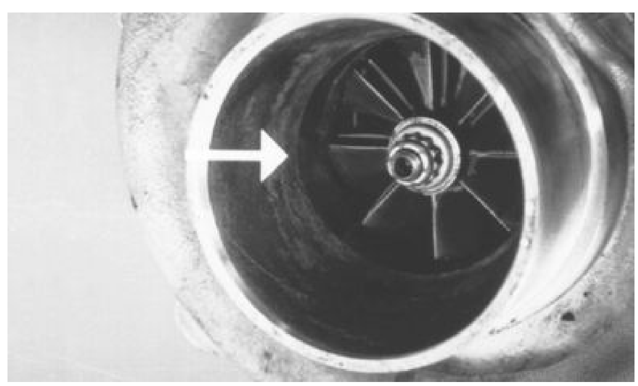
NOTE: You will need a good light source for this check.

3. Check compressor inlet for wheel rub on the housing (arrow). Look very closely for any score marks on the housing itself and check the tips of the compressor wheel blades for damage.



RG4524 —UN—05DEC97

Checking Compressor Inlet

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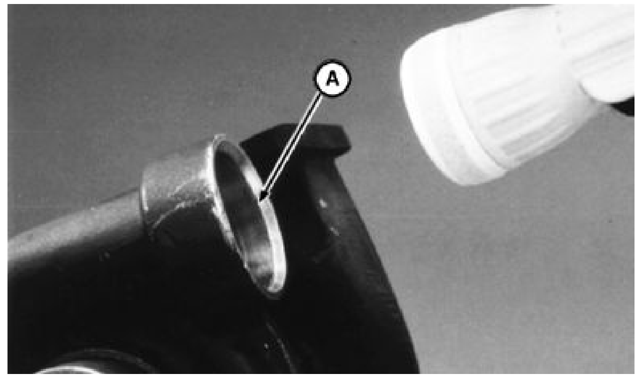
Compressor Housing Outlet

1. Check compressor housing outlet (A). The outlet should be clean and free of dirt or oil.
2. Mark it on your checklist if dirt or oil is found and continue the inspection.

A—Compressor Housing Outlet



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Checking Compressor Outlet

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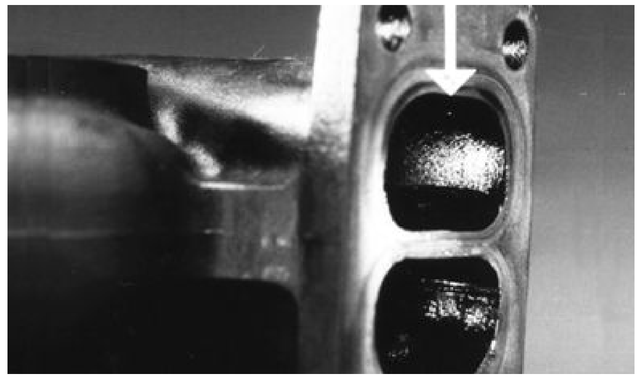
Turbine Housing Inlet

Check the turbine housing inlet ports (arrow) for oil in housing, excessive carbon deposit or erosion of center walls.

NOTE: If the inlet is wet with oil, or has excessive carbon deposits, an engine problem is likely. Center wall erosion (cracking or missing pieces), indicate excessive exhaust temperature.



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Checking Turbine Housing Inlet Ports

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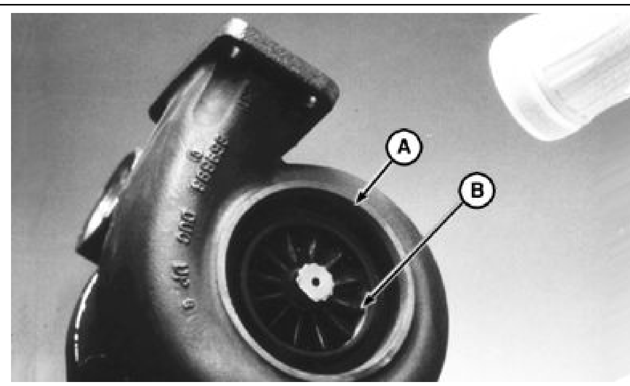
Turbine Housing Outlet and Turbine Wheel

1. Use a flashlight to look up inside the turbine housing outlet (A) and check blades (B) for foreign object damage.

A—Turbine Housing Outlet **B—Blades**



RG4527 —UN—05DEC97

Checking Turbine Wheel and Outlet

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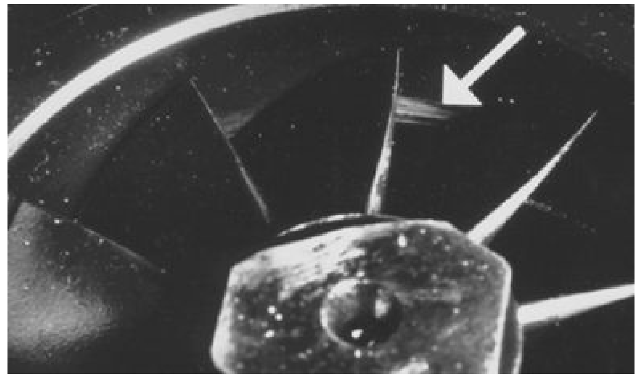
2. Inspect the wheel blades and housing for evidence of wheel rub (arrow). Wheel rub can bend the tips of the blades with the housing showing wear or damage.


RG4528 —UN—05DEC97

Checking Turbine Wheel Blades

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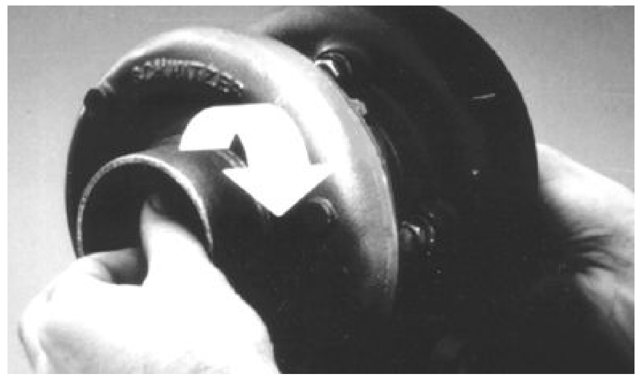
3. Rotate the shaft, using both hands, to check rotation and clearance. The shaft should turn freely, however, there may be a slight amount of drag.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Checking Shaft Rotation and Clearance

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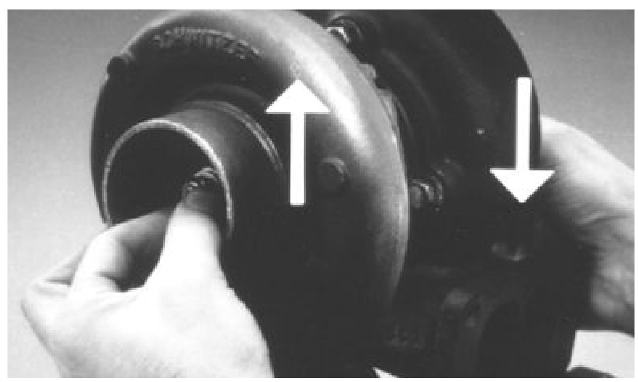
IMPORTANT: Use only moderate hand force (3-4 pounds) on each end of shaft.

4. Next, pull up on the compressor end of the shaft and press down on the turbine end while rotating shaft. Neither the compressor wheel nor the turbine wheel should contact the housing at any point.

NOTE: There will be some “play” because the bearings inside the center housing are free floating.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Checking for Contact of Compressor and Turbine Wheels

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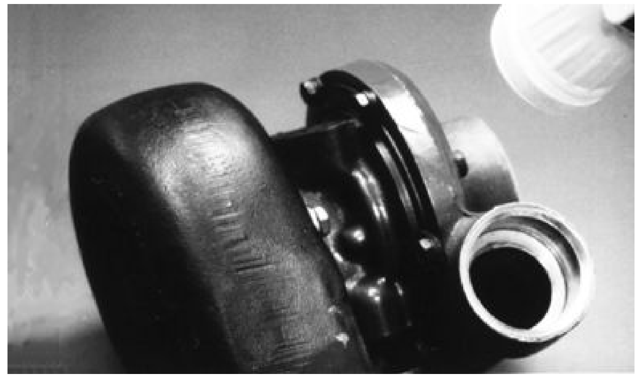
External Center Housing and Joints

Visually check the outside of the center housing, all connections to the compressor, and turbine housing for oil.

NOTE: If oil is present, make sure it is not coming from a leak at the oil supply or return line.

IMPORTANT: Before you finalize your conclusion that the turbocharger has not failed, it is strongly recommended that the following procedures of checking radial bearing clearance and axial bearing endplay with a dial indicator be performed. These procedures are not required if a failure mode has already been identified.



Checking Center Housing

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Perform Axial Bearing End Play Test

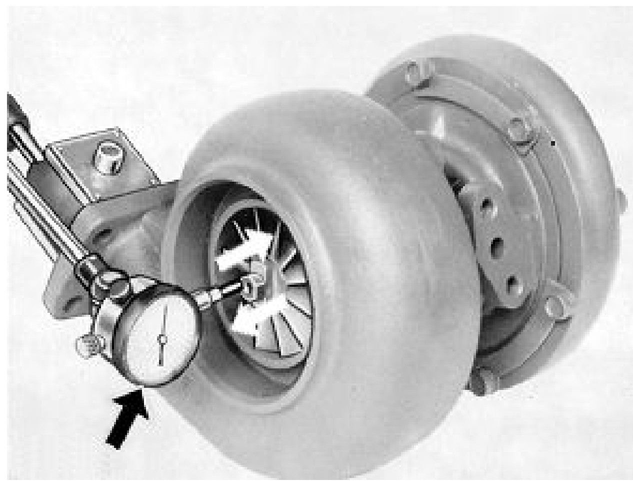
This test will give an indication of the condition of the thrust bearing within the center housing and rotating assembly.

1. Mount magnetic base dial indicator (black arrow) so that indicator tip rests on flat surface on turbine end of shaft. Preload indicator tip and zero dial on indicator.
2. Move shaft axially back and forth by hand.
3. Observe and record total dial indicator movement.

Specification

Turbocharger
Shaft—Axial Bearing End
Play...0.064—0.114 mm
(0.0025—0.0045 in.)

If bearing end play is not within specification, install a replacement turbocharger.



Checking Axial Bearing End Play

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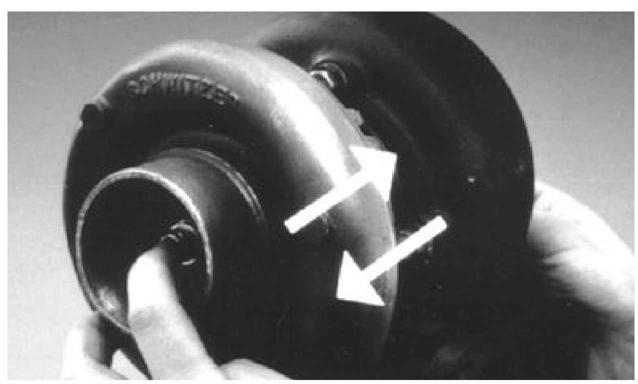
4. Next, check shaft endplay by moving the shaft back and forth (white arrows) while rotating. There will be some endplay but not to the extent that the wheels contact the housings.

NOTE: These diagnostic procedures will allow you to determine the condition of the turbocharger. If the turbocharger has failed, analysis of your inspection notes should direct you to the specific areas of the engine to correct the problems causing the turbocharger failure See *TURBOCHARGER FAILURE ANALYSIS* *outlined earlier in this group.* *It is not unusual to find that a turbocharger has not failed. If your turbocharger passes all the inspections, the problem lies somewhere else.*



Checking Shaft End Play

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Repair Turbocharger

Turbochargers used on the engines covered in this manual are available through service parts as a complete remanufactured assembly only. Individual components for repair are not available.

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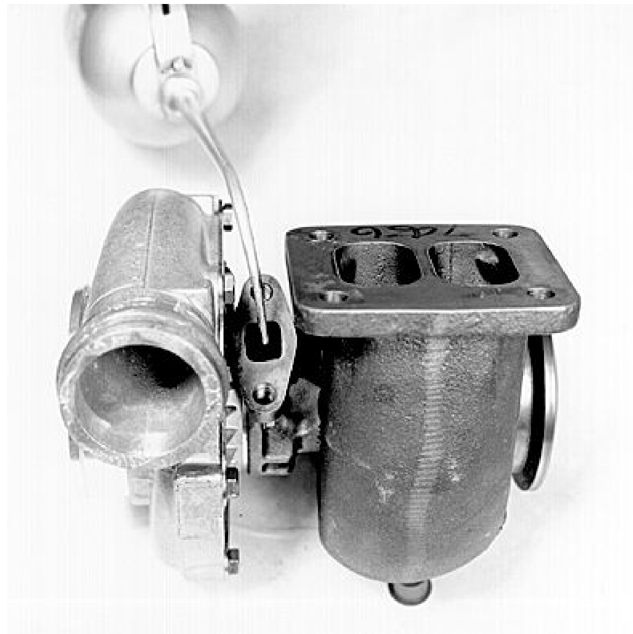
Prelube Turbocharger

IMPORTANT: DO NOT spin the rotor assembly with compressed air. Damage to bearings can occur when using compressed air.

Fill oil return (drain) port with clean engine oil and spin rotating assembly by hand to properly lubricate bearings.

If turbocharger is to be stored for an extended period of time, lubricate internally and install protective covers on all openings.



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Prelubing Turbocharger

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Install Turbocharger

IMPORTANT: BEFORE STARTING an engine with a new or repaired turbocharger, crank the engine over (but do not start) for several seconds to allow engine oil to reach turbocharger bearings. DO NOT crank engine longer than 30 seconds at a time to avoid damaging starting motor.

IMPORTANT: It should be noted that the engine WILL STILL RUN with the fuel pump SCV Valve Wiring Harness unplugged. In the past, unplugging this harness will put the pump in a "no fuel" situation. However, on this pump (Denso Model HP4) the pump will be in a "full fuel" mode. Starting the engine with this condition existing can damage the Turbocharger bearings (lack of lube) and High Pressure Common Rail Pressure Relief Valve.

IMPORTANT: If turbocharger failed because of foreign material entering the air intake system, be sure to examine the system and clean as required to prevent a repeat failure.

Visually inspect the charge air cooler and piping for residual oil and clean if necessary. Oil may have accumulated from the failed turbo. Failure to clean residual oil from the intake system may result in engine failure.

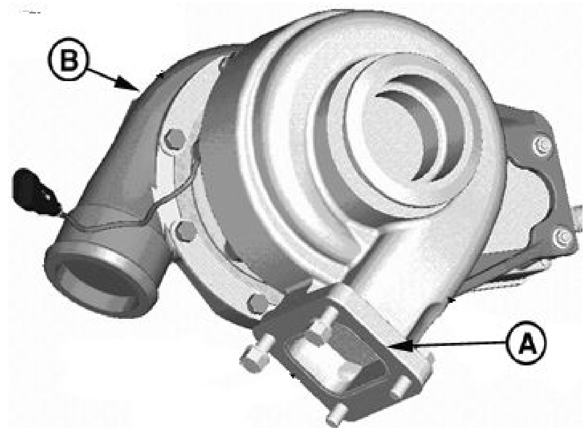
If not previously done, prime (prelube) turbocharger rotating assembly prior to installing turbocharger on engine. Prelube center housing with clean engine oil through oil return (drain) hole.. Turn rotating assembly by hand to lubricate bearings.

NOTE: Two threaded guide studs may be used to hold turbocharger-to-exhaust manifold gasket in place and aid in turbocharger installation. Place guide pins in threaded manifold mounting holes.

1. Install new gasket (A) over guide pins.
2. Position turbocharger on exhaust manifold over guide pins, with compressor inlet (B) facing front of engine.
3. Apply PT569 NEVER-SEEZ® Compound to all turbocharger mounting cap screws. Install 2 cap screws through exhaust manifold into threaded holes of turbocharger finger tight.
4. Remove guide pins and install remaining 2 cap screws through turbocharger into exhaust manifold finger tight.
5. Tighten 4 cap screws to specification.

Specification	
Turbocharger-to-Exhaust Manifold Cap Screws—Torque	40 N•m (30 lb-ft)

6. Install turbocharger oil supply line (C) to oil filter base and turbocharger. Tighten securely.



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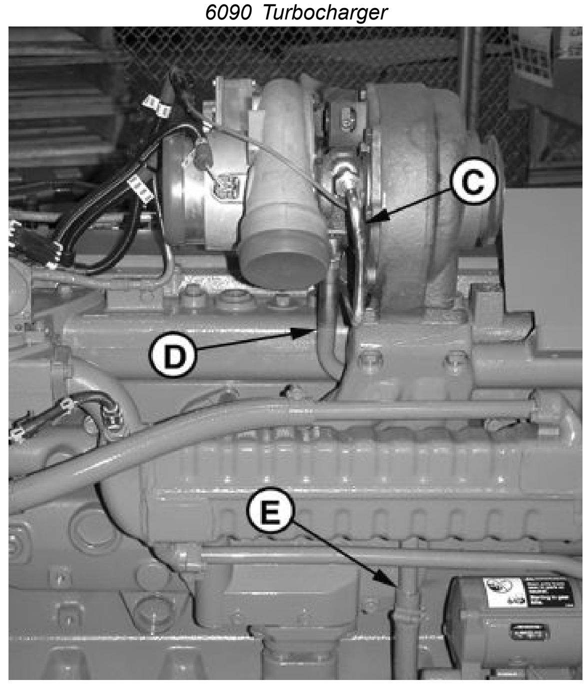
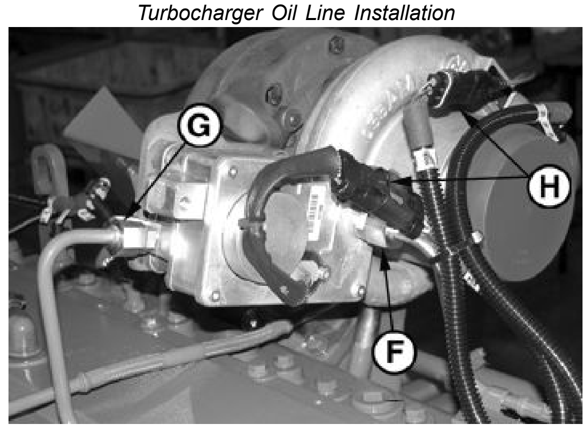
6090 Turbocharger



RG13928 —UN—28MAY05

Turbocharger Oil Line Installation



RG13929 —UN—28MAY05

Turbocharger Actuator Coolant Lines

A—Turbocharger Gasket
B—Turbocharger Compressor Inlet
C—Oil Supply Line
D—Oil Drain Line
E—Oil Drain Line-to-Hose Joint
F—Actuator Coolant Drain Line
G—Actuator Coolant Supply Line
H—Sensor Connections

Continued on next page

RE38635,000016E -19-02OCT08-1/2

7. Install oil drain line (D) behind exhaust manifold with flange end toward turbocharger.
8. Install 2 serrated cap screws through flange.
9. Install new gasket over cap screws and install flange end of drain line to turbocharger bearing housing. tighten cap screws to specification.

Specification

Turbocharger Oil Return Line—Torque...35 N•m (25 lb-ft)

10. Apply soap lubricant to inside diameter of turbo drain hose.
11. Install drain hose over end of drain line (E). Position tension clamp over hose and line joint.
12. Connect coolant supply line (G) to turbocharger actuator and tighten securely.

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13. Connect coolant drain line to turbocharger actuator (F) and tighten securely.
14. Connect both sensors to wiring harness (H).
15. Connect air intake and exhaust piping to turbocharger. Tighten all connections securely. (For vehicle engines, refer to machine Technical Manual.)

IMPORTANT: BEFORE STARTING an engine with a new or repaired turbocharger, crank the engine over (but do not start) for several seconds to allow engine oil to reach turbocharger bearings. DO NOT crank engine longer than 30 seconds at a time to avoid damaging starting motor.

16. Start and run engine at low idle while checking oil inlet and air piping connections for leaks.

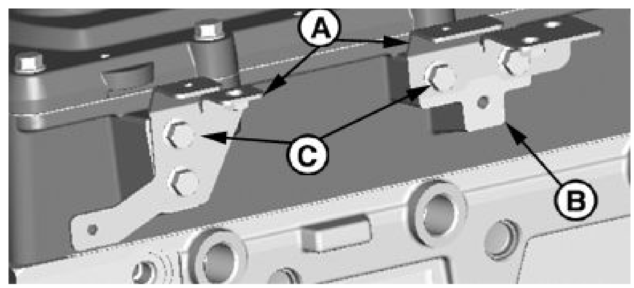
RE38635,000016E -19-02OCT08-2/2

Install Turbocharger Oil Supply Line Brackets

1. Install brackets (A) to right rear mounting pads on intake manifold (B)
2. Insert cap screws (C) finger tight - 2 each bracket - through brackets into intake manifold.
3. Tighten cap screws to specification.

Specification

Oil Supply Line Support Brackets to Intake Manifold—Torque...35 N•m (26 lb-ft)



Oil Supply Line Brackets - Right Rear Side of Engine

A—Oil Line Support Brackets
B—Intake Manifold
C—Cap Screws (4)

RE38635,0000026 -19-01JUN05-1/1

Install Turbocharger Oil Supply Line

1. Install turbocharger oil supply line on engine as shown. Attach fittings finger tight on turbocharger oil inlet (A) and oil filter adapter (B).

NOTE: P-Clamps should face upward.

2. Install 3 oil line to bracket P-clamps over oil supply line in locations shown (D). Start cap screws finger tight.

IMPORTANT: Before tightening P-Clamp cap screws, ensure there is socket clearance for rocker arm cover cap screw (C).

3. Tighten the 3 P-clamp cap screws to specification.

Specification

P-Clamp Cap Screws—Torque.. 15 N•m (11 lb-ft)

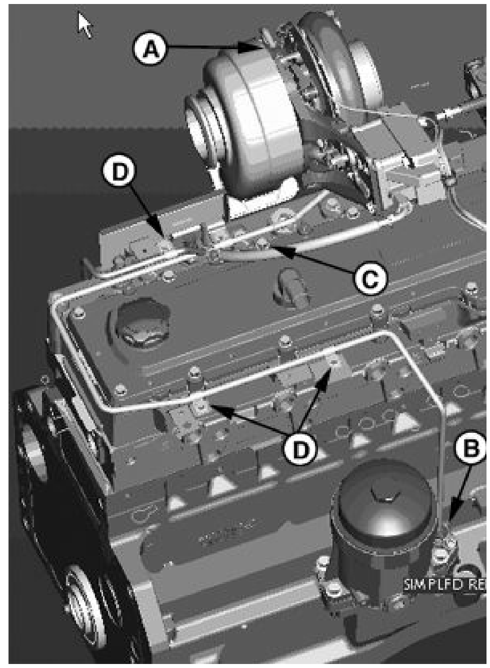
4. Using a double wrench, tighten the oil filter adapter and turbocharger inlet fittings to specification.

Specification

Turbocharger Oil Supply Line Nut to Turbocharger Inlet Fitting—Torque... 24 N•m (18 lb-ft)

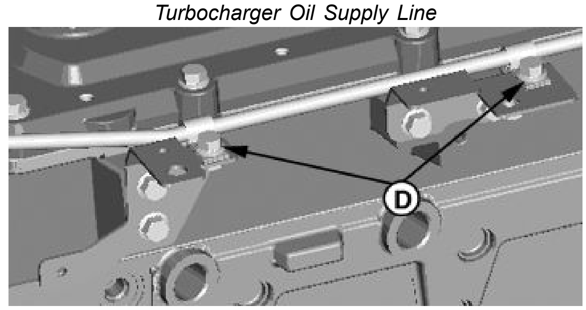
Turbocharger Oil Supply Line Nut to Oil Filter Adapter Fitting—Torque... 24 N•m (18 lb-ft)

A—Oil Line Fitting - Turbocharger
B—Oil Line Fitting - Oil Filter Adapter
C—Clearance Point
D—P Clamps (3) to Secure Line - Intake Manifold & Heat Shield



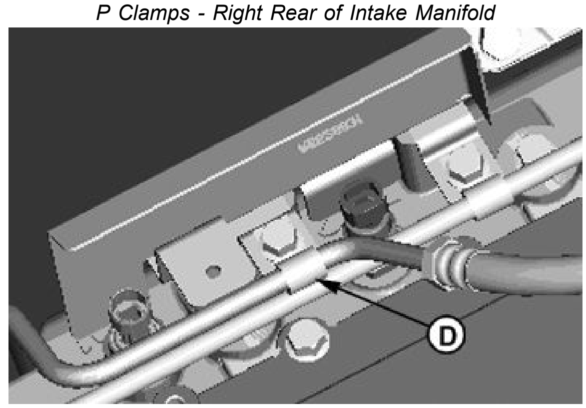
RG14245 —UN—01JUN05

Turbocharger Oil Supply Line



RG14246 —UN—01JUN05

P Clamps - Right Rear of Intake Manifold



RG14247 —UN—01JUN05

P Clamp - Heat Shield

RE38635,0000020 -19-01JUN05-1/1

Install Turbocharger Oil Drain Line

1. Orient and install oil drain line (hose end) behind exhaust manifold along cylinder block.
2. Align flange end of line (F) to turbocharger bearing housing (H).
3. Assemble 2 cap screws (E) through flange (F).
4. Install oil drain line gasket (G) over cap screws.
5. Assemble flange end of oil drain line to turbocharger bearing housing and tighten cap screws to specification.

Specification

Turbocharger Oil Drain Line to Bearing Housing—Torque....................35 N•m (26 lb-ft)

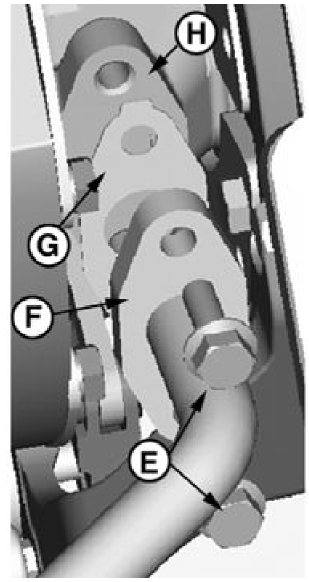
6. If cylinder block fitting (B) has been removed, reinstall at this point and tighten to specification.

Specification

Turbocharger Oil Drain Line Fitting to Cylinder Block—Torque....................60 N•m (44 lb-ft)

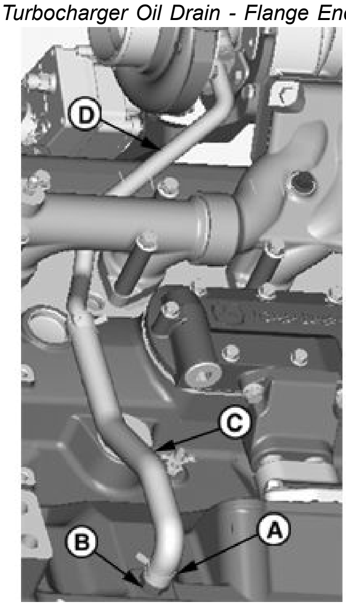
7. Apply soap lubricant to inside diameter of turbocharger drain hose (C) end - apply to both ends if hose has been removed from line.
8. Install constant tension hose clamp (A) over drain hose and assemble drain hose over bead on block fitting (B).
9. Locate and align constant tension clamps as necessary.

A—Hose Clamps (2)
B—Block Fitting
C—Drain Hose
D—Drain Line
E—Cap Screws (2)
F—Turbocharger Drain Line Flange
G—Gasket
H—Turbocharger Bearing Housing



RG14238 —UN—02JUN05

Turbocharger Oil Drain - Flange End



RG14237 —UN—02JUN05

Turbocharger Oil Drain

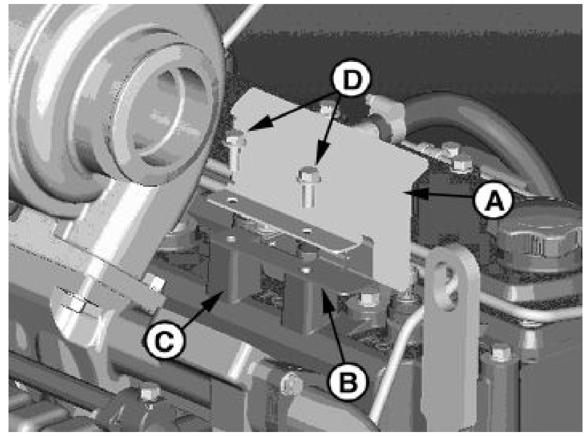
RE38635,0000021 -19-01JUN05-1/1

Install Heat Shield & Turbocharger Oil Supply Line Bracket

NOTE: There are three support brackets for the oil supply line. The third bracket is assembled with the turbocharger heat shield, as the oil line is routed inside this shield.

1. Install turbocharger oil supply line support bracket (B) and heat shield (A) to left top side of intake manifold (C).
2. Install 2 cap screws and tighten to specification.

Specification	
Oil Supply Line Support Bracket & Heat Shield to Intake Manifold—Torque	35 N•m (26 lb-ft)



RG14239 —UN—01JUN05

Heat Shield & Bracket

A—Heat Shield
B—Oil Supply Line Bracket
C—Intake Manifold
D—Cap Screws

RE38635,0000022 -19-01JUN05-1/1

Remove and Install Turbocharger Actuator

IMPORTANT: Be certain no power supply is in the "on" position when performing work on the turbocharger actuator. Damage to the ECU/Actuator communication can result. When an actuator is connected to power, it will perform a baseline learn to record the fully open and closed positions. If this baseline learn is incorrect, the actuator will not perform correctly. Disconnect the battery cables before performing any work.

1. Disconnect actuator wiring harness (A).
2. Disconnect actuator coolant supply line (B) and coolant return line (C).

NOTE: Whenever disconnecting actuator linkage, ensure that the linkage does not bind or is forced out of position.

3. Disconnect actuator linkage arm (D) by loosening and removing allen screw.
4. Loosen and remove 4 hex nuts (E) securing actuator to bracket. Remove actuator assembly from turbocharger.

To install the actuator, reverse the steps shown above.

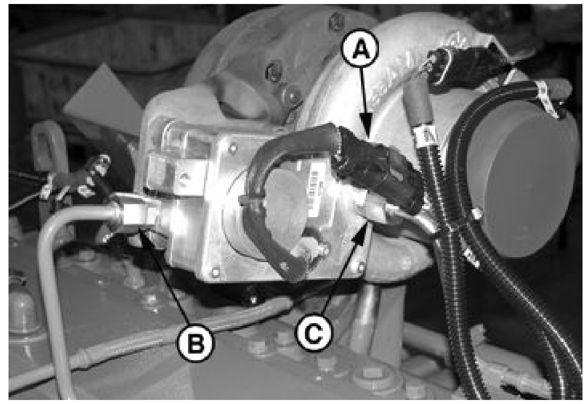
1. Position actuator to bracket and finger tighten 4 hex nuts.
2. Tighten nuts to specification

Specification

Actuator to Bracket Hardware—Torque..7 N•m (5 lb-ft)

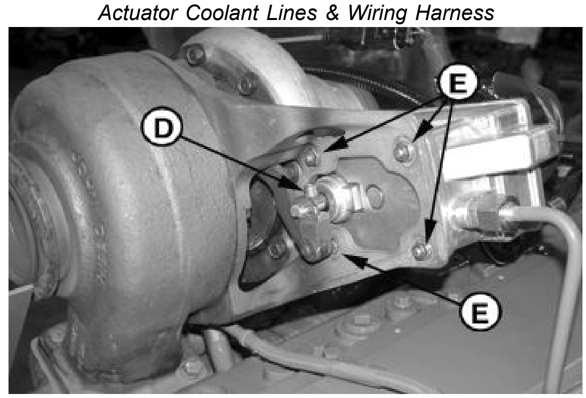
IMPORTANT: When installing actuator linkage, be certain there is free movement of the linkage, with no binding. The center joint of the linkage should be slightly loose when wiggled, with clearance between linkage arms on the pivot joint.

3. Position actuator linkage arm over actuator shaft and install stainless steel allen head screw to secure linkage to actuator shaft.
4. Carefully tighten allen screw to specification.



RG13943 —UN—04FEB05

Actuator Coolant Lines & Wiring Harness



RG13944 —UN—04FEB05

Actuator Linkage & Bracket Hardware

A—Actuator Wiring Harness
B—Actuator Coolant Supply
C—Actuator Coolant Return
D—Actuator Linkage Allen Screw
E—Actuator to Bracket Hardware

Specification

Linkage Arm to Actuator Shaft—Torque Turn...7 N•m (5 lb-ft)

5. Connect actuator coolant supply and return lines to actuator. Secure nuts on both fittings, and using a second wrench, tighten fittings to specification.

Specification

Coolant Lines to Actuator—Torque...24 N•m (18 lb-ft)

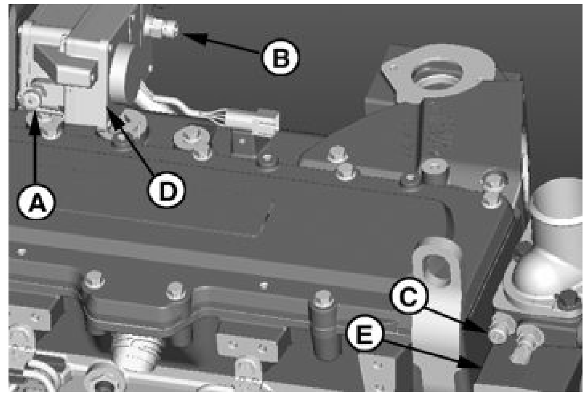
RE38635,00000BC -19-22APR05-1/1

Install Actuator Coolant Line Fittings

1. Install coolant fittings in actuator and thermostat housing.
2. Tighten fittings to specification.

Specification

Thermostat Housing (Cast Iron) Coolant Fittings—Torque............40 N•m (30 lb-ft)
Actuator Housing (Aluminum) Fittings—Torque............17 N•m (13 lb-ft)



Actuator Coolant Line Fittings

A—Actuator Coolant Supply Fitting
B—Actuator Coolant Return Fitting
C—Thermostat Housing Coolant Return Fitting
D—Turbocharger Actuator
E—Thermostat Housing

RE38635,0000023 -19-01JUN05-1/1

Install Turbocharger Actuator Coolant Return Line

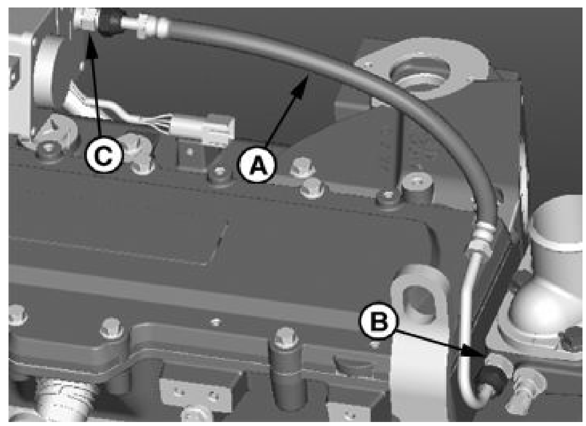
1. Assemble nut on coolant return line (A) finger tight to coolant return fitting in thermostat housing (B).
2. Orient line to and start nut on coolant line to coolant return fitting on side of actuator housing (C). Tighten finger tight.

IMPORTANT: Use a backup wrench when tightening coolant line to fittings.

3. Tighten line nuts to specification.

Specification

Coolant Return Line to Thermostat Housing Fitting—Torque............24 N•m (18 lb-ft)
Coolant Return Line to Actuator—Torque............24 N•m (18 lb-ft)



Coolant Return Line

A—Actuator Coolant Return Line
B—Fitting - Thermostat Housing
C—Fitting - Turbocharger Actuator

RE38635,0000024 -19-25APR06-1/1

Install Turbocharger Actuator Coolant Supply Line

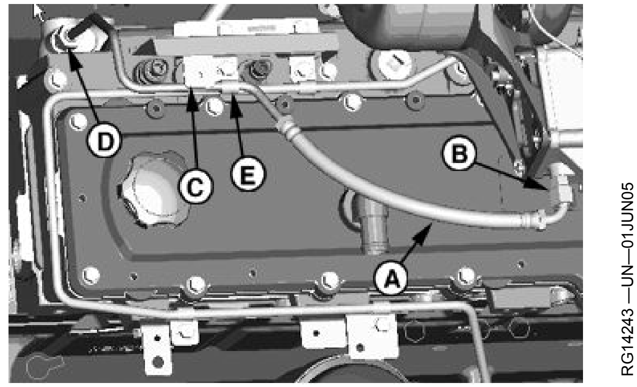
1. Orient and route coolant supply line (A) from coolant supply line fitting on actuator (B), underneath tab on wiring harness bracket (C), to coolant manifold fitting (D) at top left rear of cylinder block.
2. Start nuts on coolant supply line to vertical fitting on coolant manifold (D) and fitting on actuator (B). Tighten finger tight.
3. Install P-Clamp (E) to line with the P facing upward. Install cap screw to P-Clamp and tighten to specification.

Specification

P-Clamp Cap Screw—Torque............... 15 N•m (11 lb-ft)

IMPORTANT: Use a backup wrench when tightening coolant line to fittings.

4. Using a double wrench, tighten nuts on coolant return line to actuator fitting, then coolant manifold, to specification.



Turbocharger Actuator Coolant Supply Line

A—Coolant Supply Line
B—Supply Line Fitting - Actuator
C—Wiring Harness Bracket
D—Supply Line Fitting - Coolant Manifold
E—P-Clamp

Specification

Actuator Coolant Return Line Fittings—Torque............... 24 N•m (lb-ft)

RE38635,0000025 -19-25APR06-1/1

Install Actuator Coolant Supply Line - Tractors

1. Install turbocharger coolant supply adapter (A) into rear coolant port of block. Tighten to specification.

Specification

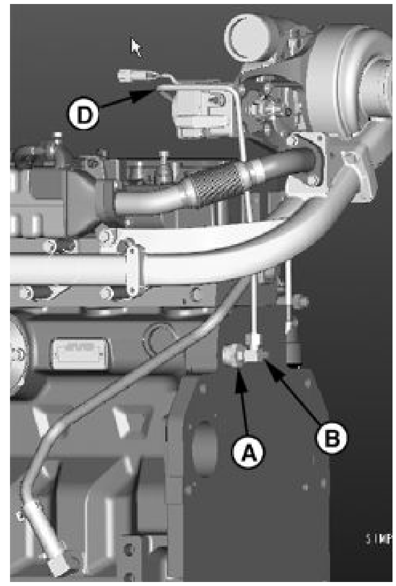
Coolant Adapter to Cylinder Block—Torque	120 N•m (90 lb-ft)

2. Install coolant supply T-fitting (B) into adapter until it bottoms. Reverse the fitting until the o-ring face seal is pointing upward (vertical), as shown.
3. Install elbow fitting finger tight into front facing turbocharger actuator port (C). Reverse until oriented approximately 20° upward from horizontal (as shown), facing left side of engine.
4. Install coolant supply line (D) to actuator and cylinder block fittings and tighten to specification.

Specification

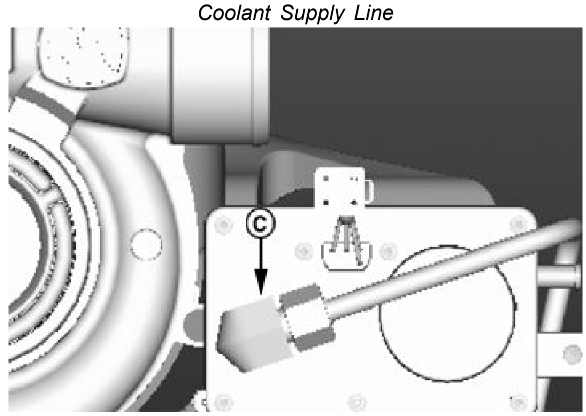
Coolant Supply Line Fittings—Torque	24 N•m (18 lb-ft)

A—Turbocharger Coolant Supply Adapter
B—Adapter T-Fitting
C—Actuator Fitting
D—Coolant Supply Line



RG14396 —UN—07JUL05

Coolant Supply Line



RG14397 —UN—07JUL05

Actuator Coolant Line Fitting

RE38635,0000028 -19-08JUL05-1/1

Remove and Install Actuator Linkage

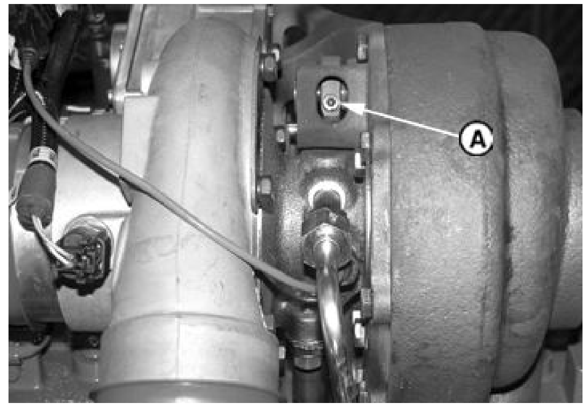
Remove Turbocharger Actuator Linkage

NOTE: Use caution when loosening or tightening linkage hardware. Stainless steel screws are brittle and break easily.

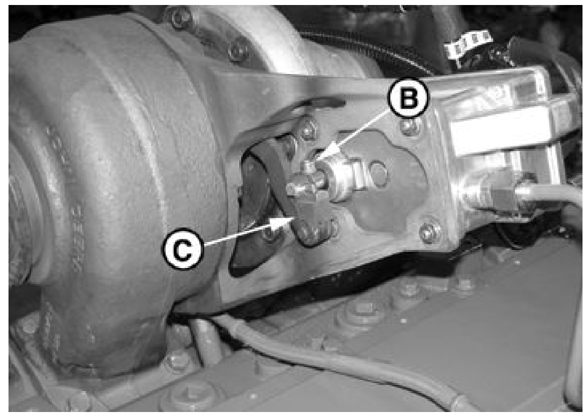
IMPORTANT: BE CERTAIN actuator wiring harness is disconnected before completing any repairs on linkage.

1. Position linkage arm so the inboard (turbocharger shaft) linkage set screw (A) is visible through bracket. Loosen and remove screw.
2. Lift actuator linkage off turbocharger shaft notch (linkage will not slide off end of shaft).
3. Position linkage on actuator shaft to access retainer screw (B). Loosen and remove screw.
4. Lift linkage assembly off notch in actuator shaft and set aside.

A—Actuator Linkage to Shaft Screw - Inboard
B—Actuator Linkage to Shaft - Outboard
C—Actuator Linkage Arm



RG14194 —UN—27MAY05



RG14195 —UN—27MAY05

Actuator Linkage Screw - Outboard Position

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RE38635,0000012 -19-23MAY05-1/4

Install Turbocharger Actuator Linkage

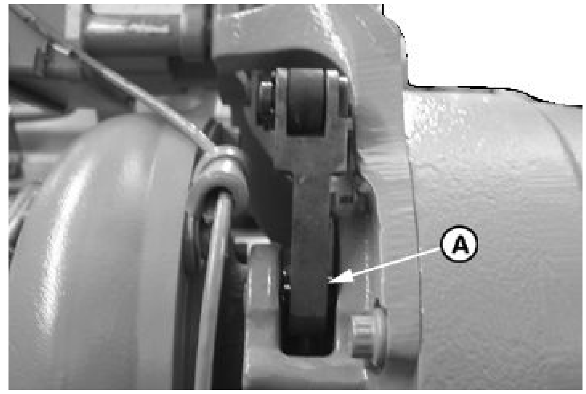
IMPORTANT: BE CERTAIN actuator wiring harness is disconnected before completing any repairs on linkage.

1. Insert linkage onto turbocharger pivot shaft flats (A).

NOTE: Use an open end wrench to exert slight pressure on linkage to align linkage with bolt hole in shaft. Additionally, use a wrench when tightening linkage hardware. Take care that the end link does not rotate on the shaft on an axis perpendicular to the axis of the shaft. This can cause binding of the linkage assembly.

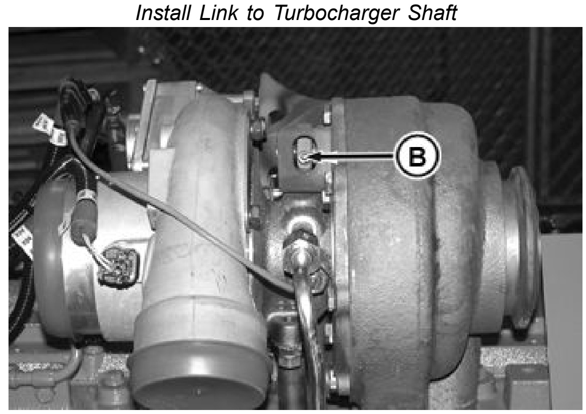
2. Install linkage (C) onto actuator shaft notch (D) and install M5 bolt through linkage and shaft finger tight (E).
3. Position linkage to notch on turbocharger shaft (B) and assemble linkage over shaft. Install M5 bolt to secure finger tight.

A—VGT Link - Turbocharger Shaft
B—M5 Bolt - Turbocharger Shaft
C—VGT Link - Actuator Shaft
D—Actuator Pivot Shaft
E—M5 Bolt - Actuator Shaft
F—Center Pivot Joint



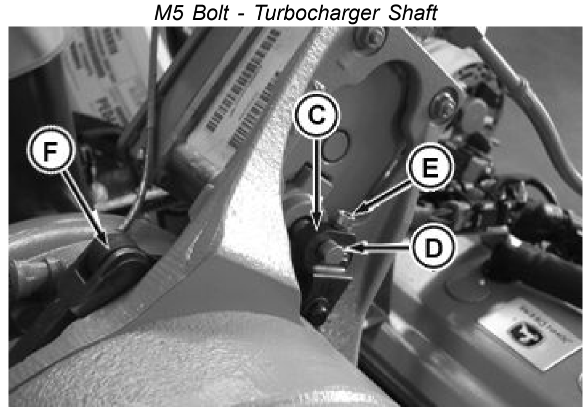
RG14210 —UN—28MAY05

Install Link to Turbocharger Shaft



RG14209 —UN—03JUN10

M5 Bolt - Turbocharger Shaft



RG14211 —UN—03JUN10

Install Link - Actuator Shaft

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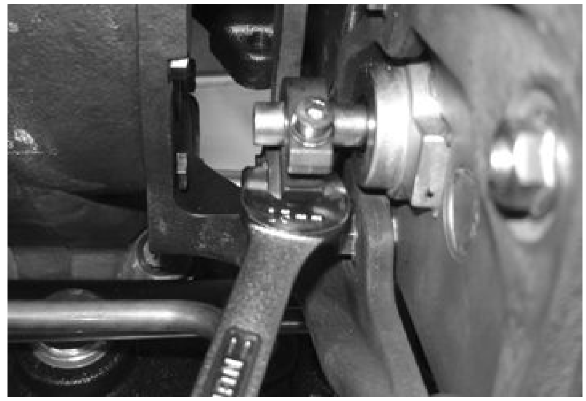
RE38635,0000012 -19-23MAY05-2/4

IMPORTANT: DO NOT over tighten linkage hardware. Stainless steel screws are brittle and break easily.

4. Using an open end wrench to stabilize the links as the bolts are being tightened. Tighten the M5 bolt to specification.

Specification	
M5 Linkage Screws - Turbocharger & Actuator End—Torque	7 N•m (5 lb-ft)



RG14520 —UN—30SEP05

Using Wrench to Support Linkage

RE38635,0000012 -19-23MAY05-3/4

5. Check linkage orientation for free travel (as shown) and to be sure there is no binding. The linkage should travel freely through its entire range of travel. Note example of proper linkage adjustment and how the linkage is perpendicular to the shaft.

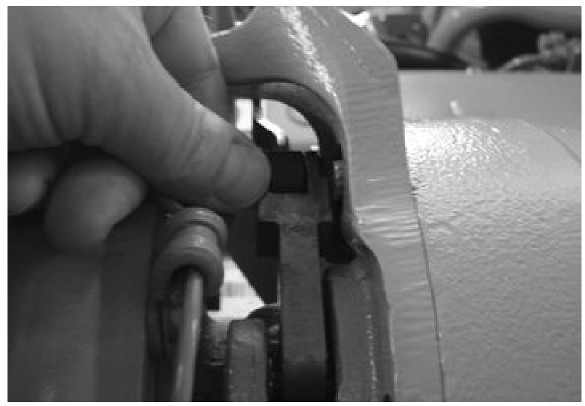
IMPORTANT: Be constantly aware of any binding in the linkage. Use an open end wrench to align and secure the linkage as hardware is tightened (as shown). After bolts are tightened, linkage should travel freely at all times and return immediately to original position when manually tested. The center pivot joint should have some play when linkage shaft is wiggled. If binding of the linkage is noted, use a wrench to gently pry the end link into necessary position such that linkage moves freely throughout its full range and the binding condition is corrected.

6. Verify again that the linkage moves freely and returns to original position when tested manually.

7. Connect engine harness to VGT actuator to turn on power.

CAUTION: When power to the actuator is "on", BE CERTAIN to keep fingers clear of linkage when performing diagnostic checks. The linkage actuates very quickly and fingers can be pinched.

8. Reference Service Advisor, Interactive Test Tab, to run Learn Value Reset Test for actuator and linkage. This test allows the actuator and linkage to check travel stops when running the learn cycle.



RG14218 —UN—28MAY05

Check for Linkage Free Travel

RG14474 —UN—12SEP05

Proper Linkage Adjustment

9. Conduct a diagnostic check of the harness and actuator. Reference CTM385 for specific procedures.

RE38635,0000012 -19-23MAY05-4/4

Remove and Install Turbocharger Actuator Linkage – Ball Type

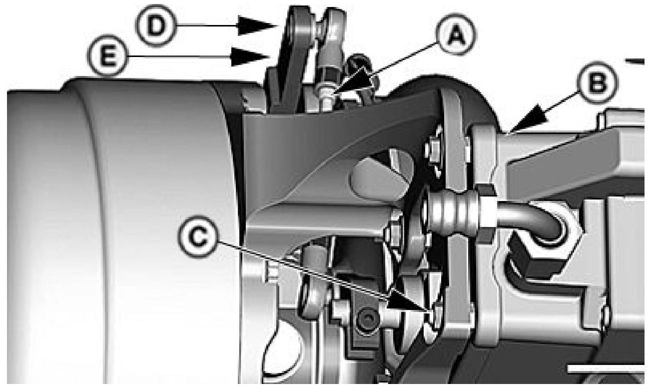
NOTE: Remove of turbocharger assembly from engine is not required to perform this repair.

Removal

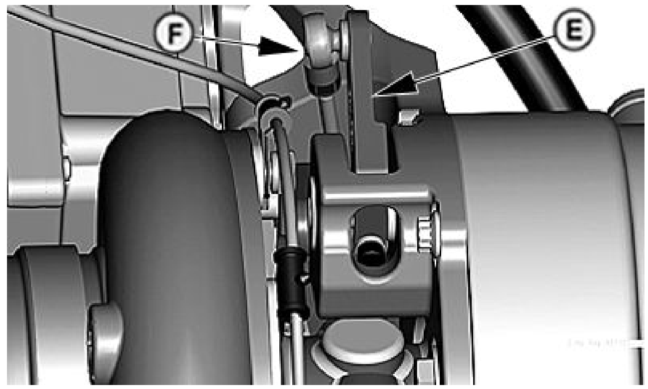
1. Unplug turbocharger wiring harness from engine wiring harness.
2. Remove VGT lever nut (D) from actuator linkage (A), using a long 4 mm Allen wrench. Insert wrench into recessed hex area, located on ball stud of the linkage (F). Twist to remove the stud from the lever.
3. Pivot actuator linkage (A) out of the way, against spring pressure, to access blocked serrated lock nut (C). Linkage can be held in place using a tie strap against spring tension.
4. Remove four serrated lock nuts (C) using 10mm socket.
5. Pull actuator away from its mounting bracket while lifting up on the SRA linkage arm. Actuator shaft may require rotation or rocking motion to remove.
6. Move turbocharger lever (E) through its normal operating motion verifying that the open and closed vane end stops are reached. If turbocharger lever (E) is sticking or you cannot reach either end stop, do not proceed with actuator installation steps below, turbocharger assembly should be replaced.

Installation

1. Insert turbocharger linkage (A) through mounting bracket opening.
2. Slide actuator studs into mounting bracket holes Rotation of shaft or linkage will be required). Install four serrated lock nuts (C) on studs. Torque nuts to 13.6 N•m (120 lbf•in). (Cut tie strap holding actuator linkage, if used.)



RG16511 —UN—16OCT08



RG16510 —UN—16OCT08

A—Actuator Linkage
B—Actuator
C—Serrated Lock Nut (4)
D—VGT Lever Nut
E—VGT Lever
F—Recessed Hex Area on Ball Stud

3. Install VTG Lever nut (D) into hex pocket on VTG lever (E) with rounded side of the nut facing outward. Hold lock nut in place and insert 4mm allen wrench into recessed hex area (F) located on the ball stud. Torque ball stud to 8.5 N-m (75 lb-in).
4. Reconnect turbocharger wiring harness connector to engine wiring harness.

SS01820,00003DA -19-10DEC08-1/1

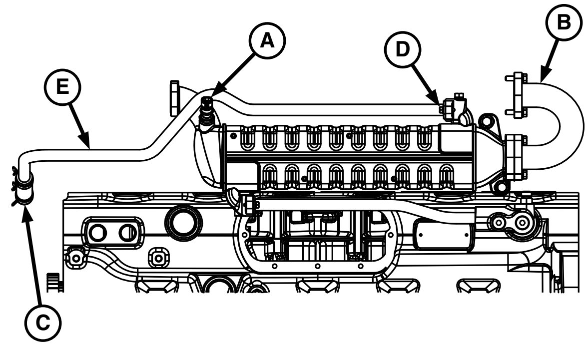
Remove Exhaust Gas Recirculator (EGR) Assembly

1. Disconnect EGR exhaust gas temperature sensor wiring harness (A).
2. Loosen and remove 4 cap screws securing EGR tube (B) from EGR tube and exhaust manifold. Remove tube and 2 gaskets.
3. Remove P clamp support securing cooler return line.
4. Loosen constant tension clamp securing coolant return hose (C) to coolant pump. Slide hose off coolant pump fitting.

NOTE: EGR coolant return and supply lines are press fit into cooler and coolant manifold.

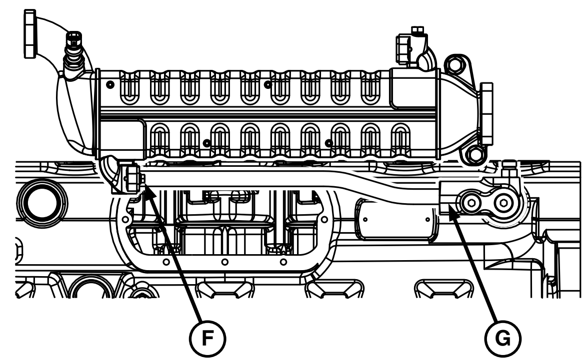
5. Loosen and remove one cap screw securing coolant return line to cooler (D). Remove EGR coolant return line and hose assembly (E) from EGR cooler.
6. Loosen and remove cap screw (F) securing EGR cooler supply line to cooler.
7. Rotate and orient supply line and remove the coolant supply line from coolant manifold (G).
8. Loosen 2 shoulder bolts with spring washers (I).
9. Remove cap screws from cooler to intake manifold joint (H) and shoulder bolts (I). Carefully remove EGR cooler assembly.

A—EGR Exhaust Gas Temperature Sensor
B—EGR Tube
C—EGR Coolant Return Line to Coolant Pump
D—Coolant Return Line to Cooler
E—EGR Coolant Return Line
F—EGR Coolant Supply Line to Cooler
G—Coolant Supply Line to Coolant Manifold
H—EGR Cooler to Intake Manifold
I— Cooler Shoulder Bolts



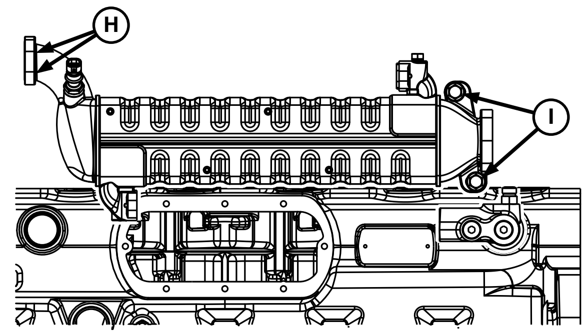
RG14182 —UN—26MAY05

EGR Assembly



RG14200 —UN—26MAY05

EGR Coolant Supply Line



RG14201 —UN—26MAY05

EGR Cooler Assembly

RE38635,0000119 -19-17APR06-1/1

Remove & Install EGR Valve

1. Disconnect wiring lead and remove 2 screws (A) securing EGR valve to intake manifold.
2. Place JDG10194 EGR Valve removal tool (D) at the base of EGR valve and install tool forcing screws into intake manifold. Carefully remove valve without binding by alternately turning the two forcing screws clockwise until the valve lands are past intake manifold port.
3. Remove gasket and clean mating surfaces. Vacuum any debris and loose carbon deposits from inside of intake manifold.
4. Replace o-rings (B) each time valve is removed.
5. Inspect valve lands (C) for wear and damage. Remove carbon deposits and debris.
6. Lubricate o-rings with clean engine oil. Carefully install new gasket and EGR valve into intake manifold as shown. Install 2 attaching screws through valve and into intake manifold to initial specification.

Specification

EGR Valve Screws -
Initial—Torque..5 N•m (4 lb-ft)

7. Tighten EGR valve attaching screws to final specification.

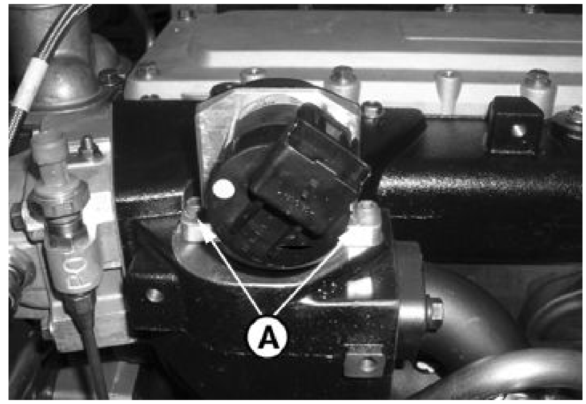
Specification

EGR Valve Screws -
Final—Torque... 15 N•m (11 lb-ft)

8. Reconnect wiring lead to EGR valve.

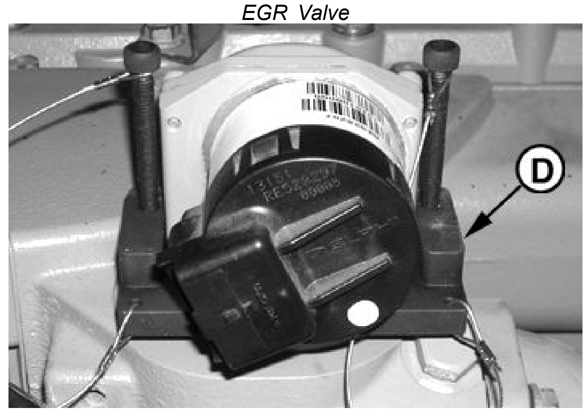
IMPORTANT: If installing a new EGR valve, re-calibrate using Service Advisor™. See EXHAUST GAS RECIRCULATION VALVE RECALIBRATION under the CALIBRATIONS tab. Leave key in "OFF" position for 30 seconds to finalize calibration.

If reusing existing EGR valve, run HARNESS DIAGNOSTIC MODE TEST through Service Advisor™ under the interactive test tab - RETEST.



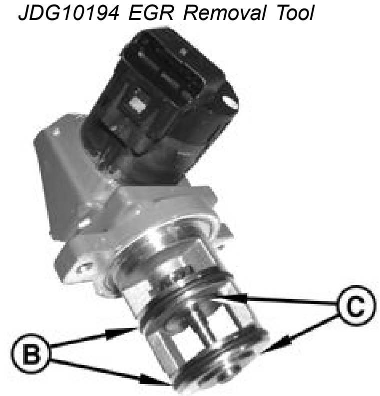
RG13947 —UN—28MAY05

EGR Valve



RG14881 —UN—26MAY06

JDG10194 EGR Removal Tool



RG14076 —UN—01APR05

Inspect EGR Valve

A—Attaching Screws
B—O-Rings
C—EGR Valve Lands
D—JDG10194 EGR Valve Removal Tool with Screws

RE38635,0000119 -19-13NOV07-1/1

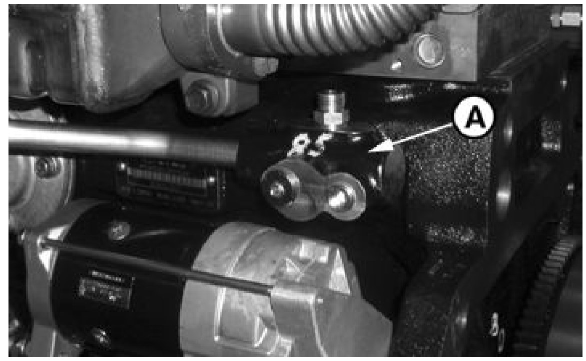
Remove and Install EGR Coolant Manifold

1. Using a pry bar carefully, remove the EGR coolant manifold (A) from cylinder block.
2. To install, apply a retaining compound LOCTITE 680® to coolant manifold press fit diameter.

NOTE: When coolant manifold is installed into cylinder block, the top surface of manifold should be parallel to head deck.

3. Press and orient coolant manifold (A), into rear coolant port on block until manifold chamfer bottoms on engine block chamfer.
4. Orient coolant manifold so the top surface is parallel to head deck within +/- 3 degrees.

LOCTITE is a trademark of Loctite Corp.



EGR Coolant Manifold

RE38635,0000053 -19-19DEC08-1/1

Remove and Install EGR Cooler Supply Line

Remove EGR Coolant Line

1. Loosen and remove cap screw (A) securing EGR coolant supply line to EGR cooler.
2. Rotate coolant line (B) and pull line to remove from coolant manifold.

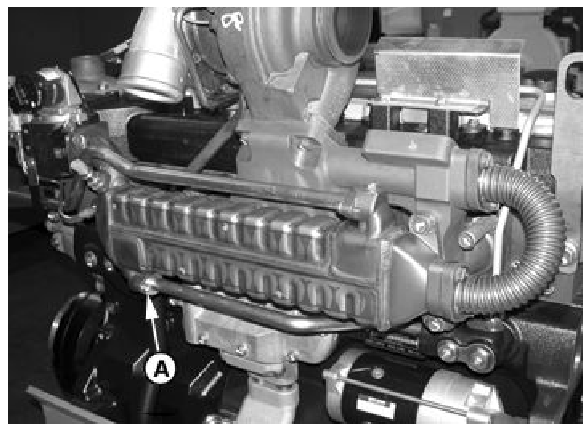
Install EGR Coolant Line

NOTE: DO NOT use lubricant to aid assembly of the coolant supply line.

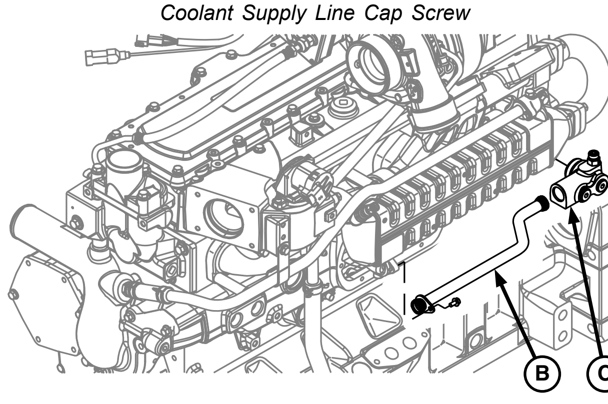
1. Assemble short end of coolant supply line (B) into coolant manifold (C) until it bottoms out on manifold counterbore.
2. Slide and orient EGR coolant supply line to cooler and install cap screw (A) to specification.

Specification

EGR Coolant Supply Line
to Cooler—Torque.. 11 N•m (8 lb-ft)



Coolant Supply Line Cap Screw



EGR Coolant Supply Line & Manifold

RE38635,0000010 -19-23MAY05-1/1

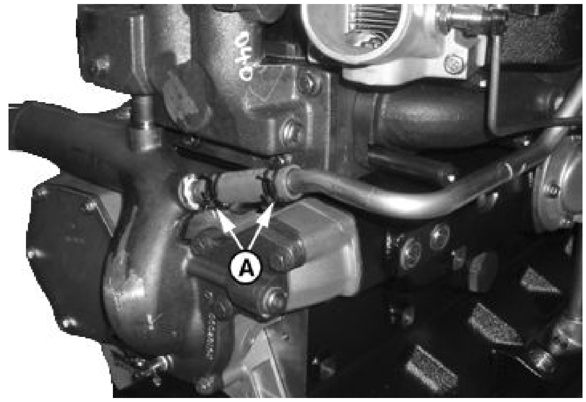
Remove and Install EGR Cooler Return Line

1. Loosen constant tension hose clamp (A) and remove hose end of line from coolant pump fitting.
2. Loosen and remove cap screw securing P Clamp. Remove P clamp and set aside.
3. Loosen cap screw securing other end of return line to cooler. Remove line from EGR cooler.
4. To install line, reverse this procedure. Tighten P clamp & coolant line flange cap screw to specification.

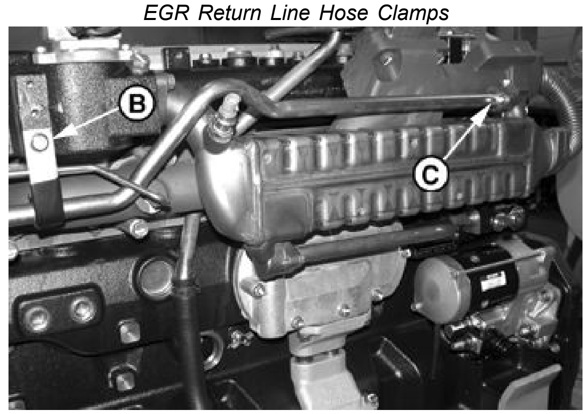
Specification

P Clamp Cap Screw—Torque	30 N•m (22 lb-ft)
Return Line to Cooler Flange Cap Screw—Torque	11 N•m (8 lb-ft)

A—Constant Tension Hose Clamps
B—P Clamp
C—Return Line to Cooler Cap Screw



EGR Return Line Hose Clamps



P Clamp & Line to EGR Cooler Cap Screw

RE38635,0000011 -19-23MAY05-1/1

Remove, Inspect, and Install Exhaust Manifold

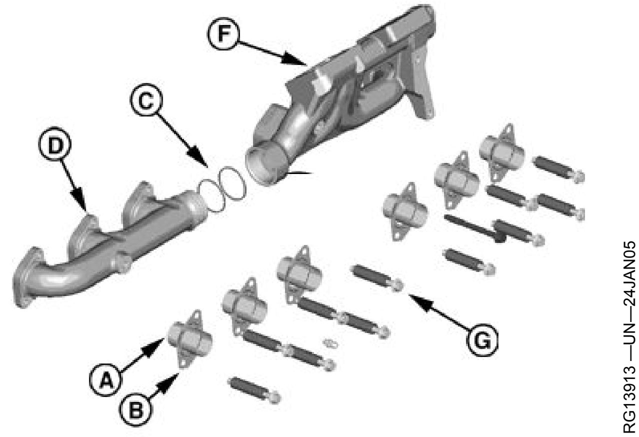
Remove and Inspect Exhaust Manifold

1. Remove turbocharger from exhaust manifold. See REMOVE TURBOCHARGER earlier in this group.
2. Remove EGR assembly. SeeREMOVE EGR earlier in this group.
3. Loosen 11 cap screws (G) with spacers, and one long bolt (H) from thick section of manifold.

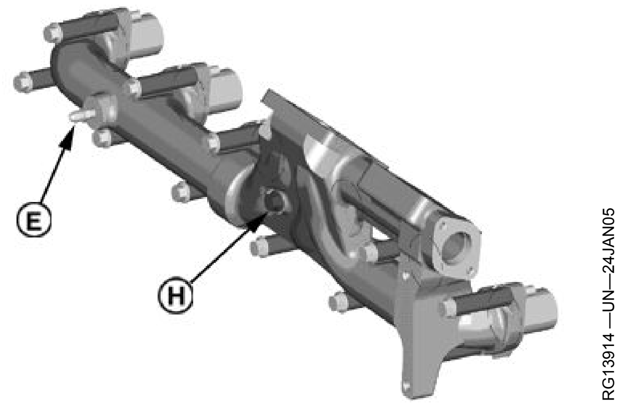
NOTE: Exhaust manifold has port liners (A) and metal gaskets (B). These can be removed with manifold or left in head and removed separately.

4. Carefully remove manifold assembly from cylinder head mounting face.
5. Separate front (D) and rear (F) manifold sections. Remove and discard the two sealing rings (C).
6. Remove all residue from gasket surfaces.
7. Thoroughly clean passages in exhaust manifold.
8. Inspect each exhaust manifold for cracks or damage. Inspect machined mounting surfaces for burrs or other defects which might prevent gaskets from sealing properly. Replace parts as needed.

A—Port Liner
B—Exhaust Manifold Gasket
C—Sealing Rings
D—Front Exhaust Manifold
E—Pressure Port Fitting
F—Rear Exhaust Manifold
G—Exhaust Manifold to Cylinder Head Cap Screws
H—Long Bolt - Manifold to Cylinder Head



Exhaust Manifold Assembly Components



Exhaust Manifold Assembly

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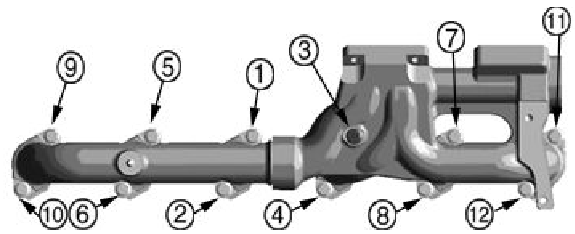
Install Exhaust Manifold

RG13915 —UN—28MAY05



Exhaust Manifold Torque Sequence

1. Install 6 port liners (A) to cylinder head.

NOTE: Guide pins and port liners will keep gaskets from rotating during assembly.

2. Install 6 guide pins to cylinder head in top cap screw hole of each port.
3. Install gaskets (B), with tab pointing down, over guide pins and port liners.

NOTE: Position one sealing ring joint at 3:00 position and the other at 9:00 position as viewed when mounted on engine.

4. Install two new sealing rings (C) to front manifold. (D)
5. If necessary, install pressure port fitting (E) into front manifold.

Specification

Pressure Port Fitting to Front Exhaust Manifold—Torque.. 20 N•m (15 lb-ft)

6. Install rear exhaust manifold (F) to front exhaust manifold (D).
7. Install exhaust manifold assembly over guide pins and port liners in cylinder head.

NOTE: It is not necessary to use an anti-seize compound on stainless steel exhaust manifold cap screws.

8. Apply PT569 NEVER-SEEZ® Compound, **only to cap screws being reused**. Install 6 cap screws (G) through spacers and into bottom holes of exhaust manifold and into cylinder head. Tighten finger tight.
9. Remove guide pins. Install 5 cap screws through spacers and into top holes finger tight in exhaust manifold and cylinder head.

IMPORTANT: The long bolt (H) on the exhaust manifold assembly CAN NOT be reused. This bolt is not stainless steel and is thus affected by the exhaust heat.

10. Install one long bolt (H) into hole through thick portion of exhaust manifold into cylinder head finger tight.

NOTE: Be certain exhaust manifold gasket tab is facing down, under bottom cap screws, as shown.

11. Tighten 12 exhaust manifold capscrews in the order shown to specification.

Specification

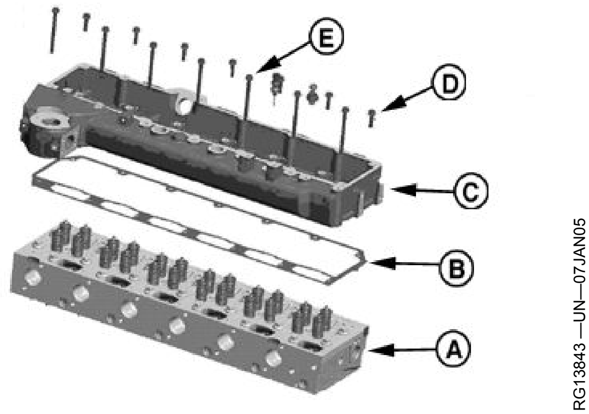
Exhaust Manifold to Cylinder Head Cap Screws—Torque.. 70 N•m (52 lb-ft)

NEVER-SEEZ is a registered trademark of Emhart Chemical Group

RE38635,000004C -19-27MAR09-2/2

Remove, Inspect, and Install Intake Manifold

A—Cylinder Head Assembly
B—Intake Manifold Gasket
C—Intake Manifold
D—Short Flange Head Cap Screws
E—Long Flange Head Cap Screws with Sealing Washer



Intake Manifold Assembly

RE38635,0000061 -19-26FEB09-1/5

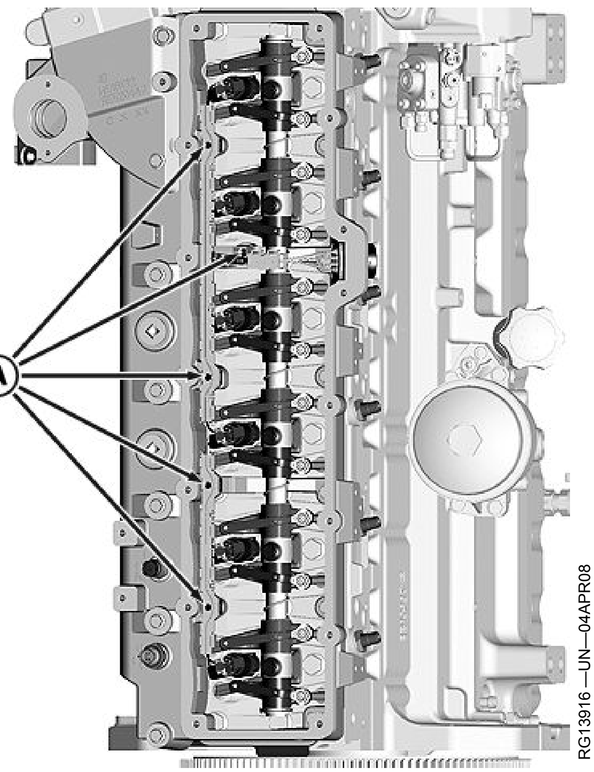
Remove and Inspect Intake Manifold

1. Remove turbocharger. See REMOVE TURBOCHARGER earlier in this group.
2. Remove EGR assembly. See REMOVE EGR earlier in this group.
3. Remove air intake connections from intake manifold as detailed in machine Technical Manual.
4. Remove air heater from manifold, if equipped.
5. Remove rocker arm cover and gasket.

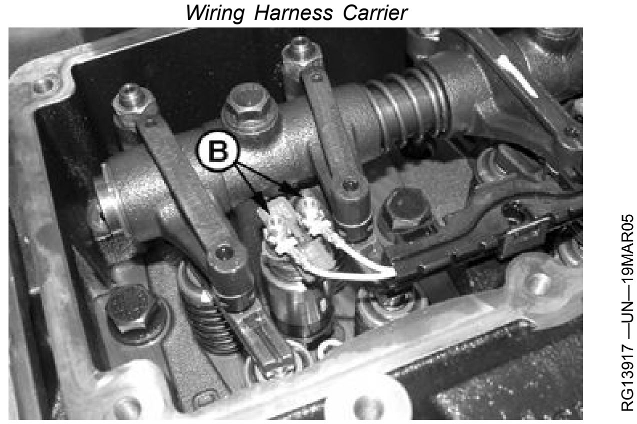
NOTE: The intake manifold can be removed from cylinder head without removing wiring harness from manifold. When reinstalling wiring harness, a low strength thread locking compound is recommended to be added to terminal threads.

6. Loosen wiring harness carrier screws (A).
7. Loosen wiring harness to fuel injector terminal nuts (B).
8. Loosen rocker arm adjusting screws.
9. Loosen and remove cap screws on rocker arm pedestals.
10. Remove rocker arm assembly and set aside.
11. Loosen and remove 7 short flange head cap screws on right side of manifold, and 7 long flange head cap screws with sealing washers on left side of manifold.
12. Carefully lift intake manifold from cylinder head.
13. Remove and discard intake manifold gasket.
14. Inspect the machined mating surfaces of cylinder head and intake manifold. Clean, as required, by using a scraper and/or wire brush, and compressed air.

A—Wiring Harness Carrier Screw Locations
B—Wiring Harness Leads to Injectors



Wiring Harness Carrier



Wiring Harness Leads to Injectors

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RE38635,0000061 -19-26FEB09-2/5

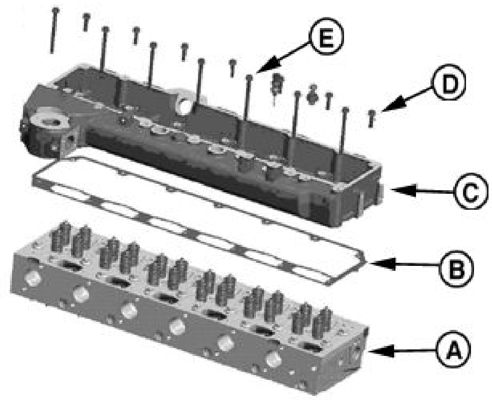
Install Intake Manifold

IMPORTANT: All intake manifold connections must be tight to prevent loss of power resulting from lack of intake manifold pressure.

Intake manifold hose and cap screw connections should be inspected periodically for tightness.

Whenever a tune-up has been performed on the engine, or whenever it is suspected that the horsepower output might be low, the intake manifold pressure (turbo-boost) should be checked. See MEASURE INTAKE MANIFOLD PRESSURE in Group 150.

1. Install 2 guide pins in cylinder head (A) to align intake manifold gasket.
2. Install new intake manifold gasket (B) over guide pins
3. Install intake manifold (C) over guide pins and place on gasket and cylinder head.
4. Remove guide pins.
5. Install 7 short flange head cap screws (D) in right side of intake manifold to cylinder head.
6. Lubricate 7 sealing washers with SAE 30 diesel engine oil and install on 7 long flange head cap screws (E).

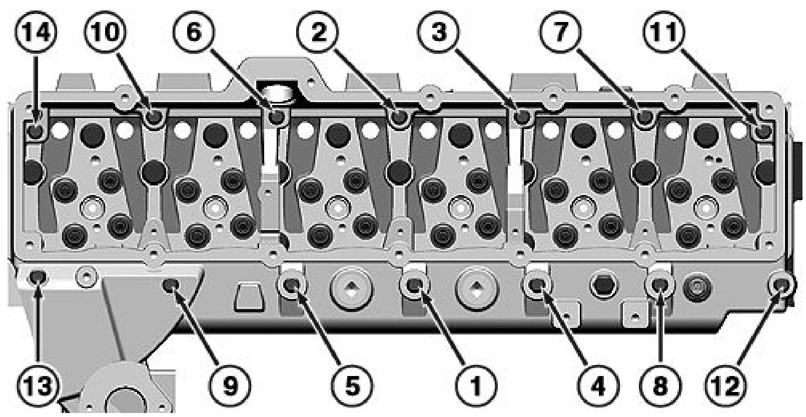


Intake Manifold Assembly

A—Cylinder Head Assembly
B—Intake Manifold Gasket
C—Intake Manifold
D—Short Flange Head Cap Screws
E—Long Flange Head Cap Screws with Sealing Washer

7. Install 7 long flange head cap screws with lubricated washers in left side of intake manifold to cylinder head.

RE38635,0000061 -19-26FEB09-3/5



Intake Manifold Torque Sequence

8. Torque all intake manifold to cylinder head cap screws to specification in the sequence shown.

Specification

Intake Manifold to Cylinder Head—Torque...35 N•m (26 lb-ft)

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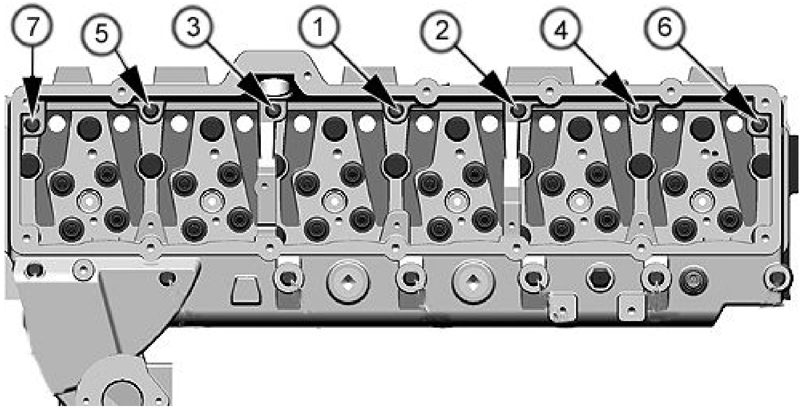


Second Torque Sequence - Short Cap Screws

9. Re-torque the short seven cap screws to specification in the sequence shown.

Specification

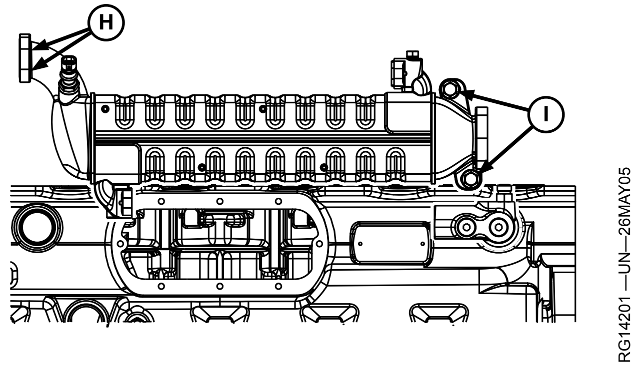
Intake Manifold to Cylinder Head—Torque...45 N•m (33 lb-ft)

10. Install exhaust manifold assembly and turbocharger as detailed earlier in this group.

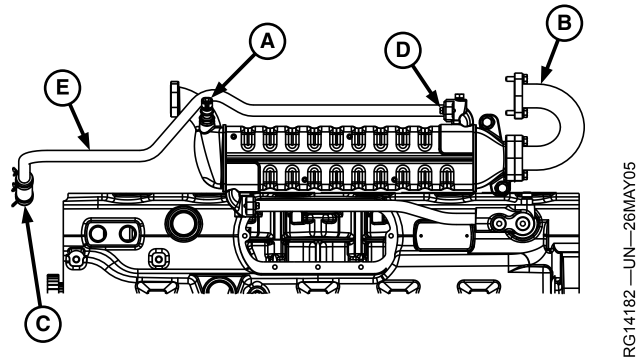
11. Connect all air intake and exhaust piping. (For vehicle engines, refer to machine Technical Manual.)

RE38635,0000061 -19-26FEB09-5/5

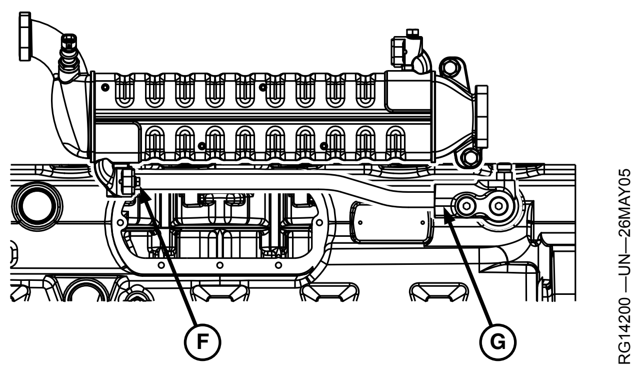
Install EGR



EGR Cooler



EGR Coolant Return Line & EGR Tube



EGR Coolant Supply Line

A—EGR Exhaust Gas Temperature Sensor
B—EGR Tube
C—EGR Coolant Return Line to Coolant Pump
D—Coolant Return Line to Cooler
E—EGR Coolant Return Line
F—EGR Coolant Supply Line to Cooler
G—Coolant Supply Line to Coolant Manifold
H—EGR Cooler to Intake Manifold
I— Cooler Shoulder Bolts

1. Install EGR cooler assembly to intake manifold by starting 2 cap screws (H) finger tight. Do not tighten.
2. Assemble spring washers to shoulder bolts.
3. Install shoulder bolts through holes in rear of EGR cooler and into exhaust manifold (I).
4. Tighten cap screws to specification.

Specification

EGR Cooler to Intake Manifold—Torque.......34 N•m (25 lb-ft)
EGR Cooler to Exhaust Manifold Shoulder Bolts—Torque.......34 N•m (25 lb-ft)

5. Install EGR coolant return line (E) to EGR cooler assembly. Tighten screw (D) securing line to cooler to specification.

Specification

EGR Coolant Return Line to Cooler Cap Screw—Torque.......11 N•m (8 lb-ft)

6. Install constant tension hose clamp to end of EGR coolant return line. Install hose end of coolant return line (C) over fitting on coolant pump.
7. Reposition constant tension clamp to secure hose to coolant pump fitting.
8. Install P clamp support for EGR coolant return line with loop toward engine. Tighten cap screw to specification.

Specification

P Clamp Cap Screw—Torque.......30 N•m (22 lb-ft)

9. Install EGR tube (B) and 2 new gaskets to exhaust manifold and EGR cooler. Tighten cap screws to specification.

Specification

EGR Tube to Exhaust Manifold & EGR Cooler Cap Screws—Torque.......34 N•m (25 lb-ft)

10. Install EGR coolant supply line (short end) into coolant manifold (G).
11. Orient opposite end of coolant supply line into EGR cooler (F). Install cap screw and tighten to specification.

Specification

EGR Coolant Supply Line to Cooler & Coolant Manifold—Torque.......11 N•m (8 lb-ft)

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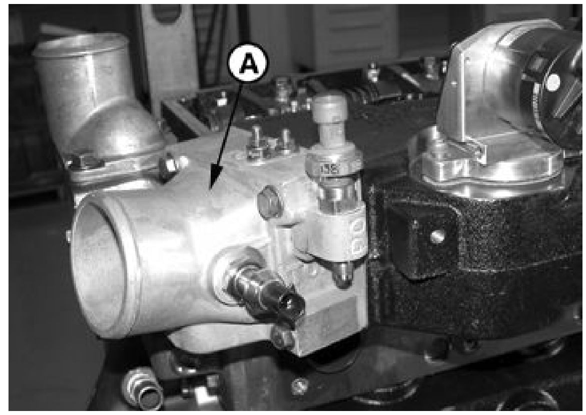
Remove and Install Air Inlet/Heater

1. Loosen and remove 4 cap screws securing air inlet (A) to intake manifold.
2. Remove air intake and gasket. Discard gasket.
3. Install new gasket and air intake. Tighten cap screws to specification.

Specification

Air Intake to Intake Manifold—Torque..35 N•m (26 lb-ft)



RG13918 —UN—19MAR05

Air Inlet with Heater

RE38635,000004E -19-25JAN05-1/1

Turbocharger — Extending Life

The PowerTech E engine is designed to use a conventional, fixed geometry turbocharger.

Turbochargers are designed to last the life of the engine. However, because they operate at such high speeds (100,000 rpm or more), a moment's carelessness can cause them to fail in seconds.

IMPORTANT: In the event of a turbocharger failure, be certain to check the air intake system (including the charge air cooler and piping) for residual oil and, if oil is present, clean thoroughly. If this step is not done, the engine will burn the residual oil following turbocharger replacement. This will result in major engine failure.

The major causes of turbocharger failures are:

- **Lack of Lube Oil (Quick Starts and Hot Shutdowns)**
- **Oil Contamination**
- **Ingestion of Foreign Objects**
- **Restricted Oil Drainage**
- **Low Oil Level**
- **Operation on Excessive Side Slopes**
- **Abnormally High Exhaust Temperatures**

Lack of Lube Oil

Oil not only lubricates the turbocharger's spinning shaft and bearings, it also carries away heat. When oil flow stops or is reduced, heat is immediately transferred from the hot turbine wheel to the bearings, which are also heating up because of the increased friction due to the lack of oil. This combination causes the turbocharger shaft temperature to increase rapidly.

If oil flow does not increase and the process continues, bearings will fail. Once the bearings fail (which can happen in just seconds) seals, shaft, turbine and compressor wheels can also be damaged.

The principle causes of turbocharger bearing lubrication problems are low oil pressure, a bent, plugged or undersized oil lube supply line, plugged or restricted oil galleries in the turbocharger, or improper machine start-up and shutdown procedure.

Oil levels and pressure should always be closely monitored and all worn hoses and lines should be replaced. The turbocharger oil supply line should be checked frequently to make sure it is not kinked or bent and it should always be replaced with a line of equal size, length and strength.

The easiest way to damage a turbocharger is through improper start-up and shutdown procedures. Always idle the engine for at least 30 seconds (no load) after start-up and before shutdown. Warming the engine up before applying a load allows oil pressure to build up and lines to fill with oil.

Idling the engine before shutdown allows the engine and turbocharger to cool. “Hot” shutdowns can cause the turbocharger to fail because after high-speed operation the turbocharger will continue to rotate long after the engine has been shut off and oil pressure has dropped to zero. This will cause heat to build up and possibly damage bearings. It can also cause carbon and varnish deposits to form.

Oil Contamination

A second cause of turbocharger failures is contaminated oil. It can be caused by a worn or damaged oil filter or not changing the lube oil at recommended intervals. Expecting the oil filter to remove dirt, sand, metal chips, etc. from the oil before they reach the engine or turbocharger can be a costly mistake because contaminated oil may completely bypass the engine oil filter if the oil filter or oil cooler is clogged, if the filter element is improperly installed, or if the oil is thick during cold weather.

Four good ways of avoiding oil contamination are:

- Always inspect the engine thoroughly during major overhaul. Look especially for any sludge or debris left in lube oil galleries.
- Change lube oil at recommended intervals. Analysis of oil samples at filter change periods can help identify potentially harmful contaminants in the oil.
- Clean the area around the oil fill cap before adding oil.
- Use a clean container when adding oil.

Ingestion of Foreign Objects

The third cause of turbocharger damage is the ingestion of foreign objects. These particles can be ingested and cause damage to the turbocharger on both compressor and turbine sides. This is easy to avoid.

On the compressor side, foreign objects usually take the form of dust, sand, or shreds of air cleaner element that enter through improperly installed air cleaner elements. Leaky air inlet piping (loose clamps or torn rubber joints) or torn pleats in dry-type air cleaner elements also create problems.

The result is erosion of compressor blades that can cause the delicately balanced wheel to wobble.

IMPORTANT: Whenever an internal engine failure (valve, valve seat, piston) occurs, a thorough inspection of the turbocharger MUST BE performed before returning engine to service.

Restricted Oil Drainage

A fourth cause of turbocharger damage is restricted lube oil drainage. The lubricating oil carries away heat generated by friction of the bearings and from the hot exhaust gases. If drainage back to the sump is impeded, the bearings will overheat with damage that will ultimately lead to failure.

Continued on next page

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There are two primary reasons for restricted drainage. A blocked drain tube, due to either damage or a buildup of sludged oil, or high crankcase pressure, which can be due to restricted crankcase breather or excessive engine blow-by.

Periodically check both the turbocharger oil drain tube and engine breather tube for damage or restriction. Correction of these conditions leads to longer turbocharger life.

Abnormally High Exhaust Temperatures

A fifth cause of turbocharger damage is abnormally high exhaust temperatures. Elevated exhaust temperatures cause coking of oil which can lead to bearing failure. Extreme over-temperature operation can cause wheel burst.

There are two basic causes of over-temperature. The first is restricted air flow and the second is overpowering the engine. In either case the engine has more fuel than available air for proper combustion; this overfueled condition leads to elevated exhaust temperatures.

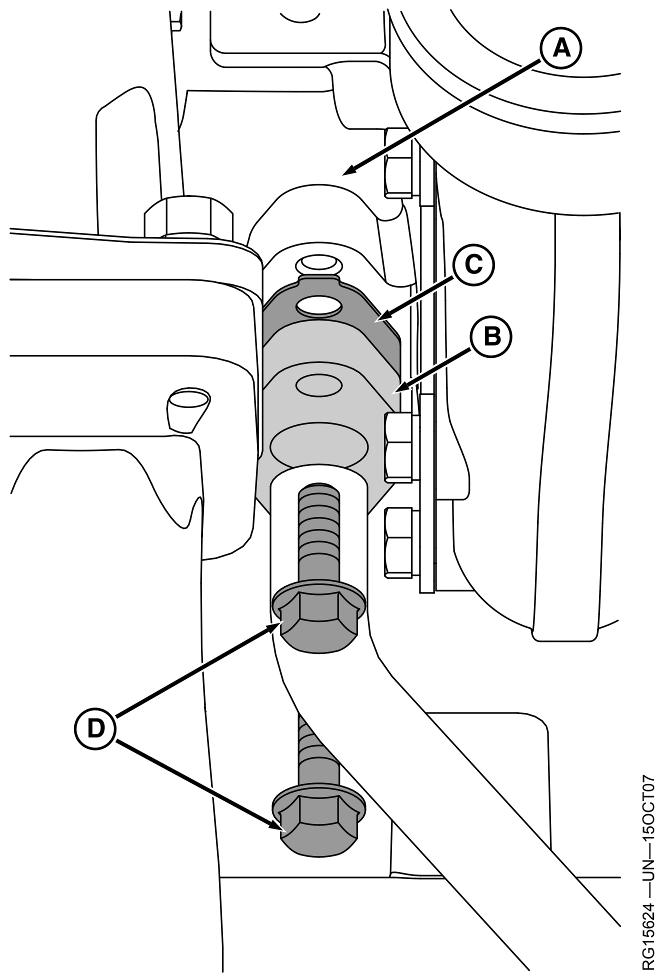
Causes of restricted air flow can include damaged inlet piping, clogged air filters, excessive exhaust restriction, or operation at extreme altitudes. Overpowering generally is due to improper fuel delivery or injection timing. If overtemperature operation has been identified, an inspection of the air inlet and exhaust systems should be performed. Also, check the fuel delivery and timing.

RE38635,00000C9 -19-29NOV07-2/2

Turbocharger — Remove Oil Drain Line

1. Loosen 2 cap screws (D).

A—Turbocharger Bearing Housing
B—Drain Line Flange
C—Gasket
D—Cap Screws - Drain Line to Bearing Housing



Remove Turbocharger Oil Drain Line

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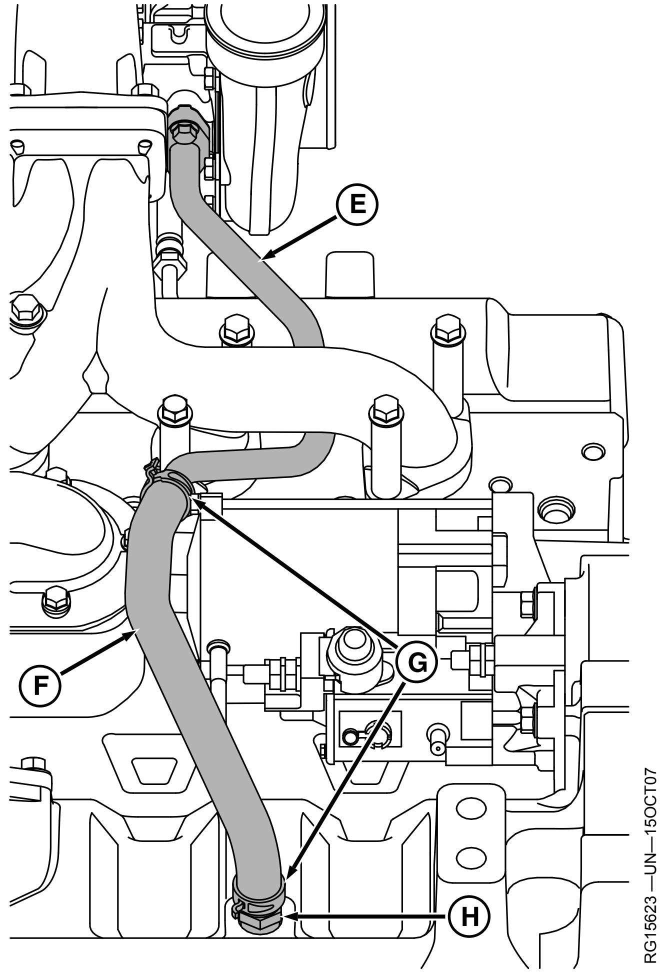
RE38635,00000CA -19-24SEP07-1/2

2. Loosen 2 constant tension hose clamps (G).
3. Remove drain line (E) from behind exhaust manifold and set aside.

E—Drain Line
F—Drain Hose
G—Constant Tension Clamps
H—Straight Fitting to Cylinder Block



Turbocharger Oil Drain Line Assembly

RE38635,00000CA -19-24SEP07-2/2

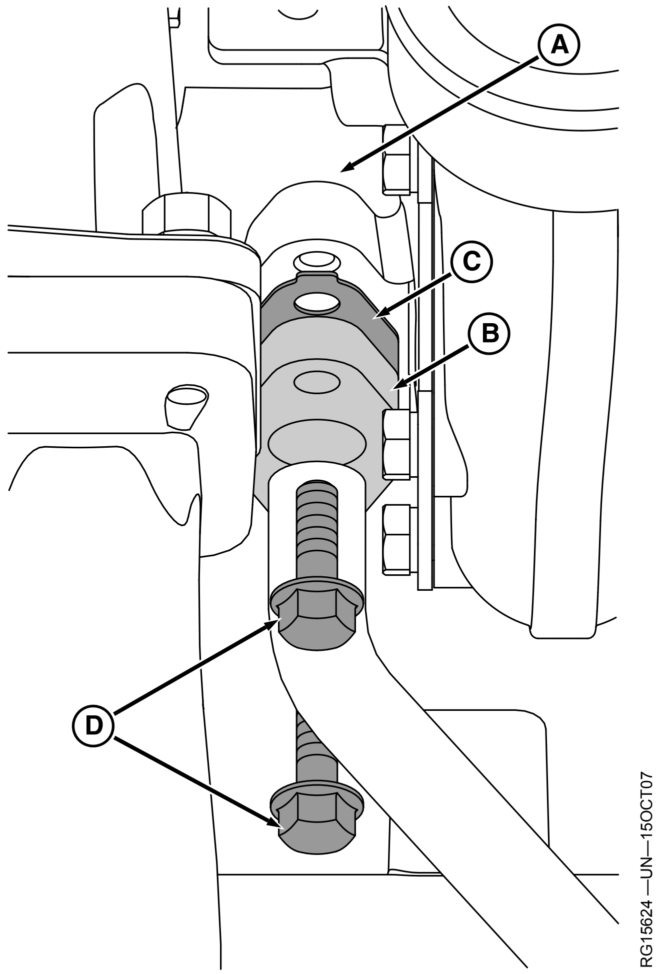
Turbocharger — Install Oil Drain Line

1. Install drain line end without flange behind exhaust manifold and move flange end toward turbocharger.
2. Install 2 serrated flange cap screws (D) into flange (B).
3. Install drain line gasket (C) over cap screws. Finger tighten cap screws into turbocharger bearing housing (A).
4. Torque drain line to turbocharger bearing housing cap screws to specification.

Specification

Drain Line to Bearing Housing Serrated Cap Screws—Torque .... 35 N•m (26 lb-ft)

A—Turbocharger Bearing Housing
B—Drain Line Flange
C—Gasket
D—Serrated Cap Screws -2-



Turbocharger Oil Drain Line Flange

Continued on next page RE38635,00000D2 -19-29NOV07-1/2

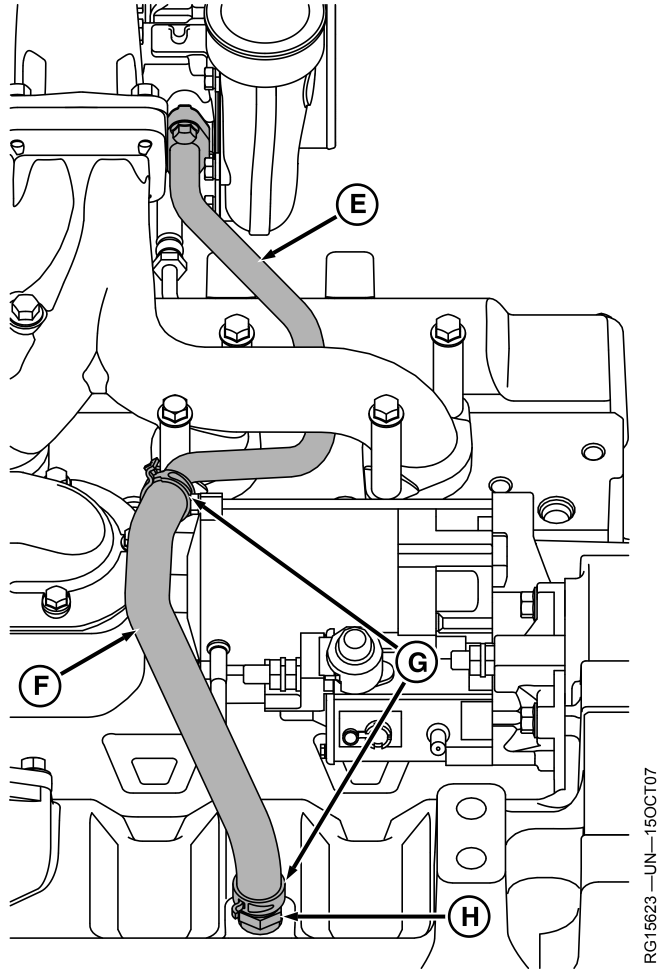
5. If necessary, install straight fitting (H) into turbocharger drain hole on left side of cylinder block.
6. Tighten fitting to specification.

Specification

Drain Line Straight Fitting to Cylinder Block—Torque................60 N•m (45 lb-ft)

7. Apply soap lubricant to inside diameter of both ends of turbocharger drain hose (F).
8. Install constant tension hose clamps (G) over drain hose.
9. Install hose over end of drain line (E) and over bead on straight fitting in cylinder block (H).
10. Locate and tighten hose clamps over each end of drain hose.

E—Oil Drain Line
F—Oil Drain Hose
G—Constant Tension Hose Clamps
H—Straight Fitting to Cylinder Block



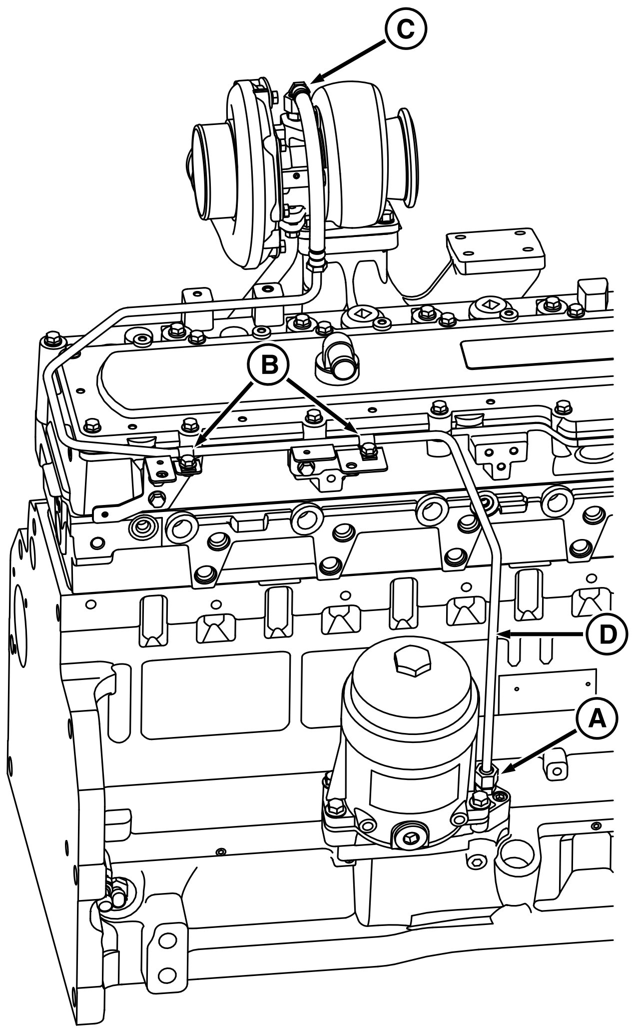
Turbocharger Oil Drain Line Assembly

RE38635,00000D2 -19-29NOV07-2/2

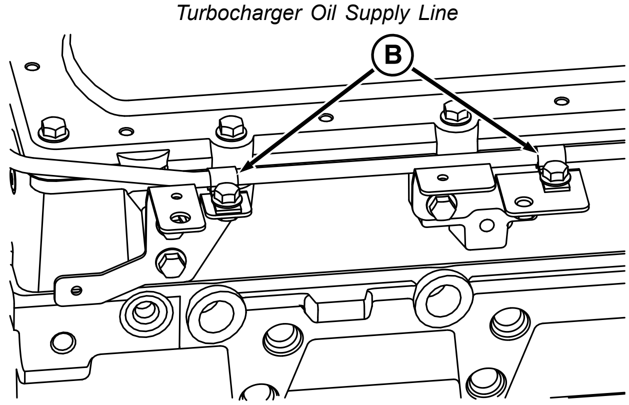
Turbocharger — Remove

1. Remove turbocharger oil drain line.
2. Loosen and remove 2 P-clamps (B) securing oil supply line to intake manifold.
3. Loosen fittings at oil filter base (A) and turbocharger bearing housing (C). Remove oil supply line (D) and set aside.

A—Oil Supply Line Fitting - Oil Filter Base
B—P-clamps
C—Oil Supply Line Fitting - Turbocharger Bearing Housing
D—Oil Supply Line



Turbocharger Oil Supply Line



Oil Supply Line P-Clamps

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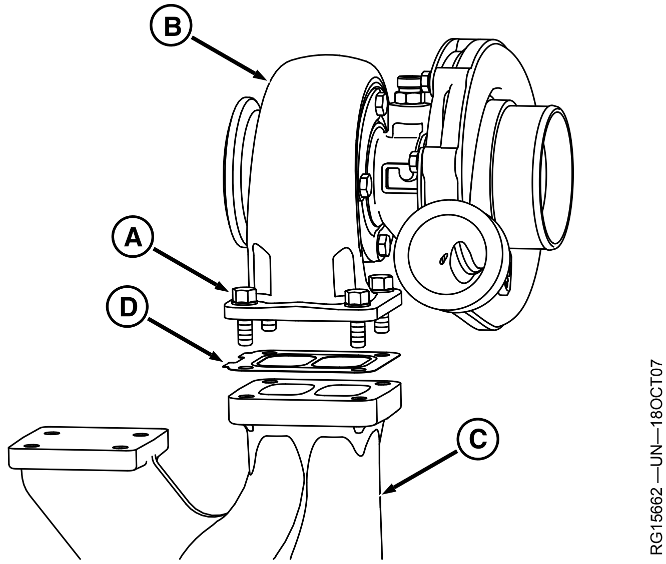
4. Loosen and remove 4 cap screws (A) securing turbocharger (B) to exhaust manifold (C).
5. Carefully lift turbocharger from exhaust manifold base and set aside.
6. Remove gasket and clean sealing surfaces of turbocharger and exhaust manifold.

A—Cap Screws - Turbocharger to Exhaust Manifold
B—Turbocharger
C—Exhaust Manifold
D—Gasket



Remove Turbocharger

RE38635,00000D3 -19-29NOV07-2/2

Turbocharger — Install

1. Install guide pins in 2 threaded exhaust manifold mounting holes to aid in turbocharger assembly.
2. Install gasket (D) over guide pins.
3. Install turbocharger (A) over guide pins with compressor inlet (B) facing rear of engine. Finger start 2 cap screws (E) through turbocharger flange into exhaust manifold (C).
4. Remove guide pins and finger start remaining 2 cap screws (E) through turbocharger into exhaust manifold.
5. Tighten 4 cap screws to specification.

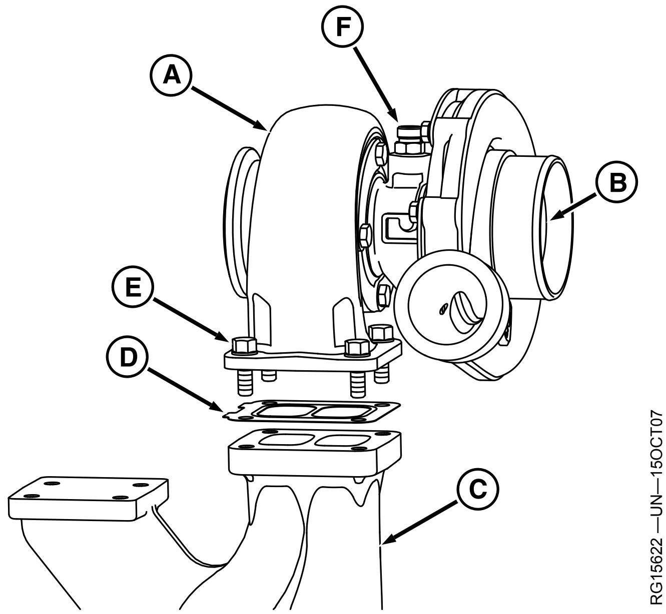
Specification

Turbocharger to Exhaust Manifold Cap Screws—Torque...40 N•m (30 lb-ft)

6. If necessary, install oil supply line fitting with O-ring. Tighten to specification.

Specification

Oil Supply Line Fitting—Torque..25 N•m (19 lb-ft)

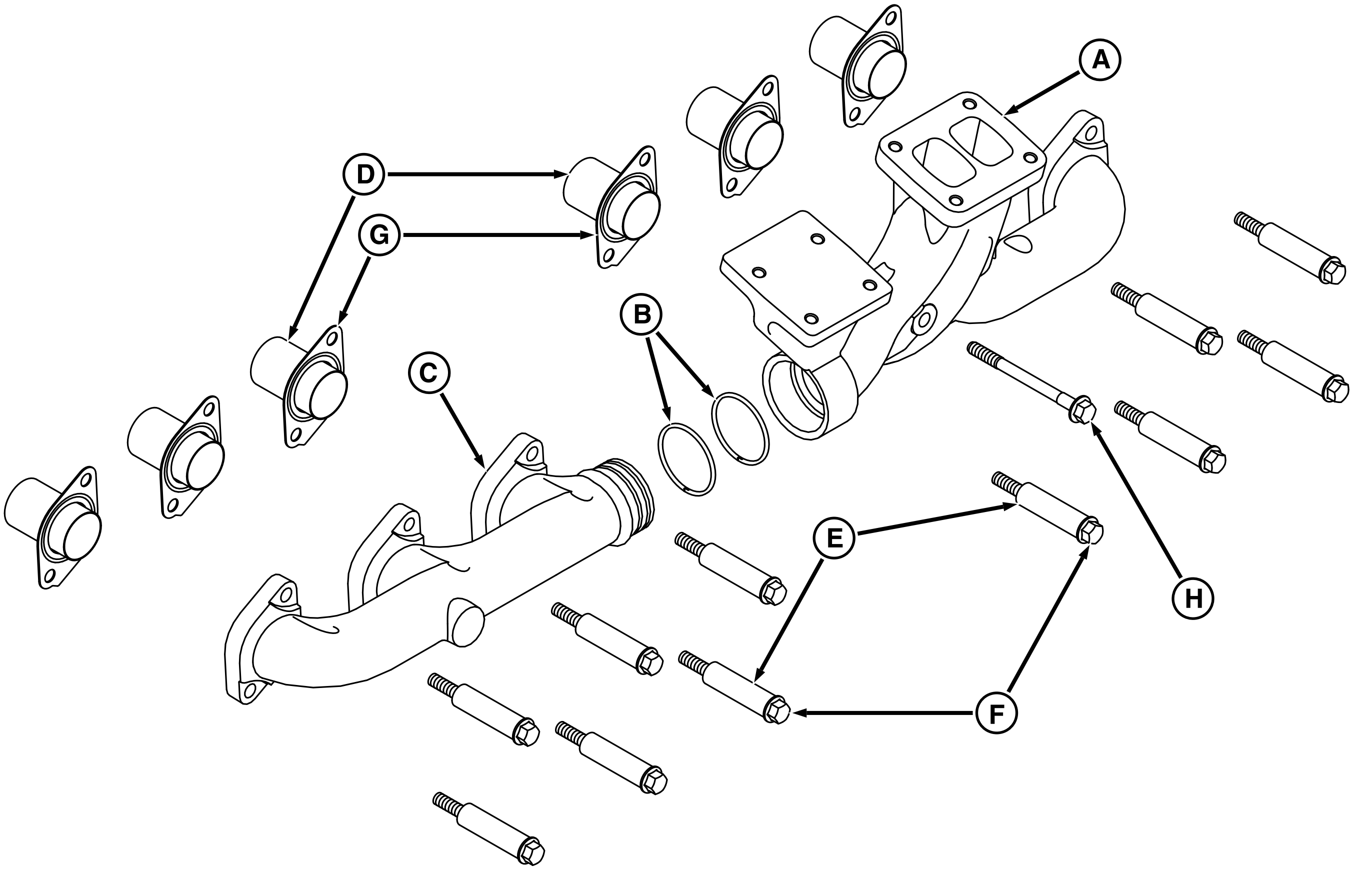


Install Turbocharger

A—Fixed Geometry Turbocharger
B—Compressor Inlet
C—Exhaust Manifold
D—Gasket
E—Cap Screws -4-
F—Oil Supply Fitting with O-ring

RE38635,00000D4 -19-29NOV07-1/1

Exhaust Manifold — Remove



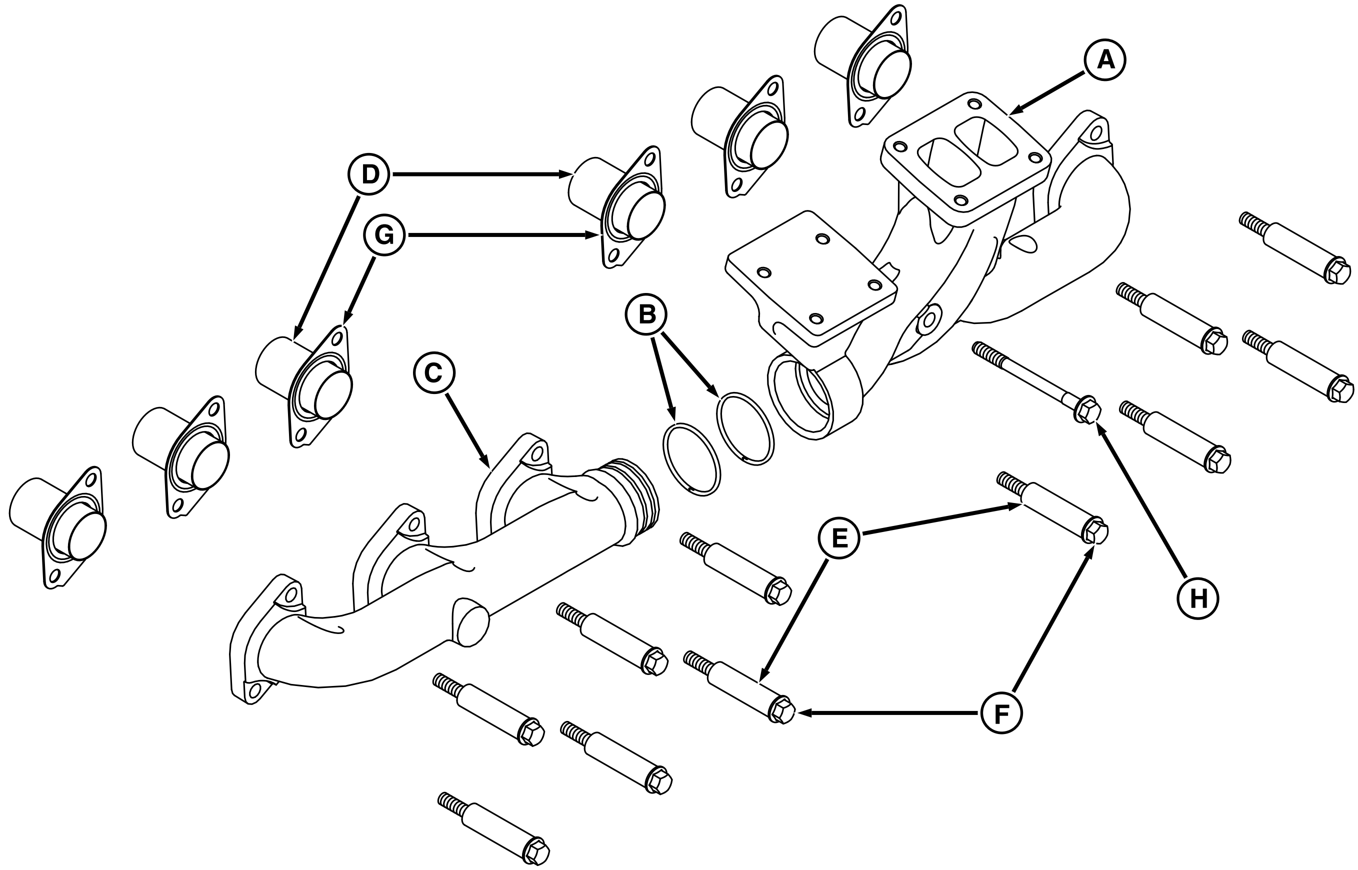
Remove Exhaust Manifold Assembly

A—Rear Exhaust Manifold
B—Sealing Rings
C—Front Exhaust Manifold
D—Cylinder Head Port Liners
E—Spacers
F—Exhaust Manifold to Cylinder Head Cap Screws
G—Gaskets
H—Long Bolt - Exhaust Manifold to Cylinder Head

1. Loosen and remove 11 short cap screws (F) with spacers (E), and one long bolt (H).
2. Remove exhaust manifold assembly from cylinder head.
3. Remove gaskets G) and cylinder head port liners (D) from cylinder head.

RE38635,00000D5 -19-29NOV07-1/1

Exhaust Manifold — Install



Exhaust Manifold Assembly

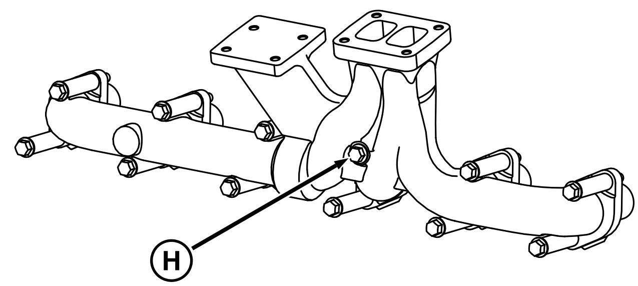
1. Install 6 port liners (D) in to cylinder head ports.

NOTE: For easier assembly, use 6 guide pins, placed in top holes of each exhaust port. Guide pins and port liners will keep gaskets from rotating during assembly.

2. Install gaskets (G), with tab pointing down, over port liners and guide pins, if used.

IMPORTANT: Position one sealing ring joint at 3:00 position and the 2nd sealing ring at 9:00 position, as mounted on engine.

3. Install 2 sealing rings (B) onto front exhaust manifold (C).
4. Install rear exhaust manifold (A), to front exhaust manifold with sealing rings (C).
5. Install exhaust manifold assembly over guide pins and port liners in cylinder head.
6. If using guide pins, install 6 cap screws (F) through spacers (E) and finger start through bottom row of holes in exhaust manifold and into cylinder head.
7. Remove guide pins, if used. Install 5 cap screws through spacers and finger start through top row of exhaust manifold holes into cylinder head.



Long Bolt Location - Assembled Position

A—Rear Exhaust Manifold
B—Sealing Rings
C—Front Exhaust Manifold
D—Cylinder Head Port Liners
E—Spacers
F—Exhaust Manifold to Cylinder Head Cap Screws
G—Gaskets
H—Long Bolt - Exhaust Manifold to Cylinder Head

8. Install 1 long bolt (H) through thick section of exhaust manifold into cylinder head finger tight.

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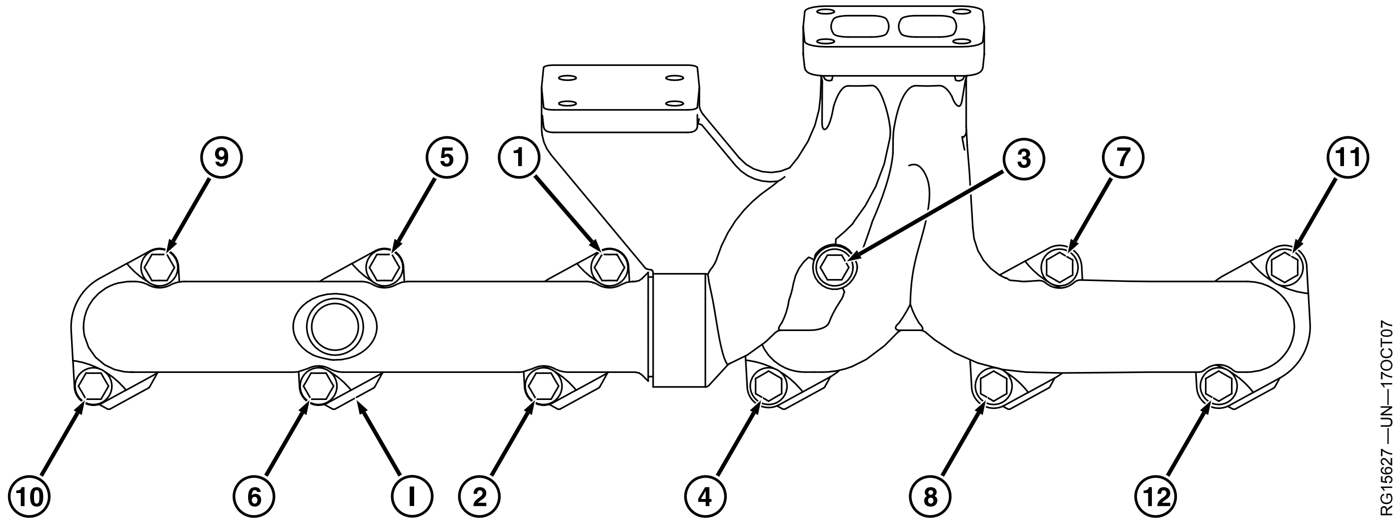
RE38635,00000D6 -19-29NOV07-1/2



Torque Sequence

NOTE: Note position of gasket tabs (I) to be sure all are in down position before tightening cap screws.

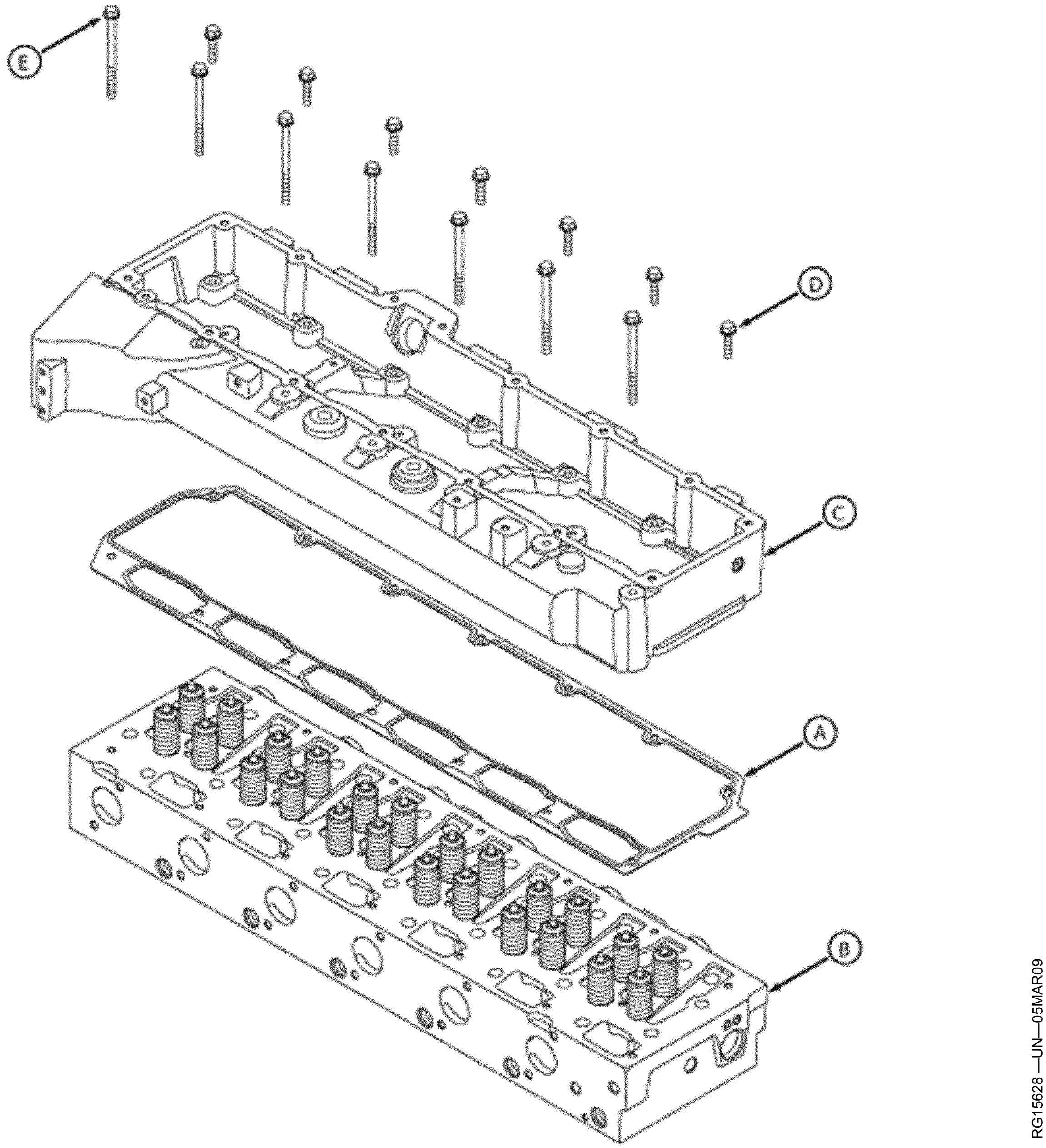
9. Tighten 12 exhaust manifold to cylinder head cap screws to specification in the sequence shown.

Specification

Exhaust Manifold to Cylinder Head Cap Screws—Torque...70 N•m (52 lb-ft)

RE38635,00000D6 -19-29NOV07-2/2

Air Intake Assembly — Remove



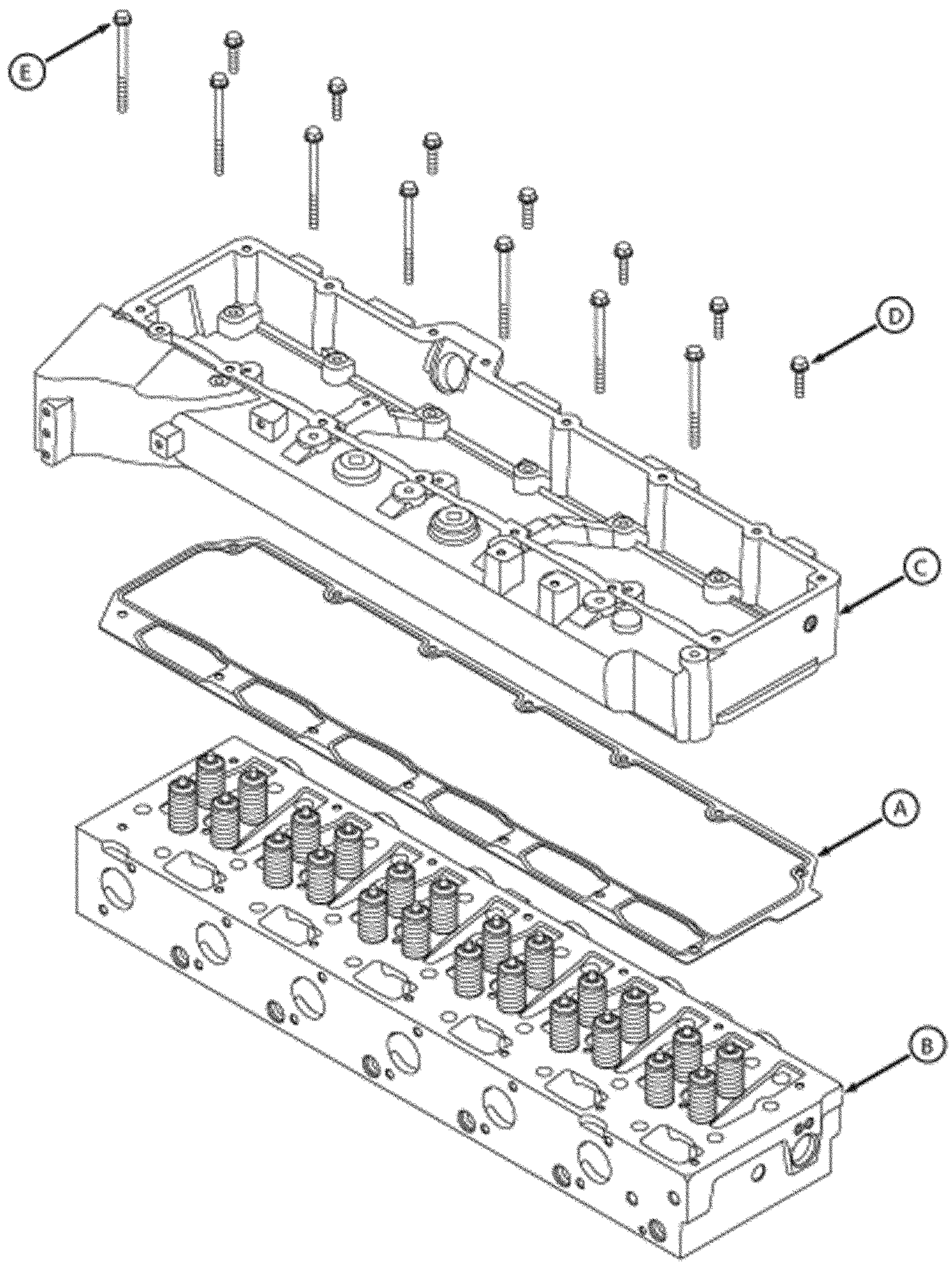
Remove Air Intake Assembly

A—Intake Manifold Gasket
B—Cylinder Head
C—Intake Manifold
D—Flange Head Cap Screws - Short
E—Flange Head Cap Screws with Washers - Long

1. Remove turbocharger, oil supply and oil drain lines.
2. Remove rocker arm cover and engine vent tube.
3. Remove injector wiring harness.
4. Remove rocker arm assembly.
5. Loosen and remove 7 short cap screws (D) and 7 long cap screws with washers (E).
6. Lift intake manifold (C) from cylinder head (B).
7. Remove gasket (A) and clean intake manifold and cylinder head gasket surfaces.

RE38635,00000D7 -19-29NOV07-1/1

Air Intake Assembly — Install



A—Intake Manifold Gasket
B—Cylinder Head
C—Intake Manifold
D—Flange Head Cap Screws - Short
E—Flange Head Cap Screws with Sealing Washer - Long

NOTE: Assembly of intake manifold to cylinder head will be easier with use of guide pins.

1. Install two guide pins in cylinder head to align intake manifold gasket (A).
2. Install intake manifold gasket (A) over guide pins.
3. Install intake manifold (C) over gasket and guide pins and carefully place on cylinder head (B).
4. Remove guide pins.
5. Install seven short flange head cap screws (D) through right side (as looking from rear of engine) of intake manifold and into cylinder head.
6. Lubricate seven sealing washers with clean engine oil and install on seven long flange head cap screws (E).
7. Install seven long flange head cap screws with lubricated washers through left side of intake manifold and into cylinder head.

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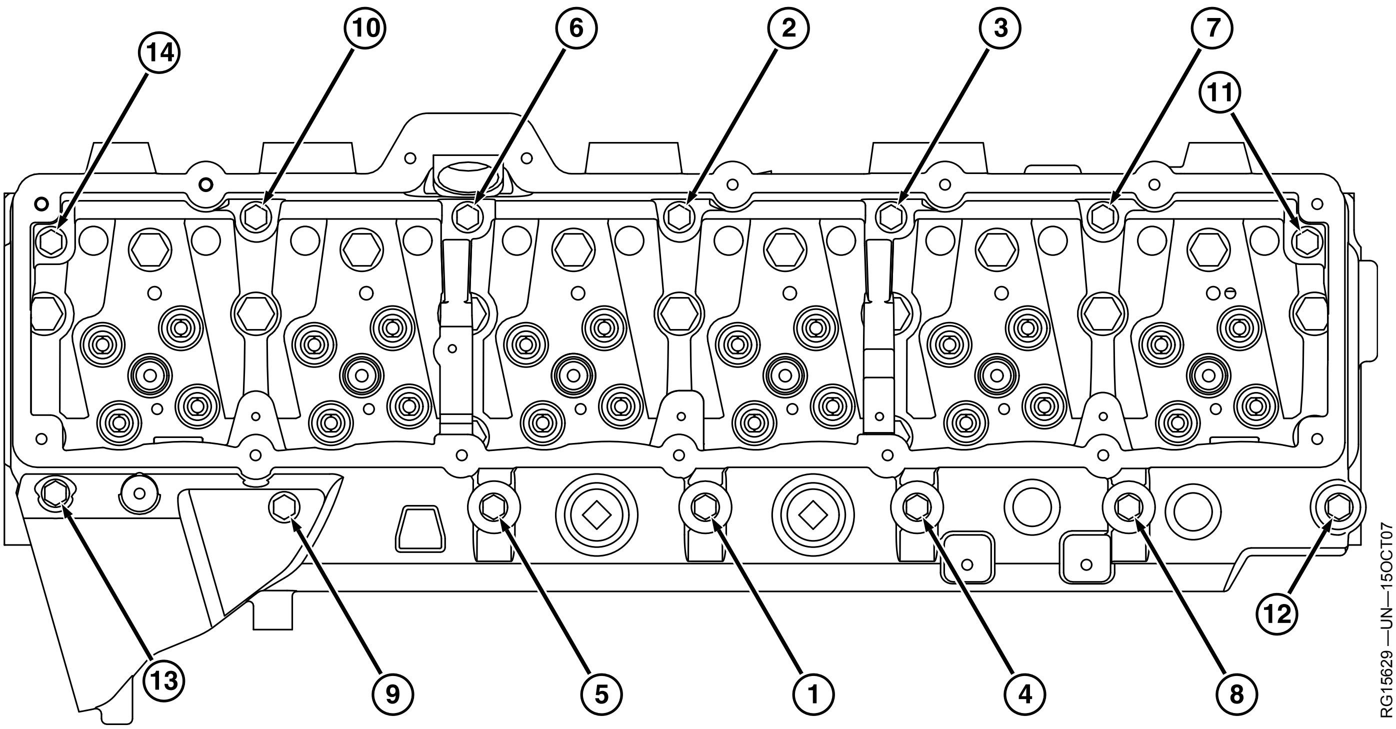
AS58880,0000212 -19-03MAR09-1/3



Intake Manifold to Cylinder Head Cap Screws Torque Sequence

8. Torque all intake manifold to cylinder head cap screws to specification in sequence shown.

Specification

Intake Manifold to Cylinder Head Cap Screws—Torque	35 N•m (26 lb-ft)

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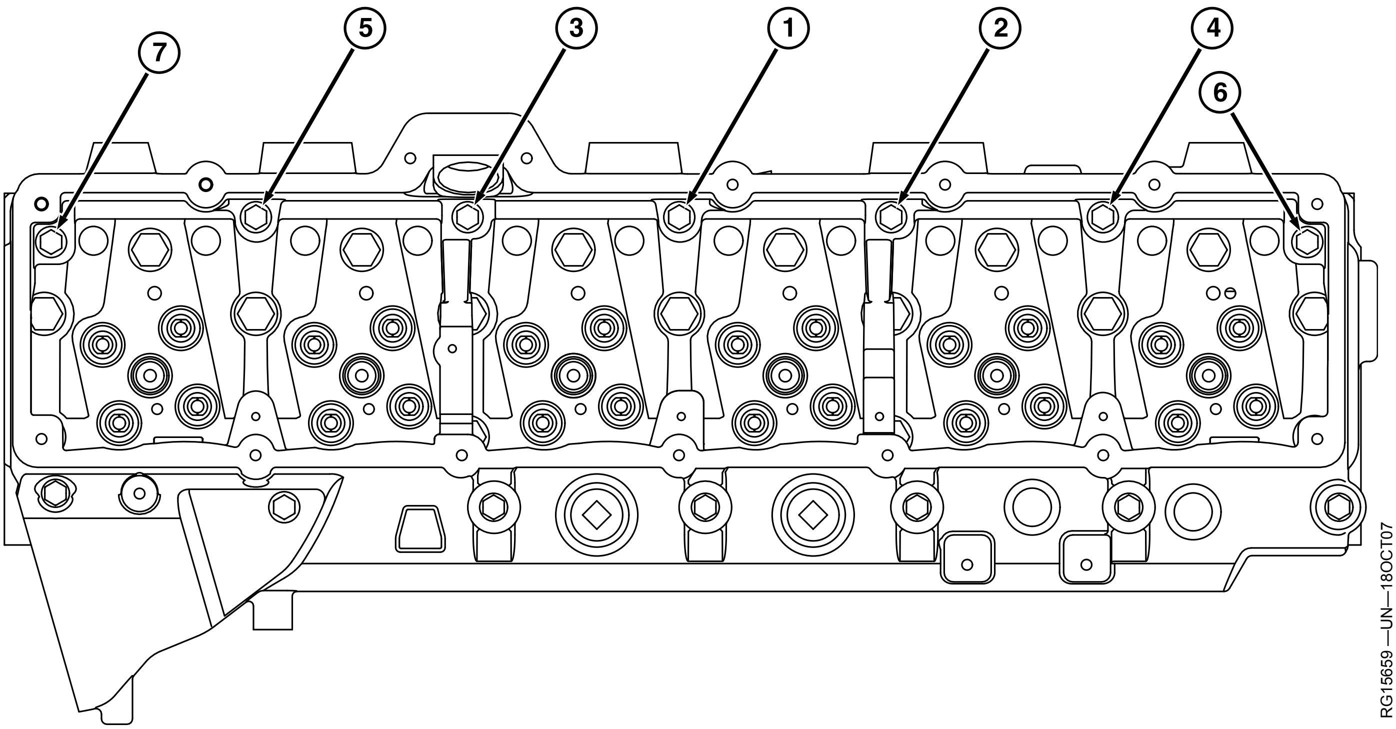
AS58880,0000212 -19-03MAR09-2/3



Second Torque Sequence - Short Cap Screws

9. Re-torque the short seven cap screws to specification in the sequence shown.

Specification

Short Cap Screws - Intake Manifold to Cylinder Head—Torque	45 N•m (33 lb-ft)

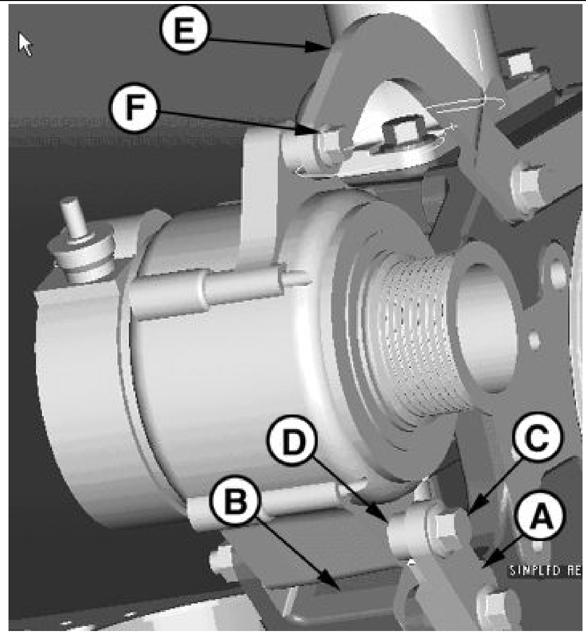
AS58880,0000212 -19-03MAR09-3/3

Remove and Install Alternator (OEM Engines)

IMPORTANT: The alternator is designed with a Transient Voltage Protector (TVP) to protect the engine electronics. A regular alternator without the TVP could cause extensive damage to the electronics.

NOTE: For test and repair of alternator, refer to CTM 77.

1. Disconnect battery ground (-) cable.
2. Disconnect positive (+) red wire and regulator connector.
3. Remove alternator belt using a 1/2 in. drive ratchet on the belt tensioner.
4. Remove mounting cap screws from alternator strap, front and rear mounts, and remove alternator.



RG14231 —UN—27MAY05

Alternator

A—Front Alternator Mount
B—Rear Alternator Mount
C—Alternator Mounting Screw
D—Spacer
E—Alternator Strap
F—Alternator Strap to Alternator Cap screw

Install Alternator

1. Position alternator between front (A) and rear (B) alternator mounts.
2. Install alternator mounting cap screw (C) through front alternator mount, spacer (D), alternator foot, and rear alternator mount. Install hex flange nut to alternator mount cap screw finger tight.
3. Adjust alternator to alternator strap (E). Install cap screw (F) through alternator strap, spacer, and into alternator ear. Tighten cap screw finger tight.
4. Tighten hardware to specification.

Specification

Alternator Mounting Cap Screw (lower cap screw)—Torque............50 N•m (37 lb-ft)

Specification

Alternator Strap to Alternator (upper cap screw)—Torque............25 N•m (19 lb-ft)
Alternator Strap to Fan Drive Plate Cap Screw (if needed)—Torque............35 N•m (26 lb-ft)

5. Inspect alternator belt for cracks and wear.

RE38635,0000013 -19-27MAY05-1/1

Remove and Install Starter Motor (OEM Engines)

NOTE: For test and repair of starter motor, refer to CTM 77.

1. Disconnect battery ground (-) cable.
2. Disconnect all cables and wires from starter solenoid.
3. Loosen two cap screws on outside of motor.
4. Using JDG2046 Special Wrench (E), loosen and remove flange nut (C) on inside of starter motor.
5. Remove starter motor and discard gasket.

Install Starter Motor

1. Install new gasket (A) onto starter. Be certain holes in gasket align with holes in starter.
2. Locate starter to engine block starter stud (B). Finger start one flange nut (C) to starter stud.

NOTE: Threads of cap screws and mating surface must be free of any oil film to ensure an effective seal.

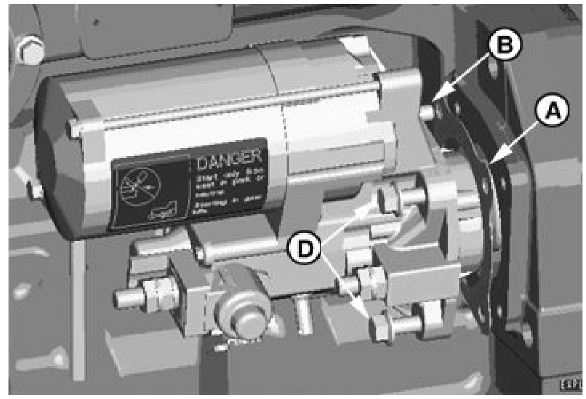
3. Coat threads of two starting motor cap screws (D) with LOCTITE® 242 thread lock.
4. Start two cap screws through starter into cylinder block. Tighten to specification.

Specification

Starter Motor Mounting Hardware—Torque.. 47.5 N·m (35 lb-ft)

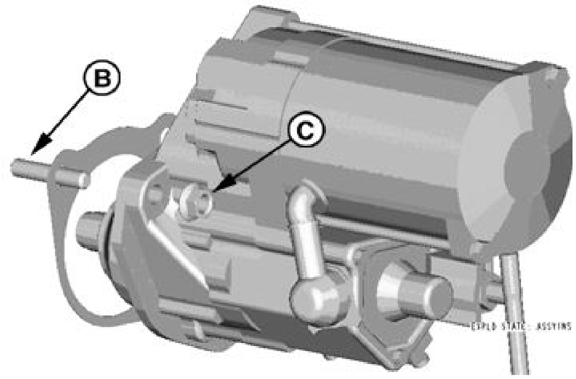
5. Use JDG2046 Special Wrench (E) to tighten flange nut (C) on inside of starter.

A—Starter Gasket
B—Starter Stud
C—Flange Nut - Starter Stud
D—Starter Mounting Cap Screws
E—JDG2046 Special 15 mm Wrench



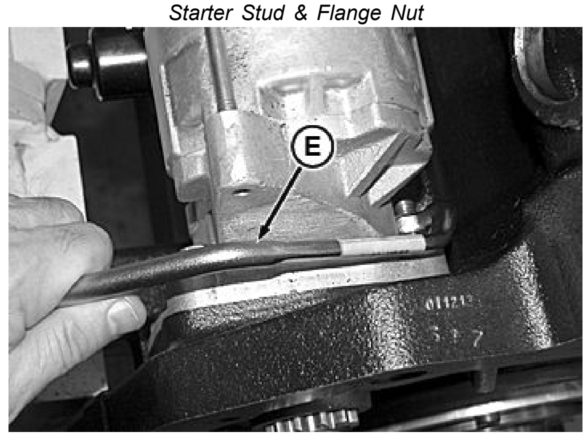
RG14229 —UN—28MAY05

Starter Assembly



RG14230 —UN—28MAY05

Starter Stud & Flange Nut



RG14228 —UN—14SEP09

Special Wrench

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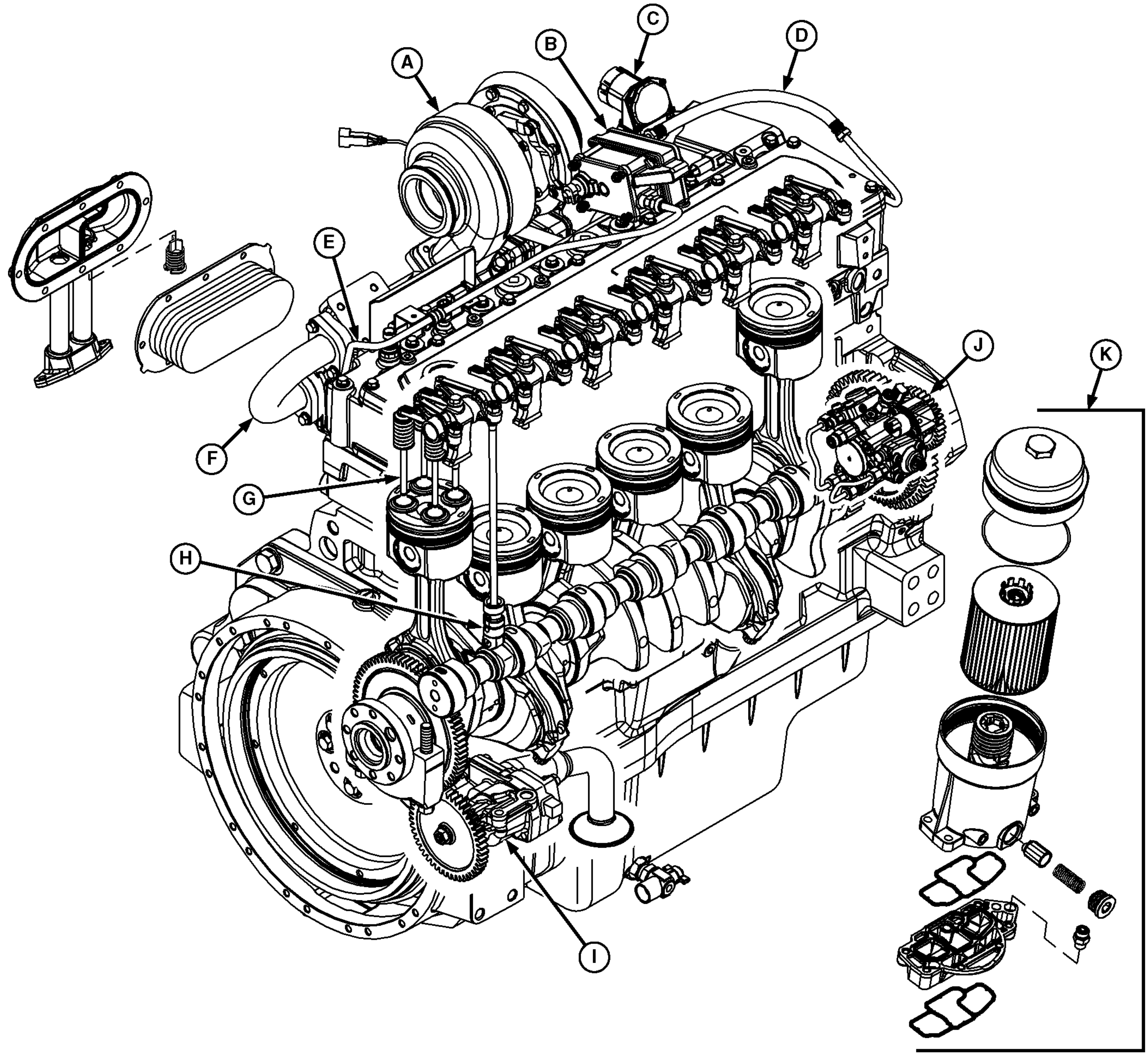
AS58880,00003F9 -19-10JUL09-1/1

Section 03
Theory of Operation

Contents

Engine Sectional View Serial Number



6090 Engine Sectional View

A—Variable Geometry Turbocharger (VGT)
B—Turbocharger Actuator
C—Exhaust Gas Recirculator (EGR) Valve
D—Actuator Coolant Supply Line
E—Actuator Coolant Return Line
F—EGR Tube - Exhaust Manifold to EGR Cooler
G—Four Valve Head Design
H—Roller Followers
I— Oil Pump
J— High Pressure Fuel Pump
K—Top Load Oil Filter

RE38635,000006A -19-21FEB05-1/1

General Engine Operation

In introducing the new Tier 3 / Stage IIIA, 9.0 L engine, John Deere meets new performance and emissions requirements along with maintaining the exceptional durability, reliability, and fuel economy for which Deere is known. The 9.0 L engine is a component in a new line of engines marketed as: John Deere PowerTech Plus Engines. PowerTech Plus engines feature:

- Four-valve cylinder head
- Common length cylinder head bolts
- Common size intake & exhaust valves
- Larger bore (thinner wall liners) and longer stroke (crankshaft/rod/piston revisions) to achieve 9.0 L displacement
- Coolant cooled exhaust gas recirculation (EGR)
- Variable geometry turbocharger (VGT)
- Higher pressure fuel system
- Full-authority electronic controls
- New engine control unit (ECU)
- Targeted spray oil cooled pistons
- Roller camshaft followers
- Metric hardware (except cylinder head bolts, bearing cap bolts, auxiliary drive hardware, and oil filter base mounting hardware

The PowerTech Plus engines will deliver horsepower and performance ratings, peak torque levels, fuel economy, and cold weather starting that are comparable, or better than, the Tier II 8.1 L engine.

All 6090 Engines are vertical stroke, in-line, 4 valve-in-head, turbocharged and air to air intercooled 6-cylinder diesel engines.

Direct fuel injection is provided by a high pressure fuel pump and high pressure common rail. The pump for the 9.0 L engine delivers fuel at a higher pressure than the 8.1 L (23,000 psi versus 18,000 psi), and the common rail on the 9.0 L is a welded rail design. The pump is driven by an intermediate gear in the timing gear train meshing with the camshaft gear. Roller cam followers, which ride on the camshaft lobes, drive push rods to the 4 valve actuation. Valve bridges similar to those used on the 12.5 L engine are used to actuate the valves. New to the 9 L engine design are identically sized intake and exhaust valves. Vertically mounted electronic injectors deliver fuel monitored by the engine control unit at pressures exceeding those on current Tier II 8.1 L engines.

The exhaust gas recirculation (EGR) and variable geometry turbocharger (VGT) are both performance and emissions control features. The EGR is operational only under high engine loads and when the engine is a operating temperature. In cold start and low load conditions, the EGR valve is in a closed position. The VG turbocharger has adjustable vanes in the exhaust turbine housing. These vanes, controlled by a water-cooled electronic actuator, open or close to direct and recirculate exhaust gases depending on engine load demand. The gases pass through a cooler which is bolted to the exhaust and intake manifold. Coolant is routed through the cooler, similar to a radiator, to cool the exhaust gases. After cooling, the exhaust gases are mixed with intake air by the EGR valve, located on the intake manifold. The engine control unit (ECU) controls the quantity of exhaust gas to be mixed with intake air for additional boost and combustion. Under full load conditions, as much as 10-12% of the intake air entering the combustion chamber is recirculated exhaust gases. The recirculating of cooled exhaust gases allows the 9.0 L engine to run with higher boost pressures. This increases power output of the engine and reduces emissions released to the atmosphere.

The turbocharger compressor (intake) discharge air is cooled by routing it through a heat exchanger before it enters the intake manifold. This heat exchanger uses no liquid coolant, but relies on air flow from the radiator fan blast to cool the charge air.

The camshaft is machined from chilled iron. The cam lobes are individually flame hardened to provide excellent wear characteristics. Additional journals are included on the 9 L camshaft for increased strength. Roller followers are adopted for 9 L for improved valve events with the four valve design. The front timing gear train consists of high contact ratio spur gears, allowing for two gear teeth contact at all times. The camshaft gear features raised ridges for speed sensor operation.

Roller cam followers, push rods, and rocker arm assembly operate the intake and exhaust valves. Valve bridges enable simultaneous valve actuation. The rocker arm shaft for 9 L is a one piece design, as opposed to two pieces for the 8.1 L engine. The four valves are identical size on the 9 L engine. Stainless steel exhaust valves withstand increased exhaust temperatures. Intake and exhaust valves are marked for visual identification. Intake and exhaust valve stem seals are part of the valve assembly.

The crankshaft is a one-piece, heat treated, dynamically balanced steel forging which rotates in replaceable two-piece main bearings. Larger connecting rod journals aid in withstanding higher firing pressures. The main thrust bearing is a two piece design and has a flange on each side to reduce crankshaft deflection and to limit end play during high load operation.

Cylinder liners are of a wet sleeve, flanged, and centrifugally cast design. O-ring type packings are used to seal the connection between cylinder block and liners. Liners are induction hardened and can be individually replaced (as a matched piston and liner set).

Pistons are machined from a steel forging (to withstand higher firing pressures) and have a three-ring configuration. The top two rings are compression rings, and the lower ring is an oil control ring.

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RE38635,000002F -19-30JUL09-1/2

The highly polished, hardened piston pins are fully-floating and held in position by means of snap rings. New piston spray jets (piston cooling orifices) in cylinder block direct pressured oil to a galley in the undercrown of the piston, providing directed cooling to the piston, necessary to withstand the higher firing pressures.

Connecting rods are of forged steel and have replaceable bushing and bearing inserts. They are weight controlled (by machining) on both ends to minimize engine vibration. The rods have the non-machined, Precision Joint™ rod and cap.

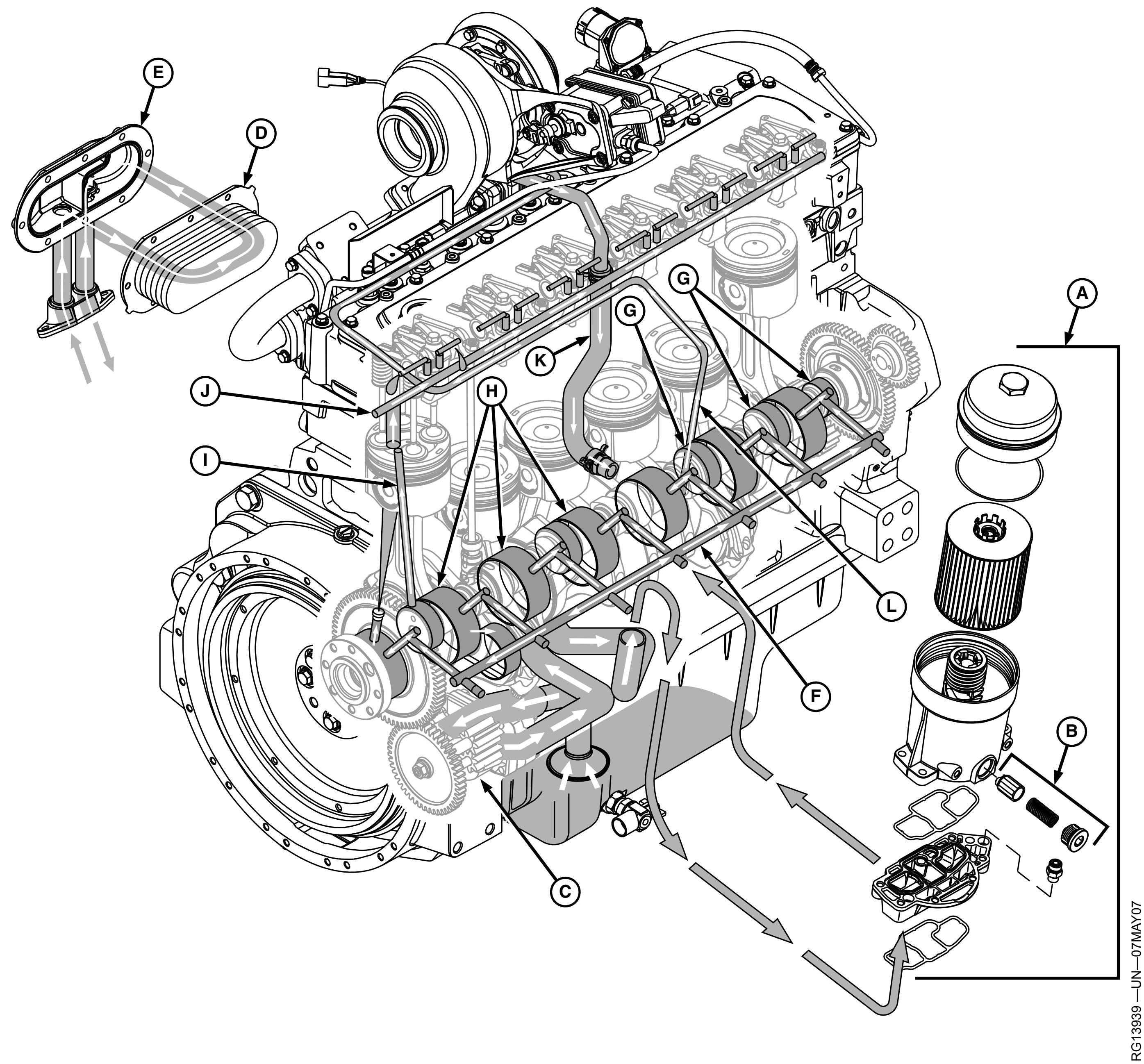
Precision Joint is a trademark of Deere & Company

The engine is supplied with lubricating oil by a spur gear pump driven off the rear of the crankshaft. Oil is conditioned by a top load full-flow filter located on the right side of the engine. Oil temperature is limited by an oil cooler located on left side of engine. Individual oil cooler and oil filter bypass valves protect the system and insure engine lubrication during times of high restriction; such as cold starts. Oil pressure is controlled by a pressure regulating valve located before the main oil gallery.

RE38635,000002F -19-30JUL09-2/2

Lubrication System Operation

Lubrication System Serial Number



6090 Lubrication System

A—Top Load Oil Filter
B—Pressure Regulating Valve
C—Oil Pump
D—Oil Cooler
E—Oil Cooler Cover
F—Main Engine Oil Galley
G—Camshaft Journals
H—Crankshaft Main Bearing Journals
I—Oil Passage to Cylinder Head
J—Oil Passage to Valve Actuation
K—Turbocharger Oil Drain
L—Turbocharger Oil Supply

The engine lubrication system consists of a crank-driven oil pump (C), oil cooler (D), top load oil filter assembly (A - see more detailed description later in this section), and oil pressure regulating valve (B).

Oil is drawn up from the sump through the oil pump and on to the oil cooler by way of the oil cooler cover which houses the oil cooler bypass valve. Oil proceeds through the oil cooler where it exchanges heat with the engine coolant, unless high restriction is sensed in which case the oil cooler is bypassed. Oil goes to the top load oil filter (A). Oil passes through the oil filter, unless high restriction is sensed in which case the oil filter is bypassed.

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RE38635,000006B -19-08SEP08-1/3

The oil pressure regulating valve (B) regulates the main oil gallery (F) pressure and permits excess oil to be returned to the sump. After flowing past the regulating valve, cooled, clean pressurized oil is supplied to the main oil gallery then distributed to the crankshaft main bearings (H), and piston cooling orifices through drilled passages in the cylinder block.

The piston cooling orifices are designed to direct oil through a cored passage in the underside of the piston. This oil flow both cools the piston and lubricates the piston pin. Higher firing pressures on the 9 L require additional piston cooling.

Oil flows from the crankshaft main bearings to the six camshaft bushings (G) while passages in the crankshaft also allow pressurized oil to lubricate the connecting rod bearings.

Oil from the front camshaft bushing travels through drilled passages in the camshaft nose to lubricate the camshaft thrust washers (not shown) and front gear drive train.

Oil from the rear camshaft bushing feeds through drilled passages (I) in the cylinder block and cylinder head into passages in the rocker arm assemblies (J) which lubricate the rocker arms, which in turn provide oil to the other valve train components as well as the roller camshaft followers.

Clean oil is also routed from the top of the oil filter base through an external line (L) to the turbocharger, where the shaft bearing is cooled, and is returned to the cylinder block crankcase through another external line and hose (K).

The fuel injection pump is pressure lubricated by way of an external line (not shown) which taps into the main oil gallery.

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Top Load Oil Filter

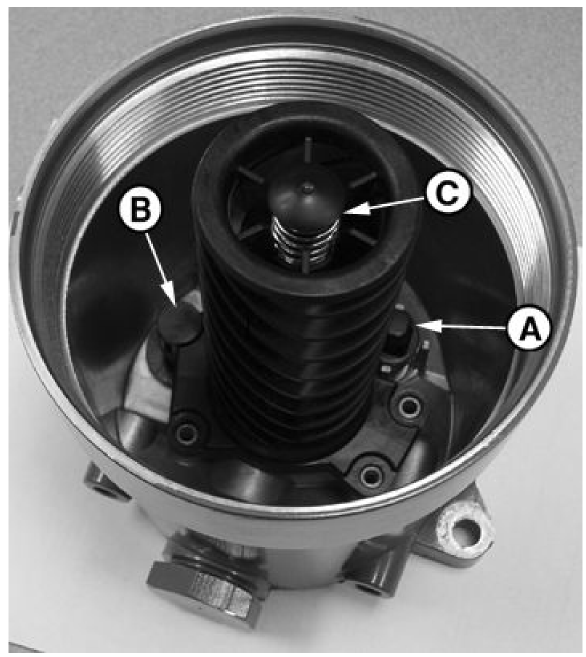
The top load oil filter assembly derives its name from the way the filter element "top loads" into the filter canister. The design is such that the filter element can be changed without the typical oil spill resulting from removal of the filter canister from the filter base. With the top load design, the filter canister remains on the filter base. Valves inside the filter canister regulate oil flow into the filter canister, pressure, and dump to sump when the filter element is changed.

When the filter element is in place and the system thus "closed", the pressure of the filter element keeps the return to sump valve (A) pressed downward, and thus closed. This prevents pressurized oil from being dumped back to sump prior to being filtered. If this valve is missing or not closed, low oil pressure will result.

Pressurized oil from the oil pump opens the inlet valve (B). This allows dirty, unfiltered oil from the sump to fill the canister and flow through the filter element. When the engine is turned off, this valve closes due to pressure from the oil within the canister, thus keeping the filter full of oil for the next start.

The bypass valve (C) protects the engine when the filter element becomes plugged, allowing unfiltered oil to reach engine components via the oil galley until the filter element can be changed.

When the oil filter element is removed for service replacement, pressure on the dump valve (A) is released, allowing oil in the canister to drain back to sump.



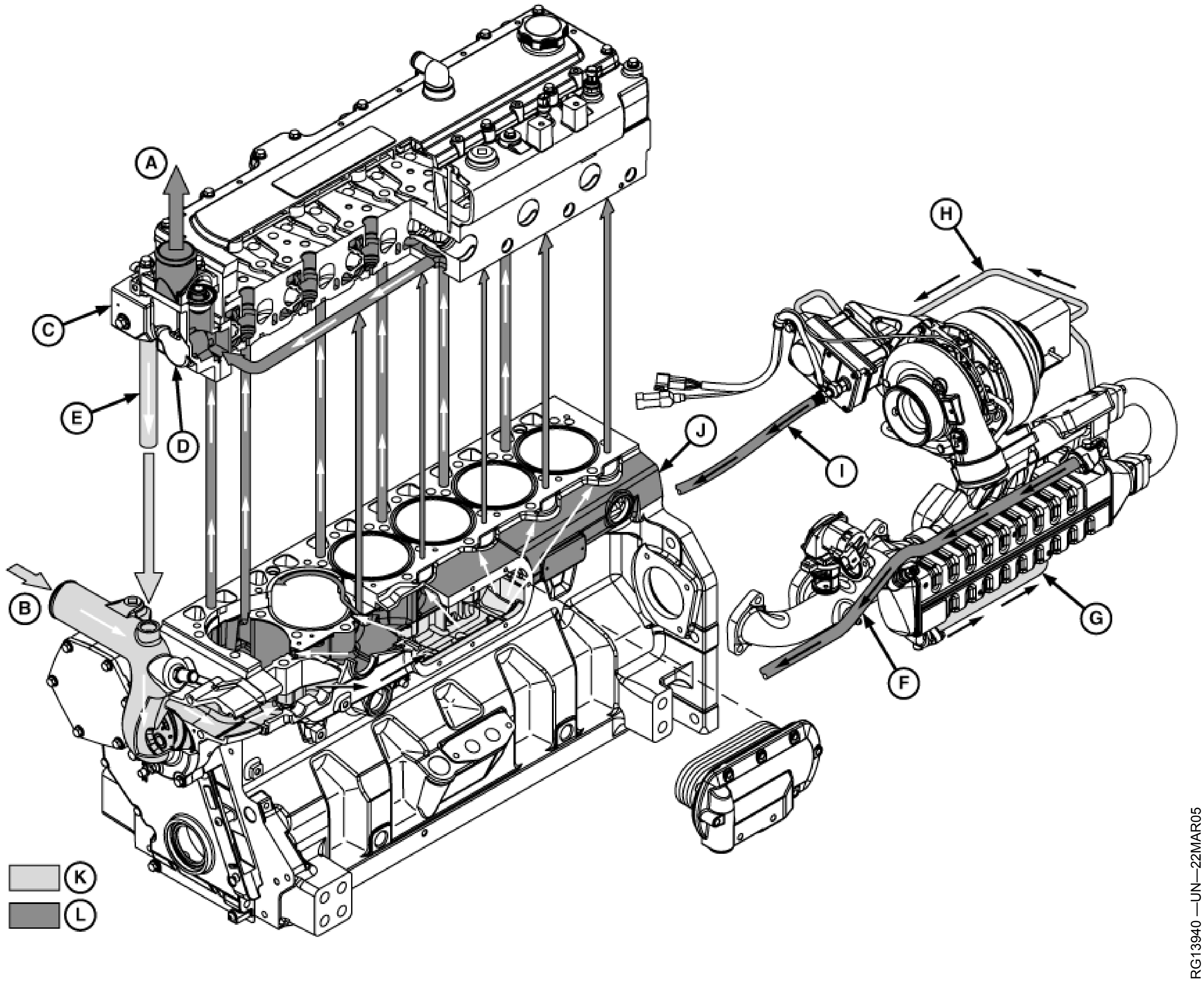
RG13823 —UN—16NOV04

Top Load Oil Filter Valves

A—Drain Valve
B—Inlet Valve
C—Bypass Valve

RE38635,000006B -19-08SEP08-3/3

Cooling System Operation



9 L Cooling System

A—Coolant Return to Radiator
B—Coolant Inlet
C—Cylinder Head
D—Thermostat Housing
E—Coolant Bypass Tube
F—EGR Cooler Return Line
G—EGR Cooler Supply Line
H—Turbocharger Actuator Coolant Supply Line
I—Turbocharger Actuator Coolant Return Line
J—Main Cylinder Block Coolant Passage
K—Low Temperature Coolant
L—High Temperature Coolant

The pressurized cooling system consists of a conventional radiator, coolant pump, thermostats, thermostat housing, and cylinder block with coolant cavities.

The pump draws coolant from the bottom of the radiator and discharges it through the lower inlet manifold on the left-hand side of the engine block. The inlet directs coolant to the engine oil cooler and provides the cooling capability from the coolant flow around it. Coolant passes through the oil cooler cavity and enters the main cylinder block coolant passage. At this time, the coolant flow will move in one of several directions. Each cylinder is unitized and has a separate flow circuit.

The main coolant passage flows through a rectangular port and around the cylinder liner, then exits the block through a vertical passage into the right-hand side of the cylinder head.

A second circuit involves flowing coolant from the block coolant passage through a small vertical passage into the left-hand side of the cylinder head.

The third circuit is called the “directed cooling” system. Coolant flows through a small port and into a groove at the top of the cylinder liner. Coolant passes around groove in liner, and exits into the vertical passage of the main circuit, then into the right-hand side of the cylinder head.

Continued on next page RE38635,000006C -19-08SEP08-1/2

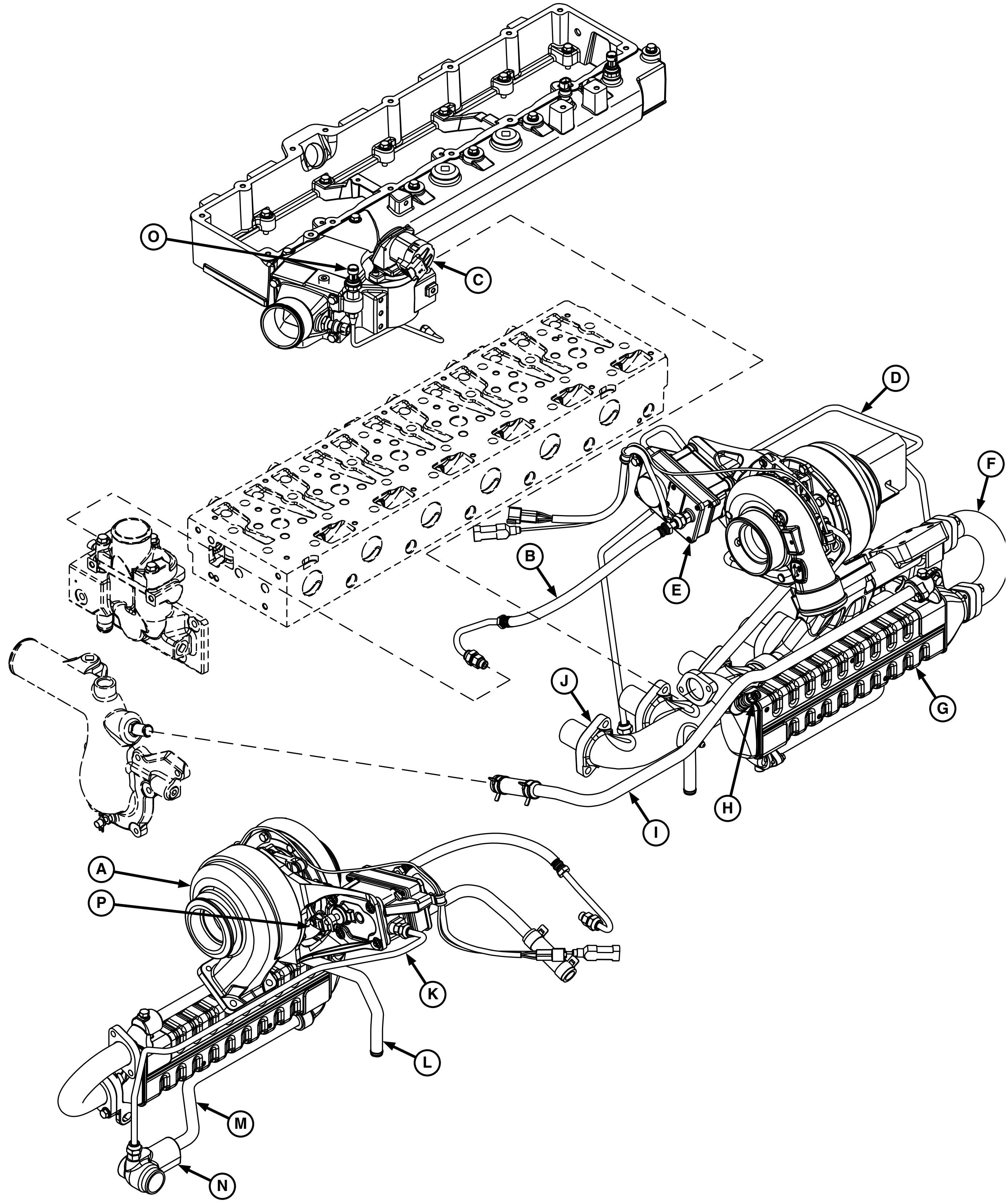
At the left rear (as looking from flywheel) of the cylinder block, mounted to the main cylinder block coolant passage, is an external coolant manifold. Coolant flows from the external manifold to the exhaust gas recirculator (EGR) cooler, and to the variable geometry turbocharger (VGT) actuator through external lines. Return coolant flows from the EGR cooler to the coolant pump, and VGT actuator return coolant flows to the thermostat housing, both through external lines.

Once the coolant is in the cylinder head, all flow is towards the front. Coolant passes into the thermostat housing, past the two open thermostats (engine at normal operating temperature), and then returns to the radiator.

If the thermostats are closed (as during warm-up periods), coolant is directed back to the pump through the bypass tube to be recirculated. This provides a faster and more uniform warm-up. Some coolant is passing through the bypass tube even while the thermostats are open.

RE38635,000006C -19-08SEP08-2/2

Exhaust Gas Recirculator (EGR) and Variable Geometry Turbocharger (VGT)



Continued on next page RE38635,0000070 -19-25APR06-1/2

A—Variable Geometry Turbocharger (VGT)
B—Turbocharger Actuator Coolant Return Line
C—Exhaust Gas Recirculator (EGR) Valve
D—Turbocharger Oil Supply Line
E—VGT Electronic Actuator
F—EGR Tube - Exhaust Manifold to Cooler
G—EGR Cooler
H—Exhaust Gas Temperature Sensor
I— EGR Cooler - Coolant Return Line
J—Exhaust Manifold
K—VGT Electronic Actuator Coolant Supply Line
L—Turbocharger Oil Drain Line
M—EGR Cooler - Coolant Supply Line
N—Coolant Manifold
O—Exhaust Pressure Sensor
P—VGT Actuator Linkage

Design features new to the air system of Tier 3 / Stage IIIA PowerTech Plus engine include Exhaust Gas Recirculation (EGR) and the Variable Geometry Turbocharger (VGT). The EGR and VGT are common features in all T3 John Deere PowerTech Plus engines.

The EGR and VGT are both performance and emissions control features. The VG turbocharger has adjustable vanes in the exhaust turbine housing. These vanes, controlled by a water-cooled electronic actuator, open or close to direct and recirculate exhaust gases. The gases then pass through a cooler which is bolted to the exhaust manifold. After cooling, the exhaust gases are mixed with intake air by the EGR valve, located in the intake manifold. The engine control unit (ECU controls the quantity of exhaust gas to be mixed with intake air for combustion. Under full load conditions, as much as 10-12% of the intake air is recirculated exhaust gases. The recirculating of cooled exhaust gases allows the 9.0 L engine to run with higher boost pressures. This increases power output of the engine and reduces emissions released to the atmosphere.

The VGT has foils, or vanes, located on pins on the outside diameter of the turbine wheel. These vanes are adjustable, which allows exhaust gas pressure to be increased or decreased based on engine load demand and speed. The Engine Control Unit (ECU) controls an electronic actuator that is a part of the turbocharger assembly. The actuator, in turn, adjusts the vanes to ensure proper exhaust pressures for the correct amount of EGR/fresh air mixing. The actuator is cooled by engine coolant, plumbed from the engine water manifold to the actuator, and returned to the thermostat housing. The variable output capability of the VGT provides the ability to increase low speed torque, provide a quicker transient response, and increase peak torque while also improving fuel economy.

As engine speed and load demands increase, the ECU signals the VGT actuator to close the vanes on the turbine wheel. This drives exhaust gas pressures and velocities upward, which in turn increases engine boost. The increase in boost pressures limits smoke and reduces emission particulates released to the atmosphere.

The exhaust gases are transmitted from the VGT to an exhaust gas cooler. The cooler is bolted to the exhaust manifold with a two-bolt flange. This cooler operates much like a radiator or charge air cooler, in that it has internal fins, which, using engine coolant routed directly from the water manifold, cools the exhaust gases. The cooler is a counterflow design, meaning engine coolant flows in the opposite direction as the exhaust gases. After engine coolant flows through the cooler, it is returned to the engine coolant manifold. The exhaust gases enter the cooler at approximately 600° C and exit at approximately 200° C.

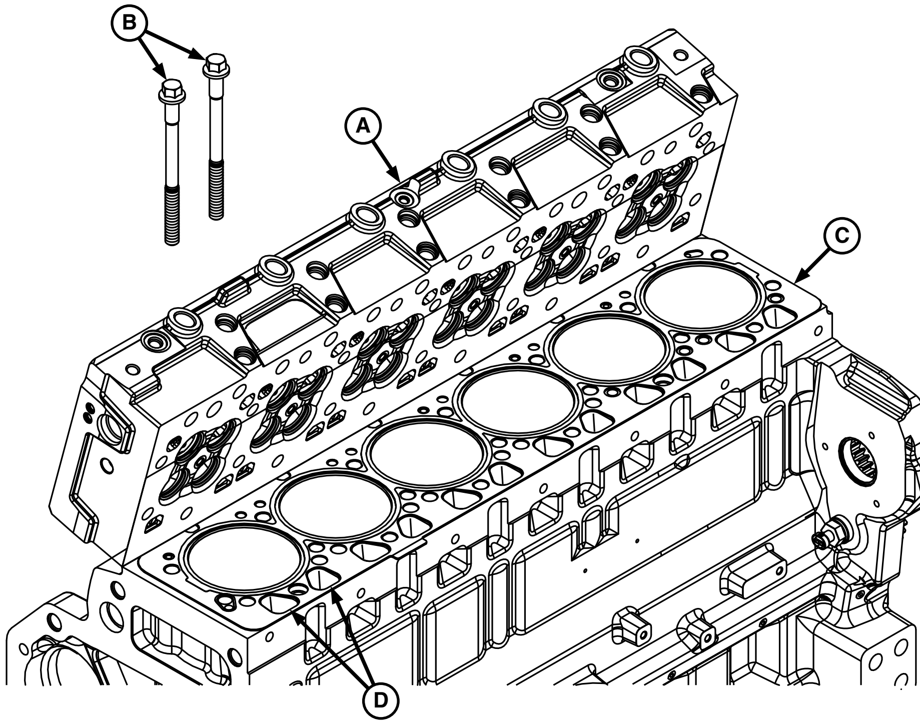
The cooled exhaust gas passes through an EGR Valve, which is a part of the intake manifold assembly. The function of the EGR valve, controlled by the engine ECU, is to mix given volumes of exhaust gases with the intake air. This mixture of exhaust gases and intake air serves two purposes: (1). It was already noted the VGT increases engine boost as the vanes close. This, in conjunction with the EGR, allows more air to be introduced into the combustion chamber. This in turn allows more fuel to be introduced to the combustion process, driving power levels upward. (2). Diluting the intake air with as much as 10-12% exhaust gases (full load conditions) aids in controlling NOX emissions released into the atmosphere following combustion.

The EGR valve is functional only when the engine is under load and the coolant is at operating temperature. At startup, when engine coolant is cold, and under no-to-light load conditions, the valve remains closed, and exhaust gases exit out the stack. When engine load and/or speed demands reach a predetermined level, the ECU signals the EGR valve to open. The valve then mixes the proper amount of cooled exhaust gas with the cooled intake air and releases this mixture to the intake manifold for combustion. Exhaust gases not mixed with intake air are recirculated and mixed a second time.

The EGR function, exhaust and intake manifolds, and VGT are monitored closely by several sensors. The sensors are monitored by the ECU, and fault codes will be generated if conditions are outside of design guidelines. Sensors include: exhaust gas temperature, charge air temperature, mixed air (intake and exhaust) temperature, manifold air pressure intake, manifold air pressure exhaust

RE38635,0000070 -19-25APR06-2/2

Head Gasket Joint Construction and Operation



Cylinder Head Gasket Joint

A—Cylinder Head **B—Cylinder Head Cap Screws** **C—Head Gasket** **D—Push Rod Openings**

The head gasket joint consist of:

- Cylinder head gasket
- Cylinder head
- Cylinder block
- Cylinder liners
- Cylinder head cap screws

The head gasket must form an air-tight seal between cylinder liners and cylinder head that can withstand the temperatures and pressures of the combustion process. The gasket must also form a liquid-tight seal between the cylinder head and cylinder block to retain coolant and oil in their respective passages. The gasket is constructed of thin, formed sheets of steel-inserted, non-asbestos material. The surface of gasket is treated to improve liquid sealing and anti-stick characteristics. A fire ring combustion seal is located at each cylinder bore and is held in place by a U-shaped stainless steel flange.

The cylinder head and block must be flat to provide an even clamping pressure over the entire surface of gasket, and must have the proper surface finish to keep gasket material from moving in the joint. Dowels are used to properly locate head gasket and cylinder head on block.

The cylinder liners must protrude evenly from top of cylinder block the specified amount to provide adequate clamping force on fire ring of each cylinder.

The cap screws must be proper length, made of proper material, and be tightened to proper torque in order to provide an adequate clamp load between other joint components. All cylinder head bolts are equal length on the 9 L engine.

Each of the above components contributes to the integrity of the head gasket joint. If any of these components do not conform to specifications, gasket joint may fail resulting in combustion leaks, coolant leaks, or oil leaks.

Operating conditions such as coolant, oil, and combustion temperatures, and combustion pressures can reduce the ability of the head gasket joint to function properly. Failure of head gasket and mating parts may occur when coolant and oil temperatures become excessive, or when abnormally high combustion temperatures and pressures exist.

RE38635,000006D -19-27MAR09-1/1

Air Intake and Exhaust System Operation

Engine suction draws dust-laden outside air through an air inlet stack into the air cleaner. Air is filtered through dry-type primary and secondary (safety) filter elements in the air cleaner canister. Clean air travels through the air intake hose to the turbocharger and intake manifold to the engine.

Exhaust, as it is expelled out the exhaust elbow, drives the turbocharger to deliver a larger quantity of air to meet the engine requirements than what could be delivered under naturally aspirated (non-turbocharged) conditions.

The 6090 engine features a Variable Geometry Turbocharger (VGT). An electronically controlled and liquid cooled actuator is a part of the turbocharger assembly. The VGT features moveable vanes in the exhaust turbine housing, which, controlled by the Engine Control Unit (ECU) through the actuator, routes exhaust gases through a cooler and Exhaust Gas Recirculator (EGR). The EGR valve, also controlled by the ECU, mixes cooled exhaust gas with cooled intake air as engine load demands increase. This mixing of exhaust and intake air drives boost pressures upward (increased power) and reduces emissions released to the atmosphere. The mix of intake and exhaust gases is inoperable when the engine is at no or low load conditions or is not at operating temperatures.

On air-to-air aftercooled engines (6090H), the turbocharger compressor discharge air is routed through a heat exchanger (located in front of radiator) before it enters the engine. The heat exchanger uses no liquid coolant but relies on air flow to cool the charge air.

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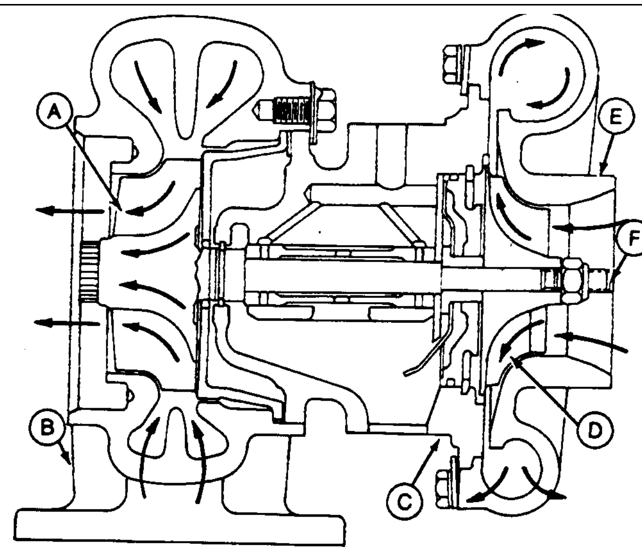
Turbocharger Operation



The turbocharger, which is basically an air pump that is driven by exhaust gases, allows the engine to produce added power without increasing displacement. Turbochargers are precisely matched to meet performance and emission requirements of each specific application.

Exhaust gases from the engine pass through the turbine housing (B) causing the turbine wheel (A) to rotate before the exhaust gas is discharged to the atmosphere. The turbine wheels mounted on a shaft (F) to drive the compressor wheel (D) which is also mounted on the shaft.

As the compressor wheel rotates in the compressor housing (E), an increased volume of (compressed) inlet air is drawn into the housing and delivered to the intake manifold (through an aftercooler or heat exchanger, if so equipped). All rotating components of the turbocharger are lubricated within the center housing (C).

A—Turbine Wheel
B—Turbine Housing
C—Center Housing
D—Compressor Wheel
E—Compressor Housing
F—Shaft

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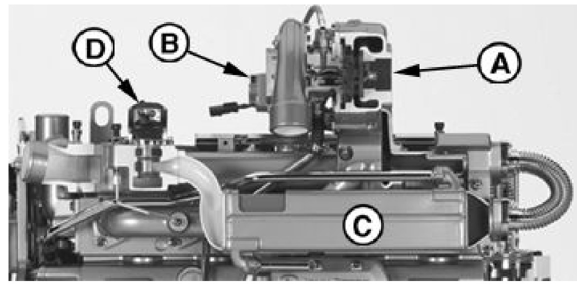
RE38635,000006F -19-21FEB05-1/2

The 6090 engine features a Variable Geometry Turbocharger (VGT) (A). An electronically controlled and liquid cooled actuator is a part of the turbocharger assembly. The VGT features moveable vanes (E) in the exhaust turbine housing, which, controlled by the Engine Control Unit (ECU) through the turbocharger actuator (B), routes exhaust gases through an Exhaust Gas Recirculator (EGR) cooler (C). The EGR valve (D), also controlled by the ECU, is located on the intake manifold and mixes cooled exhaust gas with cooled intake air as engine load demands increase. This mixing of exhaust and intake air drives boost pressures upward (increased power) and reduces emissions released to the atmosphere. The EGR is inoperable when the engine is at no or low load conditions or is not at operating temperatures.



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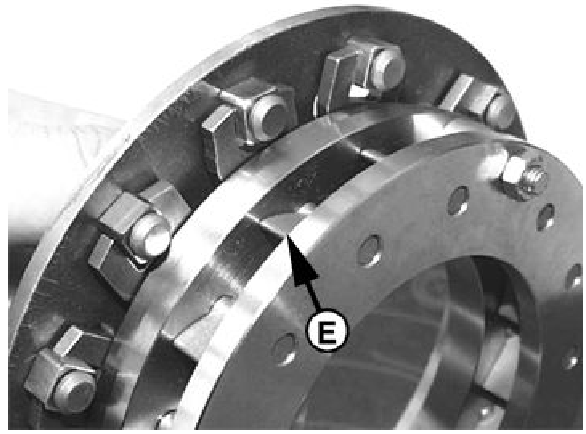
EGR & VGT



RG13765 —UN—28MAY05

VGT Adjustable Vanes

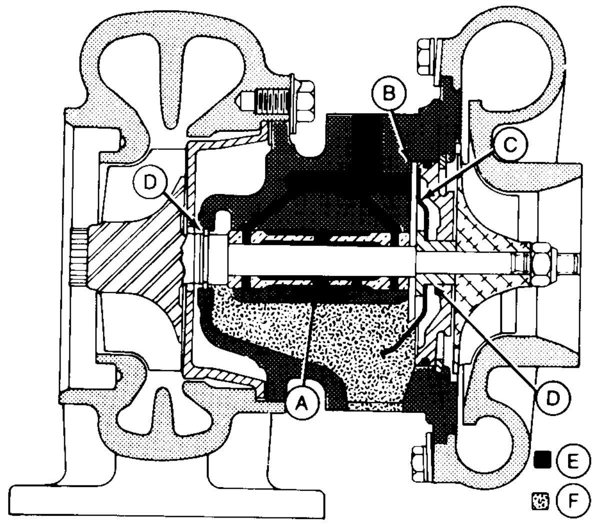
A—Variable Geometry Turbocharger (VGT)
B—VGT Actuator
C—Exhaust Gas Recirculator (EGR) Cooler
D—EGR Valve
E—VGT Adjustable Vanes

RE38635,000006F -19-21FEB05-2/2

How the Turbocharger is Lubricated

Engine oil under pressure from the engine lubrication system is pumped through a passage in the bearing housing and directed to the bearing (A), thrust plate (B), and thrust sleeve (C). Oil is sealed from the compressor and turbine by a piston ring (D) at both ends of bearing housing.

The turbocharger contains a single floating bearing. This bearing has clearance between the bearing OD and the housing wall as well as clearance between the bearing ID and the shaft OD. These clearances are lubricated by the oil supply and the bearings are protected by a cushion of oil. Discharge oil drains by gravity from the bearing housing to the engine crankcase.



RG4646 —UN—29AUG94

A—Bearing
B—Thrust Plate
C—Thrust Sleeve
D—Piston Ring
E—Pressure Oil
F—Discharge Oil

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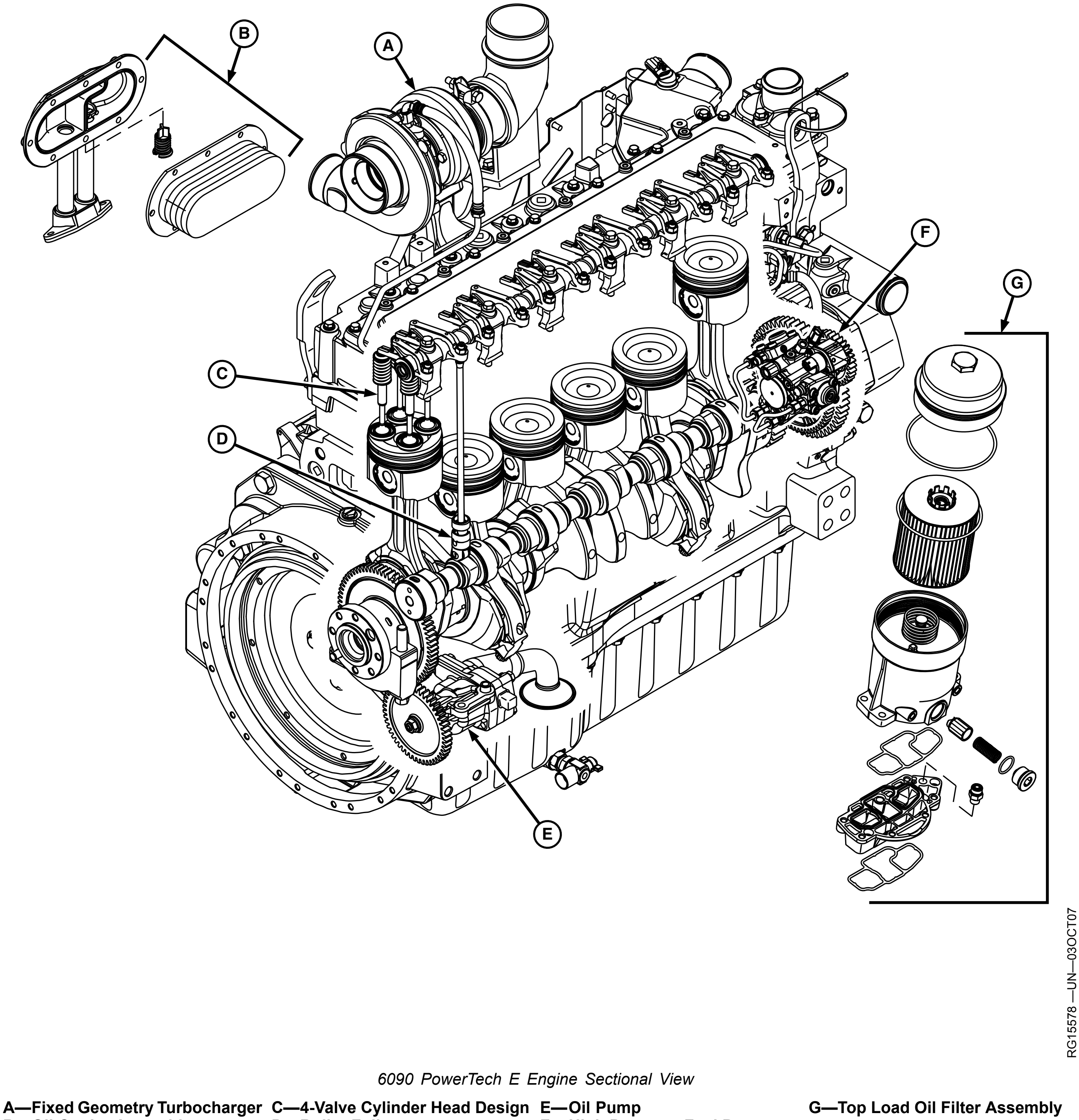
Engine Sectional View Serial Number



6090 PowerTech E Engine Sectional View

A—Fixed Geometry Turbocharger
B—Oil Cooler Assembly
C—4-Valve Cylinder Head Design
D—Roller Followers
E—Oil Pump
F—High Pressure Fuel Pump
G—Top Load Oil Filter Assembly

RE38635,00000CC -19-08OCT07-1/1

General Engine Operation

The Tier 3 /Stage IIIA, 9.0 L PowerTech E engine, John Deere meets performance and emissions requirements along with maintaining the exceptional durability, reliability, and fuel economy. The PowerTech E engine is similar to the PowerTech Plus engine, except the turbocharger is a fixed geometry design, and there is no recirculation of exhaust gases as with PowerTech Plus. PowerTech E engines feature:

- Four-valve cylinder head
- Common length cylinder head bolts
- Common size intake & exhaust valves
- Larger bore (thinner wall liners) and longer stroke (crankshaft/rod/piston revisions) to achieve 9.0 L displacement
- Fixed geometry turbocharger (VGT)
- Higher pressure fuel system
- Full-authority electronic controls
- New engine control unit (ECU)
- Targeted spray oil cooled pistons
- Roller camshaft followers
- Metric hardware (except cylinder head bolts, bearing cap bolts, auxiliary drive hardware, and oil filter base mounting hardware

The PowerTech E engines will deliver horsepower and performance ratings, peak torque levels, fuel economy, and cold weather starting that are comparable, or better than, the Tier II 8.1 L engine.

All 6090 Engines are vertical stroke, in-line, 4 valve-in-head, turbocharged and air to air intercooled 6-cylinder diesel engines.

Direct fuel injection is provided by a high pressure fuel pump and high pressure common rail. The pump for the 9.0 L engine delivers fuel at a higher pressure than the 8.1 L (23,000 psi versus 18,000 psi), and the common rail on the 9.0 L is a welded rail design. The pump is driven by an intermediate gear in the timing gear train meshing with the camshaft gear. Roller cam followers, which ride on the camshaft lobes, drive push rods to the 4 valve actuation. Valve bridges similar to those used on the 12.5 L engine are used to actuate the valves. As in the PowerTech Plus engine, the 9 L E engine design utilizes identically sized intake and exhaust valves. Vertically mounted electronic injectors deliver fuel monitored by the engine control unit at pressures exceeding those on previous Tier II 8.1 L engines.

The turbocharger compressor (intake) discharge air is cooled by routing it through a heat exchanger before it enters the intake manifold. This heat exchanger uses no liquid coolant, but relies on air flow from the radiator fan blast to cool the charge air.

The camshaft is machined from chilled iron. The cam lobes are individually flame hardened to provide excellent wear characteristics. Additional journals are included on the 9 L camshaft for increased strength. Roller followers are adopted for 9 L for improved valve events with the four valve design. The front timing gear train consists of high contact ratio spur gears, allowing for two gear teeth contact at all times. The camshaft gear features raised ridges for speed sensor operation.

Roller cam followers, push rods, and rocker arm assembly operate the intake and exhaust valves. Valve bridges enable simultaneous valve actuation. The rocker arm shaft for 9 L E is a one piece design, same as on the 9 L PowerTech Plus engine. The four valves are identical size on the 9 L engine. Stainless steel exhaust valves withstand increased exhaust temperatures. Intake and exhaust valves are marked for visual identification. Intake and exhaust valve stem seals are part of the valve assembly.

The crankshaft is a one-piece, heat treated, dynamically balanced steel forging which rotates in replaceable two-piece main bearings. Larger connecting rod journals aid in withstanding higher firing pressures. The main thrust bearing is a two piece design and has a flange on each side to reduce crankshaft deflection and to limit end play during high load operation.

Cylinder liners are of a wet sleeve, flanged, and centrifugally cast design. O-ring type packings are used to seal the connection between cylinder block and liners. Liners are induction hardened and can be individually replaced (as a matched piston and liner set).

Pistons are machined from a steel forging (to withstand higher firing pressures) and have a three-ring configuration. The top two rings are compression rings, and the lower ring is an oil control ring.

The highly polished, hardened piston pins are fully-floating and held in position by means of snap rings. New piston spray jets (piston cooling orifices) in cylinder block direct pressured oil to a galley in the undercrown of the piston, providing directed cooling to the piston, necessary to withstand the higher firing pressures.

Connecting rods are of forged steel and have replaceable bushing and bearing inserts. They are weight controlled (by machining) on both ends to minimize engine vibration. The rods have the non-machined, Precision Joint™ rod and cap.

The engine is supplied with lubricating oil by a spur gear pump driven off the rear of the crankshaft. Oil is conditioned by a top load full-flow filter located on the right side of the engine. Oil temperature is limited by an oil cooler located on left side of engine. Individual oil cooler and oil filter bypass valves protect the system and insure engine lubrication during times of high restriction; such as cold starts. Oil pressure is controlled by a pressure regulating valve located before the main oil gallery.

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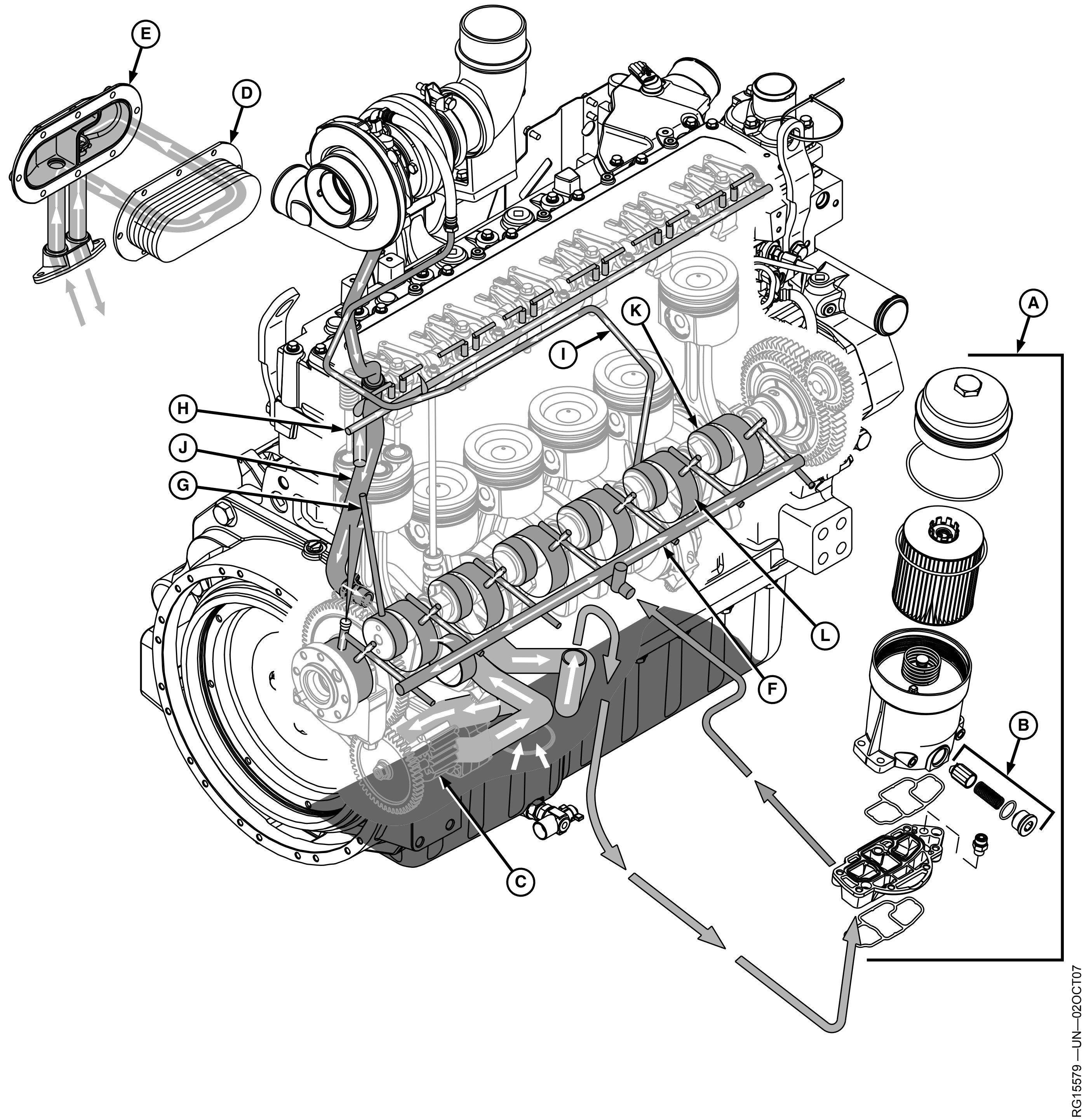
Lubrication System Operation

Lubrication System



9 L PowerTech E Lubrication System

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RE38635,00000CE -19-08OCT07-1/3

A—Top Load Oil Filter
B—Oil Pressure Regulating Valve
C—Oil Pump
D—Oil Cooler
E—Oil Cooler Cover
F—Main Engine Oil Galley
G—Oil Passage to Cylinder Head
H—Oil Passage to Valve Actuation
I— Turbocharger Oil Supply
J— Turbocharger Oil Drain
K—Camshaft Journals
L—Crankshaft Main Bearing Journals

The engine lubrication system consists of a crank-driven oil pump (C), oil cooler (D), top load oil filter assembly (A - see more detailed description later in this section), and oil pressure regulating valve (B).

Oil is drawn up from the sump through the oil pump and on to the oil cooler by way of the oil cooler cover which houses the oil cooler bypass valve. Oil proceeds through the oil cooler where it exchanges heat with the engine coolant, unless high restriction is sensed in which case the oil cooler is bypassed. Oil goes to the top load oil filter (A). Oil passes through the oil filter, unless high restriction is sensed in which case the oil filter is bypassed.

The oil pressure regulating valve (B) regulates the main oil gallery (F) pressure and permits excess oil to be returned to the sump. After flowing past the regulating valve, cooled, clean pressurized oil is supplied to the main oil gallery then distributed to the crankshaft main bearings (L), and piston cooling orifices through drilled passages in the cylinder block.

The piston cooling orifices are designed to direct oil through a cored passage in the underside of the piston. This oil flow both cools the piston and lubricates the piston pin. Higher firing pressures on the 9 L require additional piston cooling.

Oil flows from the crankshaft main bearings to the six camshaft bushings (K) while passages in the crankshaft also allow pressurized oil to lubricate the connecting rod bearings.

Oil from the front camshaft bushing travels through drilled passages in the camshaft nose to lubricate the camshaft thrust washers (not shown) and front gear drive train.

Oil from the rear camshaft bushing feeds through drilled passages (G) in the cylinder block and cylinder head into passages in the rocker arm assemblies (H) which lubricate the rocker arms, which in turn provide oil to the other valve train components as well as the roller camshaft followers.

Clean oil is also routed from the top of the oil filter base through an external line (I) to the turbocharger, where the shaft bearing is cooled, and is returned to the cylinder block crankcase through another external line and hose (J).

The fuel injection pump is pressure lubricated by way of an external line (not shown) which taps into the main oil gallery.

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RE38635,00000CE -19-08OCT07-2/3

Top Load Oil Filter

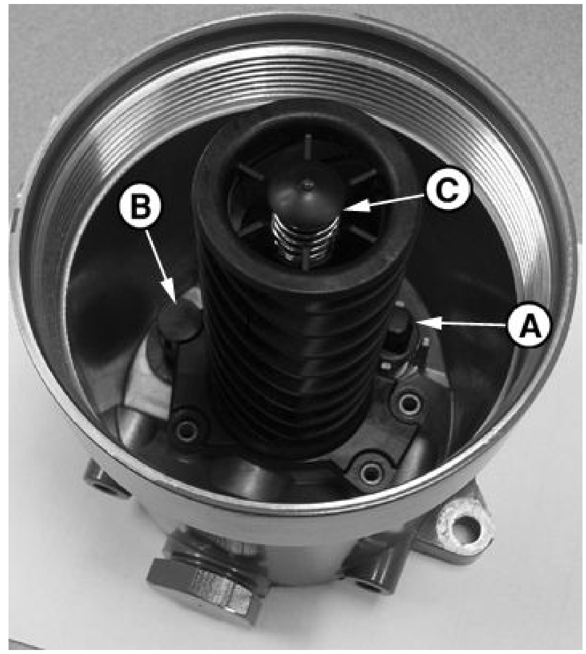
The top load oil filter assembly derives its name from the way the filter element "top loads" into the filter canister. The design is such that the filter element can be changed without the typical oil spill resulting from removal of the filter canister from the filter base. With the top load design, the filter canister remains on the filter base. Valves inside the filter canister regulate oil flow into the filter canister, pressure, and dump to sump when the filter element is changed.

When the filter element is in place and the system thus "closed", the pressure of the filter element keeps the return to sump valve (A) pressed downward, and thus closed. This prevents pressurized oil from being dumped back to sump prior to being filtered. If this valve is missing or not closed, low oil pressure will result.

Pressurized oil from the oil pump opens the inlet valve (B). This allows dirty, unfiltered oil from the sump to fill the canister and flow through the filter element. When the engine is turned off, this valve closes due to pressure from the oil within the canister, thus keeping the filter full of oil for the next start.

The bypass valve (C) protects the engine when the filter element becomes plugged, allowing unfiltered oil to reach engine components via the oil galley until the filter element can be changed.

When the oil filter element is removed for service replacement, pressure on the dump valve (A) is released, allowing oil in the canister to drain back to sump.



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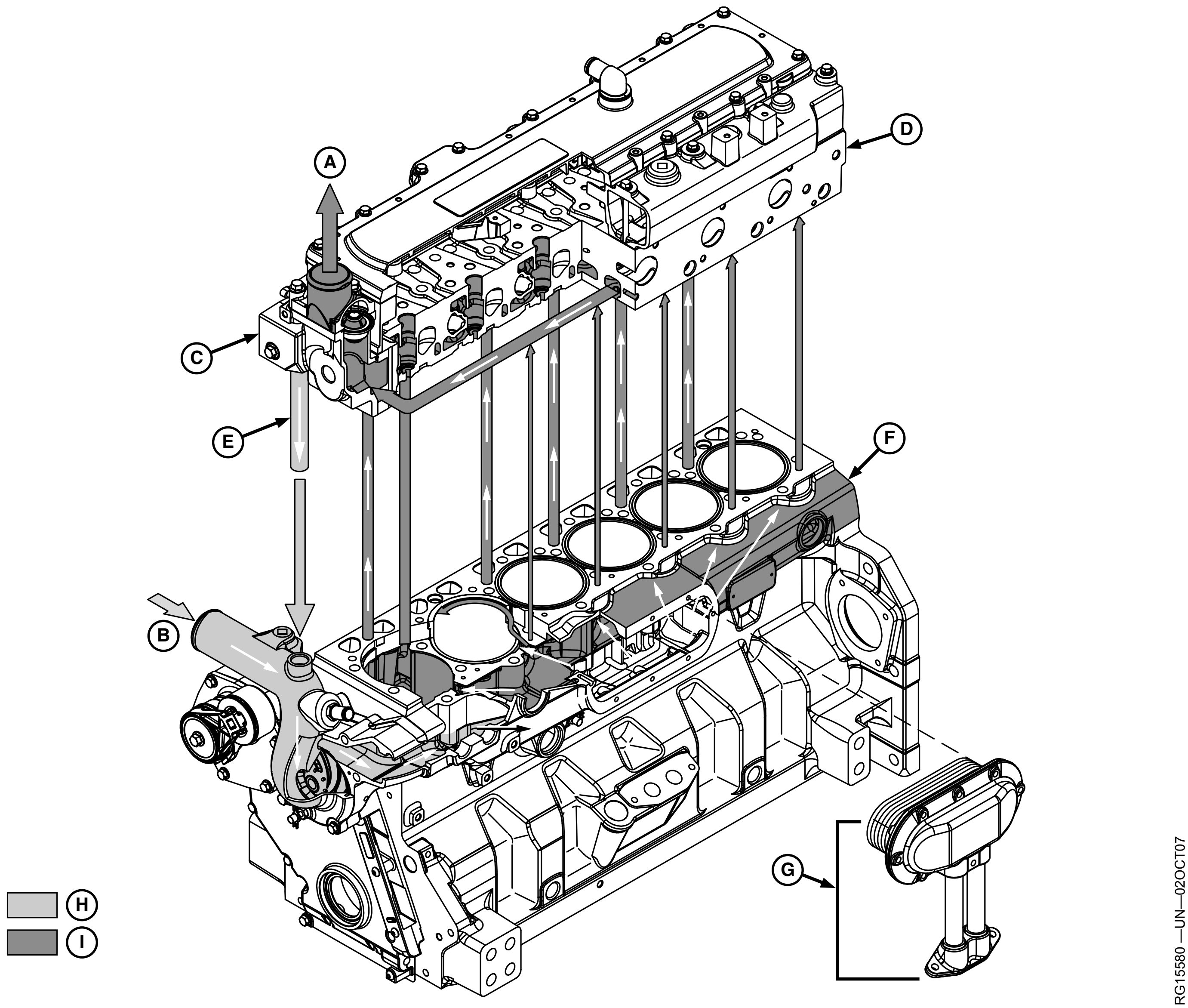
Top Load Oil Filter Valves

A—Drain Valve
B—Inlet Valve
C—Bypass Valve

RE38635,00000CE -19-08OCT07-3/3

Cooling System Operation



9 L PowerTech E Cooling System

A—Coolant Return to Radiator
B—Coolant Inlet
C—Thermostat Housing
D—Cylinder Head
E—Coolant Bypass Tube
F—Cylinder Block Main Coolant Passage
G—Oil Cooler
H—Low Temperature Coolant
I— High Temperature Coolant

The pressurized cooling system consists of a conventional radiator, coolant pump, thermostats, thermostat housing, and cylinder block with coolant cavities.

The pump draws coolant from the bottom of the radiator and discharges it through the lower inlet manifold on the left-hand side of the engine block. The inlet directs coolant to the engine oil cooler and provides the cooling capability from the coolant flow around it. Coolant passes through the oil cooler cavity and enters the main cylinder block coolant passage. At this time, the coolant flow will move in one of several directions. Each cylinder is unitized and has a separate flow circuit.

The main coolant passage flows through a rectangular port and around the cylinder liner, then exits the block through a vertical passage into the right-hand side of the cylinder head.

A second circuit involves flowing coolant from the block coolant passage through a small vertical passage into the left-hand side of the cylinder head.

The third circuit is called the “directed cooling” system. Coolant flows through a small port and into a groove at the top of the cylinder liner. Coolant passes around groove in liner, and exits into the vertical passage of the main circuit, then into the right-hand side of the cylinder head.

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RE38635,00000CF -19-01OCT07-1/2

Once the coolant is in the cylinder head, all flow is towards the front. Coolant passes into the thermostat housing, past the two open thermostats (engine at normal operating temperature), and then returns to the radiator.

If the thermostats are closed (as during warm-up periods), coolant is directed back to the pump through the bypass tube to be recirculated. This provides a faster and more uniform warm-up. Some coolant is passing through the bypass tube even while the thermostats are open.

RE38635,00000CF -19-01OCT07-2/2

Air Intake and Exhaust System Operation

Engine suction draws dust-laden outside air through an air inlet stack into the air cleaner. Air is filtered through dry-type primary and secondary (safety) filter elements in the air cleaner canister. Clean air travels through the air intake hose to the turbocharger and intake manifold to the engine.

Exhaust, as it is expelled out the exhaust elbow, drives the turbocharger to deliver a larger quantity of air to meet the engine requirements than what could be delivered under naturally aspirated (non-turbocharged) conditions.

The 6090 PowerTech E engine features a conventional Fixed Geometry Turbocharger. Exhaust gases drive the turbine wheel of the turbocharger assembly, which in turn drives the compressor, or intake, side. The compressor discharge air is routed through a heat exchanger (charge air cooler), which cools the intake air. The air flows from the charge air cooler to the intake manifold. The cooler intake air allows a greater volume of air to flow into cylinders for increasing horsepower demands. With the additional air, a greater amount of fuel can be injected into the cylinder as loads demand, thus increasing horsepower levels.

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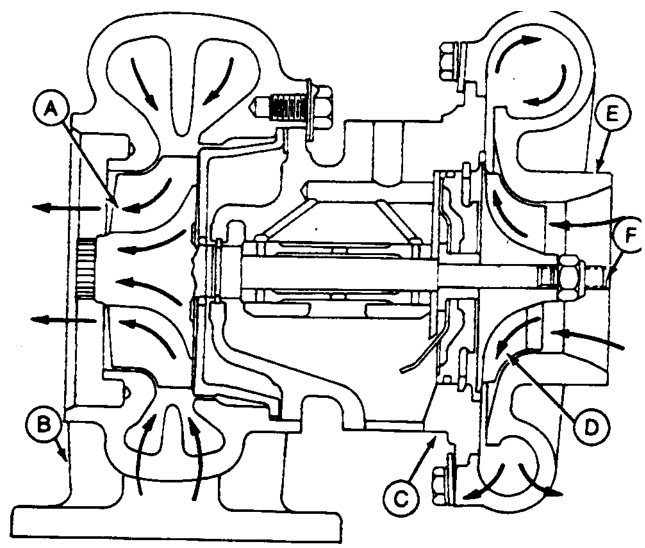
Turbocharger Operation



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The turbocharger, which is basically an air pump that is driven by exhaust gases, allows the engine to produce added power without increasing displacement. Turbochargers are precisely matched to meet performance and emission requirements of each specific application.

Exhaust gases from the engine pass through the turbine housing (B) causing the turbine wheel (A) to rotate before the exhaust gas is discharged to the atmosphere. The turbine wheels mounted on a shaft (F) to drive the compressor wheel (D) which is also mounted on the shaft.

As the compressor wheel rotates in the compressor housing (E), an increased volume of (compressed) inlet air is drawn into the housing and delivered to the intake manifold (through a charge air cooler, or heat exchanger). All rotating components of the turbocharger are lubricated within the center housing (C).

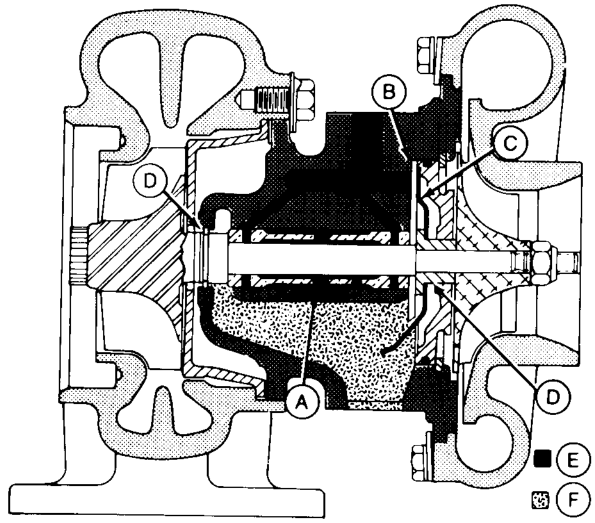
A—Turbine Wheel
B—Turbine Housing
C—Center Housing
D—Compressor Wheel
E—Compressor Housing
F—Shaft

RE38635,00000D1 -19-08OCT07-1/1

How the Turbocharger is Lubricated

Engine oil under pressure from the engine lubrication system is pumped through a passage in the bearing housing and directed to the bearing (A), thrust plate (B), and thrust sleeve (C). Oil is sealed from the compressor and turbine by a piston ring (D) at both ends of bearing housing.

The turbocharger contains a single floating bearing. This bearing has clearance between the bearing OD and the housing wall as well as clearance between the bearing ID and the shaft OD. These clearances are lubricated by the oil supply and the bearings are protected by a cushion of oil. Discharge oil drains by gravity from the bearing housing to the engine crankcase.

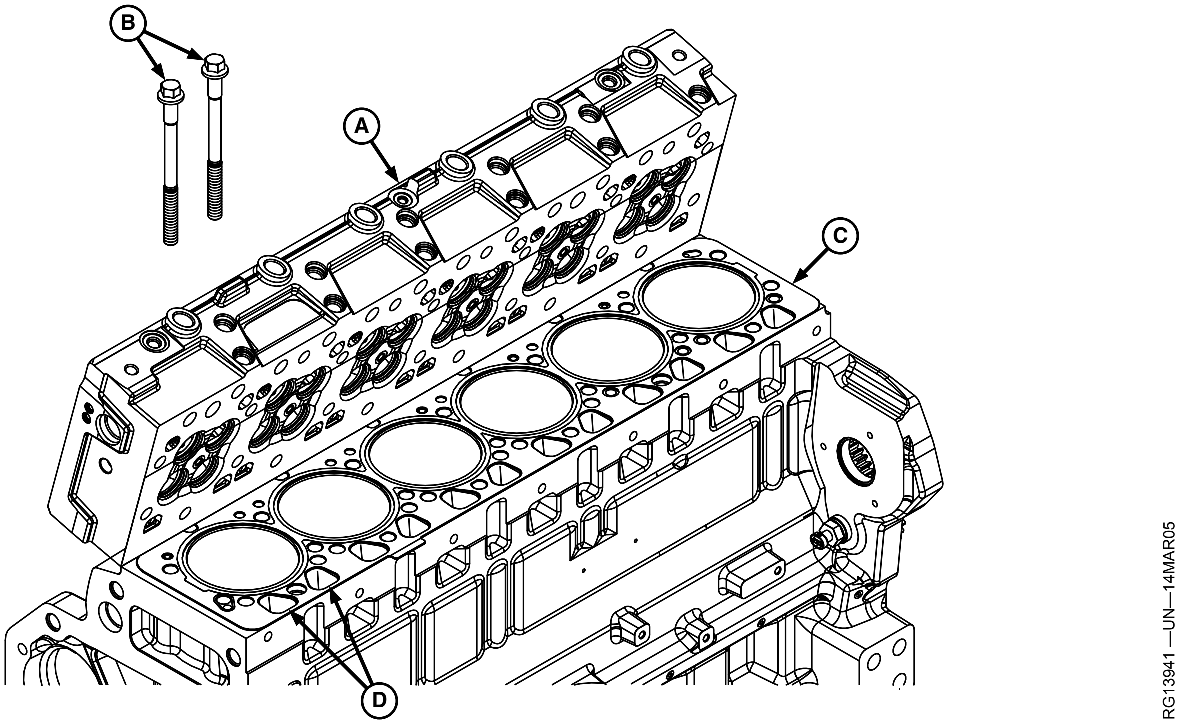


RG4646 —UN—29AUG94

A—Bearing
B—Thrust Plate
C—Thrust Sleeve
D—Piston Ring
E—Pressure Oil
F—Discharge Oil

RG,CTM61,G110,5 -19-27MAR09-1/1

Head Gasket Joint Construction and Operation



Cylinder Head Gasket Joint

A—Cylinder Head **B—Cylinder Head Cap Screws** **C—Head Gasket** **D—Push Rod Openings**

The head gasket joint consist of:

- Cylinder head gasket
- Cylinder head
- Cylinder block
- Cylinder liners
- Cylinder head cap screws

The head gasket must form an air-tight seal between cylinder liners and cylinder head that can withstand the temperatures and pressures of the combustion process. The gasket must also form a liquid-tight seal between the cylinder head and cylinder block to retain coolant and oil in their respective passages. The gasket is constructed of thin, formed sheets of steel-inserted, non-asbestos material. The surface of gasket is treated to improve liquid sealing and anti-stick characteristics. A fire ring combustion seal is located at each cylinder bore and is held in place by a U-shaped stainless steel flange.

The cylinder head and block must be flat to provide an even clamping pressure over the entire surface of gasket, and must have the proper surface finish to keep gasket material from moving in the joint. Dowels are used to properly locate head gasket and cylinder head on block.

The cylinder liners must protrude evenly from top of cylinder block the specified amount to provide adequate clamping force on fire ring of each cylinder.

The cap screws must be proper length, made of proper material, and be tightened to proper torque in order to provide an adequate clamp load between other joint components. All cylinder head bolts are equal length on the 9 L engine.

Each of the above components contributes to the integrity of the head gasket joint. If any of these components do not conform to specifications, gasket joint may fail resulting in combustion leaks, coolant leaks, or oil leaks.

Operating conditions such as coolant, oil, and combustion temperatures, and combustion pressures can reduce the ability of the head gasket joint to function properly. Failure of head gasket and mating parts may occur when coolant and oil temperatures become excessive, or when abnormally high combustion temperatures and pressures exist.

RE38635,000006D -19-27MAR09-1/1

Section 04
Diagnostics

Contents

About This Group of the Manual

This section of the manual contains necessary information to diagnose some base engine, all lubrication system, and all cooling system problems. This section is divided into two areas: diagnosing malfunctions and testing procedures. The diagnostic malfunctions area is further divided into the following headings, containing the following systems:

- **(L)** Diagnosing Lubrication System Malfunctions:
  - L1 - Excessive Oil Consumption
  - L2 - Engine Oil pressure Low
  - L3 - Engine Oil Pressure High
- **(C)** Diagnosing Cooling System Malfunctions
  - C1 - Engine Coolant Temperature Above Normal
  - C2 - Engine Coolant Temperature Below Normal
  - C3 - Coolant In Oil or Oil In Coolant

Procedures for diagnosing some of the above symptoms are formatted such that a test or repair is recommended, then based on the results another test or repair is recommended. Other symptoms are formatted in a symptom - problem - solution format. In these symptoms, the problems are arranged in the most likely or easiest to check problems first. Symptoms arranged in both formats refer to testing procedures in the second part of this section. The second part of this section of the manual contains the following testing procedures:

- Base Engine Testing Procedures:
  - Test Engine Compression Pressure
  - Check Engine Cranking Speed
- Lubrication System Testing Procedures:
  - Check Engine Oil Pressure
  - Check For Excessive Crankcase Pressure (Blow-by)
  - Check For Turbocharger Oil Seal Leak
- Cooling System Testing Procedures:
  - Inspect Thermostat And Test Opening Temperature
  - Pressure Test Cooling System And Radiator Cap
  - Pressure Test Exhaust Gas Recirculator (EGR) Cooler
  - Check For Head Gasket Failures
- Air Supply And Exhaust Systems Testing Procedures:
  - Measure Intake Manifold Pressure (Turbo Boost)
  - Check For Intake And Exhaust Restrictions
  - Test For Intake Air Leaks
  - Check For Exhaust Air Leaks

RE38635,00000B0 -19-07APR05-1/1

Excessive Oil Consumption

RE38635,000002B -19-27MAR10-1/7

9 L - L1 - Excessive Oil Consumption

Before using this diagnostic procedure:

Check for too low or too high engine oil level.

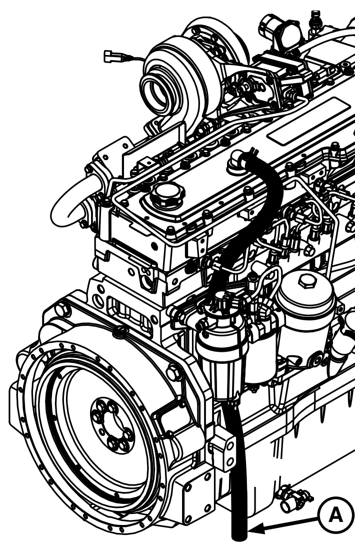
Check for too low viscosity, or coolant or fuel diluted engine oil.

Check for excessive external oil leaks.

RE38635,000002B -19-27MAR10-2/7

1 Oil In Coolant Check	Check the coolant for signs of oil.	**No oil found in coolant:** GO TO 2 **Oil found in coolant:** See Coolant in Oil or Oil in Coolant earlier in this Group.

RE38635,000002B -19-27MAR10-3/7

2 Crankcase Breather Tube Check	RG14156 —UN—18APR05 *Crankcase Breather Tube* A restricted crankcase breather tube (A) can cause excessive pressure to build up and force oil into the combustion chamber. Check the breather tube to make sure there is no blockage, no kinks, and no restrictions.	**Breather tube NOT restricted:** GO TO 3 **Restriction found in breather tube:** Remove restriction or replace breather tube and retest.

Continued on next page

RE38635,000002B -19-27MAR10-4/7

3 Excessive Crankcase Pressure Check	Check for excessive crankcase pressure. See Crankcase Pressure (Blow-by) Test in Section 4, Group 155.	**No fumes and no dripping oil observed:** GO TO 4 **Excessive fumes or dripping oil observed; appears to be caused by boost pressure:** Check the turbocharger, repair/replace as needed. See Turbocharger Failure Analysis in Section 02, Group 080 of this manual. **Excessive fumes or dripping oil observed; does NOT appear to be caused by boost pressure:** Excessive blow-by, not caused by boost pressure is most likely caused by faulty piston rings/cylinder liners not providing an adequate combustion seal. Perform a compression test to verify this is the case. See Mechanical Compression Test in Section 04, Group 155.

RE38635,000002B -19-27MAR10-5/7

4 Turbocharger Oil Seal Leak Check	Check for turbocharger oil seal leaks. See Turbocharger Oil Seal Leak Check in Section 04, Group 155.	**NO signs of oil leakage:** GO TO 5 **Signs of oil leakage present:** Investigate problems associated with oil leakage as outlined it the test procedure, perform necessary repairs, and retest.

Continued on next page

RE38635,000002B -19-27MAR10-6/7

5 Pistons, Rings, Cylinder Liners Check	At this point, the most likely cause of the excessive oil consumption is one of the following failures in the pistons, rings, and/or cylinder liners or in the valve guides. Check the most likely item as needed. • Oil control rings worn or broken • Scored cylinder liners or pistons • Piston ring grooves excessively worn • Piston rings sticking in ring grooves • Insufficient piston ring tension • Piston ring gaps not staggered • Cylinder liners glazed (insufficient load during engine break-in) • Worn valve guides or stems	**Problem found with pistons, rings, and/or liners or valve guides:** Repair problem as necessary.

RE38635,000002B -19-27MAR10-7/7

Engine Oil Consumption

All engines consume some oil. The consumption rate depends on loading, design of key parts and engine condition. Since fuel consumption is an indicator of operating power levels, fuel used versus oil consumed is a critical factor in analyzing oil consumption. Oil consumption should be measured over a 100-hour period.

Long-term oil consumption (three oil drain intervals after the engine is broken in) with consumption rates poorer than 400:1 (100 gallons of fuel and 1 quart of oil) indicates a need to monitor/investigate. Suggested steps would be:

- Check for signs of ingested dust or perform an OILSCAN® test to check for silicon.
- Check for proper crankcase oil fill level.
- Perform compression test to find low compression cylinders.
- Remove head and inspect for glazed or worn liners.
- Inspect pistons for carbon deposits in the ring land grooves.
- Measure valve stem OD and valve guide ID to determine clearance.

NOTE: Ring gap alignment does not identify the leak source.

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PLUS-50 is a registered trademark of Deere & Company

When changing to a premium oil such as TORQ-GARD SUPREME® PLUS-50®, little oil consumption change is expected, although a small percentage of engines may experience a noticeable change in consumption rates. This may be due to the following:

- The previous oil may have left deposits on internal components. Use of PLUS-50® oil will cause different chemical reactions in those deposits. The time required for the engine to regain the previous oil consumption rate will vary from one to three normal drain intervals.
- TORQ-GARD SUPREME® PLUS-50® contains a high-performance anti-oxidant along with other additives resulting in the oil remaining in the specified viscosity grade throughout the recommended drain interval. API oil grades CD, CE, and CF-4 universal engine oils do not provide this oxidation resistance which results in more rapid thickening. Increased oil viscosity can reduce oil consumption.

DPSG,OUO1004,114 -19-15MAY08-1/1

9.0L - L2 - Engine Oil Pressure Low

Symptom	Problem	Solution
9.0L - L2 - Engine Oil Pressure Low	Fuel in Oil, or High Oil Level	Diagnose leak in fuel system - leak path to crankcase.
	Low crankcase oil level	Fill crankcase to proper level.
	Incorrect oil	Drain crankcase and refill with proper grade and viscosity oil. See DIESEL ENGINE OIL in Section 01, Group 002 of this manual.
	Plugged oil filter	Change oil and oil filter
	Faulty or failed drain valve inside oil filter	Change oil filter
	Faulty oil pressure switch/sensor or oil pressure indicator light/gauge	Measure engine oil pressure with a mechanical gauge to verify pressure is low. See CHECK ENGINE OIL PRESSURE later in this Group.
	Excessive oil temperature	Remove and inspect engine oil cooler. See REMOVE, INSPECT, AND INSTALL ENGINE OIL COOLER in Section 02, Group 060 of this manual.
	Faulty oil pressure regulating valve	Remove and inspect engine oil pressure regulating valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060 of this manual.
	Plugged oil pump screen or cracked pick-up tube	Remove oil pan and clean screen. Replace oil intake (pick-up) tube. See REMOVE, INSPECT, AND INSTALL OIL PUMP PICKUP TUBE in Section 02, Group 060 of this manual.
	Faulty oil pump	Remove and inspect engine oil pump. See REMOVE ENGINE OIL PUMP and INSPECT AND CLEAN OIL PUMP in Section 02, Group 060 of this manual.
	Faulty or missing piston cooling orifice	Check piston cooling orifices.

Continued on next page

RE38635,0000070 -19-25OCT10-1/2

Symptom	Problem	Solution
	Excessive main or connecting rod bearing clearance	Determine bearing clearance. See CHECK MAIN BEARING OIL CLEARANCE in Section 02, Group 050 of this manual.
	Drain back valve in top load oil filter canister is out of position.	Remove top load oil filter element and check that the drain back valve is in proper position. See TOP LOAD OIL FILTER theory of operation in Section 03, Group 120 of this manual.

RE38635,0000070 -19-25OCT10-2/2

9.0L - L2 - Engine Oil Pressure Low

Symptom	Problem	Solution
9.0L - L2 - Engine Oil Pressure Low	Fuel in Oil, or High Oil Level	Diagnose leak in fuel system - leak path to crankcase.
	Low crankcase oil level	Fill crankcase to proper level.
	Incorrect oil	Drain crankcase and refill with proper grade and viscosity oil. See DIESEL ENGINE OIL in Section 01, Group 002 of this manual.
	Plugged oil filter	Change oil and oil filter
	Faulty oil pressure switch/sensor or oil pressure indicator light/gauge	Measure engine oil pressure with a mechanical gauge to verify pressure is low. See CHECK ENGINE OIL PRESSURE later in this Group.
	Excessive oil temperature	Remove and inspect engine oil cooler. See REMOVE, INSPECT, AND INSTALL ENGINE OIL COOLER in Section 02, Group 060 of this manual.
	Faulty oil pressure regulating valve	Remove and inspect engine oil pressure regulating valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE in Section 02, Group 060 of this manual.
	Plugged oil pump screen or cracked pick-up tube	Remove oil pan and clean screen. Replace oil intake (pick-up) tube. See REMOVE, INSPECT, AND INSTALL OIL PUMP PICKUP TUBE in Section 02, Group 060 of this manual.
	Faulty oil pump	Remove and inspect engine oil pump. See REMOVE ENGINE OIL PUMP and INSPECT AND CLEAN OIL PUMP in Section 02, Group 060 of this manual.
	Faulty or missing piston cooling orifice	Check piston cooling orifices.
	Excessive main or connecting rod bearing clearance	Determine bearing clearance. See CHECK MAIN BEARING OIL CLEARANCE in Section 02, Group 050 of this manual.
	Drain back valve in top load oil filter canister is out of position.	Remove top load oil filter element and check that the drain back valve is in proper position. See TOP LOAD OIL FILTER theory of operation in Section 03, Group 120 of this manual.

RE38635,0000172 -19-27MAR09-1/1

9.0L - L3 - Engine Oil Pressure High

Symptom	Problem	Solution
9.0L - L3 - Engine Oil Pressure High	Incorrect oil	Drain crankcase and refill with proper grade and viscosity oil. See DIESEL ENGINE OIL in Section 01, Group 002 of this manual.
	Faulty oil pressure sensor or gauge	Measure engine oil pressure with a mechanical gauge to verify pressure is high. See CHECK ENGINE OIL PRESSURE later in this Group.
	Faulty oil pressure regulating valve	Remove and inspect engine oil pressure regulating valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE, OIL FILTER BYPASS VALVE, AND OIL COOLER BYPASS VALVE in Section 02, Group 060 of this manual.
	Stuck oil filter bypass valve	Remove and inspect engine oil filter bypass valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE, OIL FILTER BYPASS VALVE, AND OIL COOLER BYPASS VALVE in Section 02, Group 060 of this manual.
	Stuck oil cooler bypass valve	Remove and inspect engine oil cooler bypass valve. See REMOVE, INSPECT, AND INSTALL OIL PRESSURE REGULATING VALVE, OIL FILTER BYPASS VALVE, AND OIL COOLER BYPASS VALVE in Section 02, Group 060 of this manual.

RE38635,0000093 -19-29MAR05-1/1

9.0 L - C1 - Engine Coolant Temperature Above Normal

Symptom	Problem	Solution
9.0L - C1 - Engine Coolant Temperature Above Normal	Low coolant level	Add coolant to proper level.
	Plugged radiator core and/or side shields	Clean radiator and/or side shields as required.
	Engine overloaded	Reduce engine load.
	Low crankcase oil level	Fill crankcase to proper level.
	Loose or faulty fan belt	Replace/tighten fan belt as required.
	Faulty coolant temperature switch/sensor or coolant temperature indicator light/gauge	Measure coolant temperature with a gauge of known accuracy to determine if coolant temperature is above normal.
	Faulty radiator cap	Test radiator cap. See PRESSURE TEST COOLING SYSTEM AND RADIATOR CAP later in this Group.
	Faulty thermostats	Test thermostat opening temperature. See INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE later in this Group.
	Faulty cylinder head gasket	Look for signs of a head gasket failure. See CHECK FOR HEAD GASKET FAILURES later in this Group.
	Faulty coolant pump	Remove and inspect coolant pump. If pump is failed, be certain to change engine oil and filter as a part of the repair process. See VISUALLY INSPECT COOLANT PUMP and REMOVE COOLANT PUMP ASSEMBLY in Section 02, Group 070 of this manual.

RE38635,000011A -19-29NOV07-1/1

9.0L - C2 - Engine Coolant Temperature Below Normal

Symptom	Problem	Solution
9.0L - C2 - Engine Coolant Temperature Below Normal	Faulty coolant temperature switch/sensor or coolant temperature indicator light/gauge	Measure coolant temperature with a gauge of known accuracy to determine if coolant temperature is below normal.
	Faulty thermostats	Test thermostat opening temperature. See INSPECT THERMOSTAT AND TEST OPENING TEMPERATURE later in this Group.

RE38635,0000095 -19-29MAR05-1/1

9.0L - C3 - Coolant In Oil or Oil In Coolant

Symptom	Problem	Solution
9.0L - C3 - Coolant In Oil or Oil In Coolant	Faulty cylinder head gasket	Look for signs of a head gasket failure. See CHECK FOR HEAD GASKET FAILURES later in this Group.
	Faulty oil cooler	Remove and inspect engine oil cooler. See REMOVE, INSPECT, AND INSTALL ENGINE OIL COOLER in Section 02, Group 060 of this manual.
	Leaking cylinder liner seals	Remove and inspect cylinder liners. See REMOVE CYLINDER LINERS in Section 02, Group 030 of this manual.
	Cracked cylinder head or block	Locate crack, repair/replace components as required.

RE38635,0000096 -19-29MAR05-1/1

Test Engine Compression Pressure with Mechanical Gauge

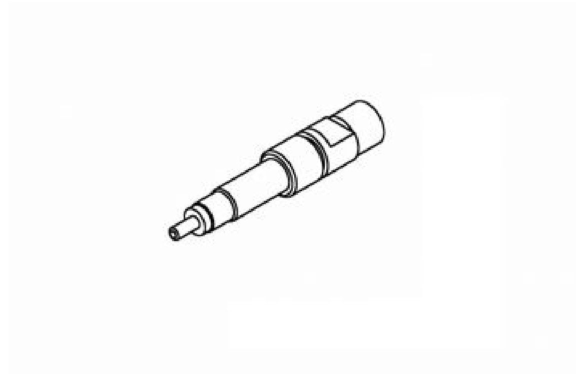
IMPORTANT: Compression pressures are affected by the cranking speed of the engine. Before beginning the test, ensure that batteries are fully charged and injection nozzle area is thoroughly cleaned.

1. Start engine and run at rated speed until it warms up to normal operating temperature. (From a cold start, operate engine 10-15 minutes at slow idle.)
2. Remove injection lines, leak-off lines, inlet connectors, and injection nozzles.
3. Install the JDG2047 Nozzle adapter into injection nozzle bore. Install injector clamp and tighten cap screw to 47 N•m (35 lb-ft).
4. Connect JT01682 Gauge and Hose Assembly to nozzle adapter.
5. Remove battery power supply to the Engine Control Unit (ECU) by removing the ECU power supply fuse, or by disconnecting the ECU from the wiring harness.

NOTE: A 3.6% reduction in gauge pressure will result for each additional 300 m (1000 ft) of altitude.

All cylinders within an engine should have approximately the same pressure. There should be less than 340 kPa (3.4 bar) (50 psi) difference between cylinders.

6. Crank engine over with starting motor for approximately 10 seconds and record compression readings. Compare readings with adjacent cylinders. There should be less than 340 kPa (3.4 bar) (50 psi) difference between cylinders.
7. If pressure difference between cylinders is excessive, remove gauge and apply oil to ring area of piston through injection nozzle bore. Do not use too much oil and do not get oil on valves.



RG14220 —UN—20OCT06

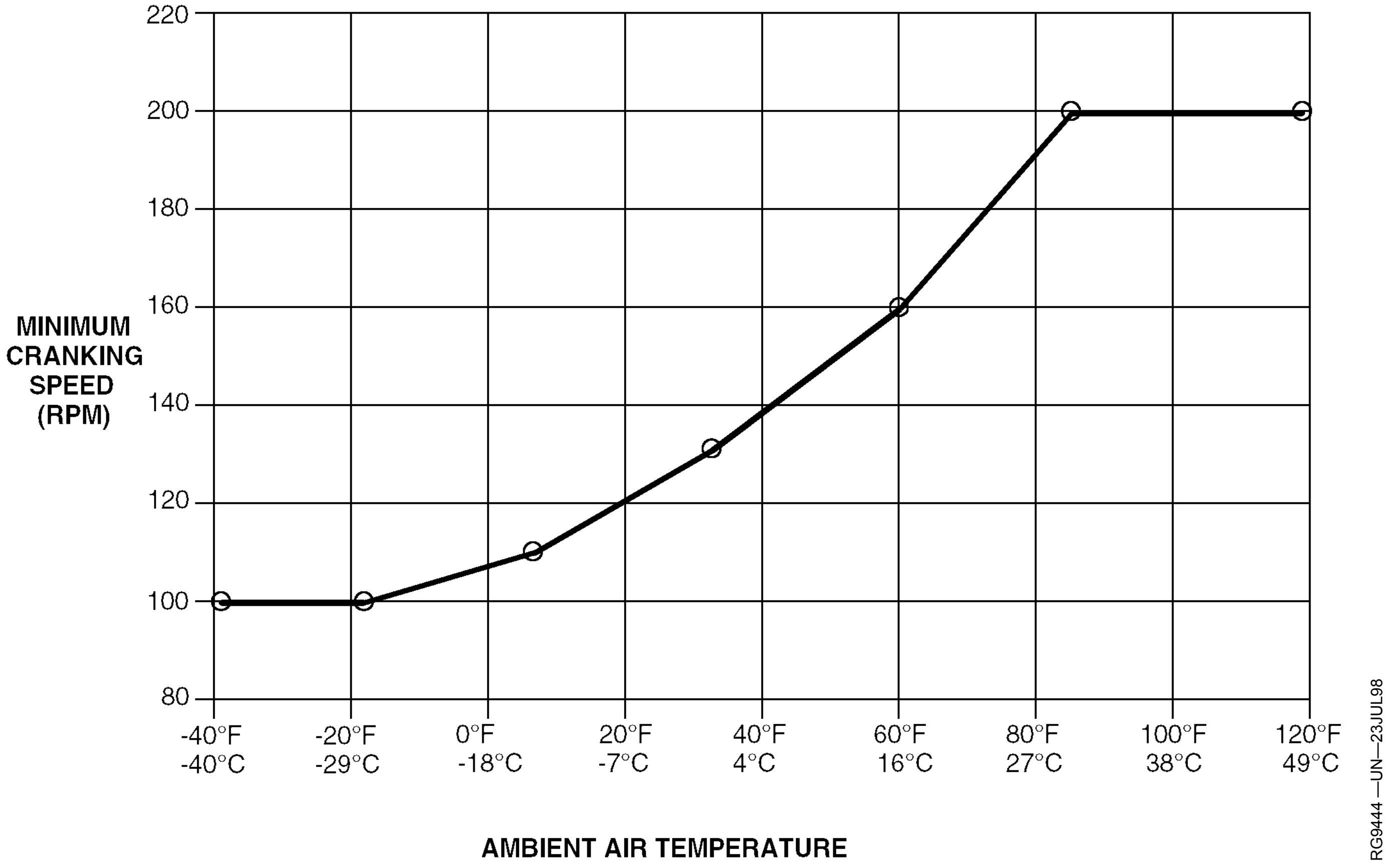
JDG2047 Compression Test Adapter

8. Crank engine over and record compression reading again.
   - If pressure is significantly higher than the first compression reading taken, worn or stuck rings are indicated. Either replace piston rings or install new piston and liner set as needed. and Section 02, Group 030 of this manual.
   - If pressure remains much lower than the specification, it is possible that valve lash is incorrect or valves are worn or sticking. Measure valve lash to specifications or recondition cylinder as needed.
9. Measure compression pressure in all remaining cylinders and compare readings. Recondition power cylinders and cylinder head as required.

RE38635,000002C -19-10MAY07-1/1

Check Engine Cranking Speed

IMPORTANT: Make sure that batteries are fully charged before performing this test.



1. Disable the fuel supply system at the injection pump so fuel delivery is in the OFF position.
2. If not using the machine tachometer, install a photo tachometer.
3. Crank engine for 15 seconds and record engine speed.
4. Compare recorded engine speed to chart above.

Cranking speed should meet or exceed specified engine rpm for a given ambient air temperature. For example, at 85°F (29°C) ambient temperature, cranking speed should be at least 200 rpm.

If cranking speed is below specifications, check the following:

- Starting system problems (low battery, loose or defective wiring, defective starter, etc.)
- Excessive engine loads (hydraulic pumps/thick oil, thick engine oil, etc.).

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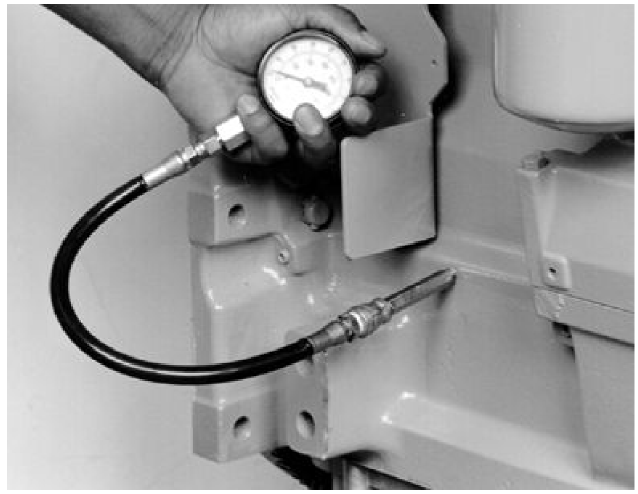
Check Engine Oil Pressure



RG7067 —UN—20AUG98

1. Check engine crankcase oil level. Adjust as necessary.
2. Check overall condition of oil (viscosity, presence of coolant, etc.). Change engine oil and replace oil filter if necessary.
3. Remove pipe plug from main oil gallery using JDG782 Oil Gallery Plug Tool.
4. Attach pressure gauge to oil galley.

IMPORTANT: To achieve an accurate oil pressure reading, warm up engine to 105°C (220°F).

5. Start engine, run at speeds given below, measure oil pressure, and compare readings.

Specification

OIL PRESSURE SPECIFICATIONS—Minimum No Load at 800 rpm (Slow Idle)	160 kPa (1.60 bar) (23.20 psi)
Minimum No Load at 900 rpm	180 kPa (1.80 bar) (26.1 psi)
Maximum Full Load at 2200 rpm (Tractors = 2100) Rated Speed	330 kPa (3.30 bar) (47.85 psi)

6. Refer to “Engine Oil Pressure Low” and/or “Engine Oil Pressure High” as detailed under DIAGNOSING ENGINE MALFUNCTIONS, earlier in this group if oil pressure is not within specification.

NOTE: The oil pressure regulating valve is designed so that adjustment of oil pressure should not be required using shims.

RE38635,00000B1 -19-04FEB09-1/1

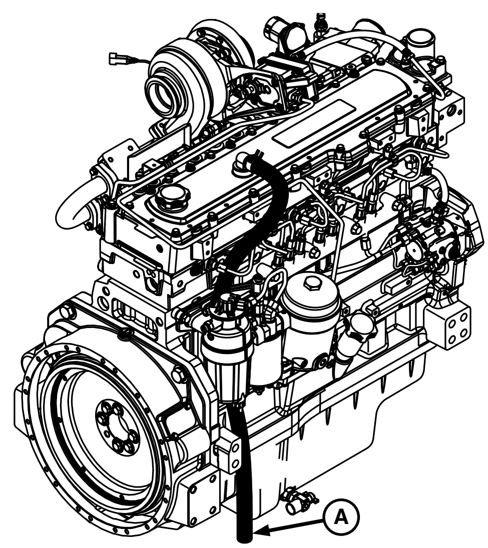
Check for Excessive Engine Crankcase Pressure (Blow-by)

Excessive blow-by coming out of the crankcase breather tube (A) indicates that either the turbocharger seals are faulty or the piston rings and cylinder liners are not adequately sealing off the combustion chamber. This is a comparative check that requires some experience to determine when blow-by is excessive.

Run engine at high idle and check crankcase breather tube. Look for significant fumes and/or dripping oil coming out of the breather tube at fast idle, with no load.

If excessive blow-by is observed, perform the following to determine if the turbocharger is causing the blow-by:

1. Remove the turbocharger oil drain line where it connects to the engine block and run the line into a bucket.
2. Run engine at high idle, slightly loaded and determine if boost pressure is forcing oil through the drain line, and check crankcase breather tube to determine if blow-by has decreased.
3. If it appears that boost pressure is forcing oil through the drain line, and/or blow-by decreases with the drain line disconnected from the block, replace the turbocharger and retest.



Crankcase Breather Tube

RG14156 —UN—18APR05

DPSG,RG40854,7 -19-24NOV98-1/1

Check for Turbocharger Oil Seal Leak

Seals are used on both sides of the turbocharger rotor assembly. The seals are used to prevent exhaust gases and air from entering the turbocharger housing. Oil leakage past the seals is uncommon but can occur.

A restricted or damaged turbocharger oil return line can cause the housing to pressurize causing oil to leak by the seals. Additionally, intake or exhaust restrictions can cause a vacuum between the compressor and turbocharger housing causing oil to leak by the seals.

1. Remove intake tube and exhaust pipe.

NOTE: The intake tube from the air cleaner would not have to be removed for this test.

2. Inspect the intake tube and turbocharger turbine casing for evidence of oil leakage.

   If oil leakage is present, perform the following:

   - Inspect turbocharger oil return line for kinks or damage. Replace if necessary.
   - Check the air intake filter and hoses for restrictions.
   - Check the exhaust system for restrictions to include position of exhaust outlet.

3. Perform necessary repairs and retest.

RE38635,00000B2 -19-07APR05-1/1

Inspect Thermostat and Test Opening Temperature

Visually inspect thermostat for corrosion or damage. Replace as necessary.

- Test thermostat as follows:

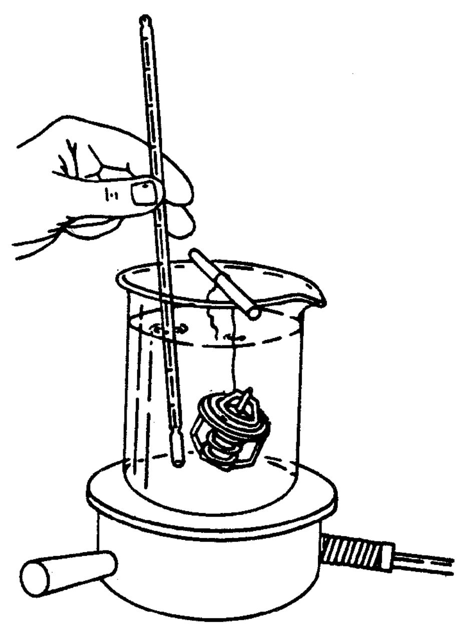
CAUTION: DO NOT allow thermostat or thermometer to rest against the side or bottom of container when heating water. Either may rupture if overheated.

1. Suspend thermostat and a thermometer in a container of water.
2. Stir the water as it heats. Observe opening action of thermostats and compare temperatures with specification given in chart below.

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

THERMOSTAT TEST SPECIFICATIONS

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



RG5971 —UN—23NOV97

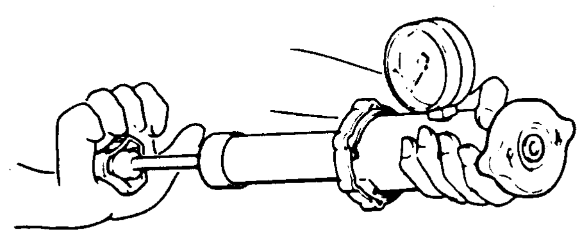
3. Remove thermostat and observe its closing action as it cools. In ambient air the thermostat should close completely. Closing action should be smooth and slow.
4. If any thermostat is defective on a multiple thermostat engine, replace all thermostats.

DPSG,RG40854,10 -19-15MAY08-1/1

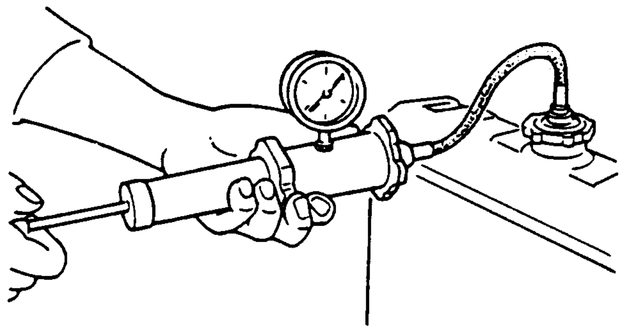
Pressure Test Cooling System and Radiator Cap

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.



RG6557 —UN—20JAN93



RG6558 —UN—20JAN93

Test Radiator Cap Pressure:

1. Remove radiator cap and attach to D05104ST Tester as shown.
2. Pressurize cap to 50 kPa (0.5 bar) (7 psi)[1]. Gauge should hold pressure for 10 seconds within normal range if cap is acceptable.
3. Remove the cap from gauge, turn it 180°, and retest cap. This will verify that the first measurement was accurate.

Test Cooling System for Leaks:

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.

IMPORTANT: 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 50 kPa (0.5 bar) (7 psi)[2].
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. See CHECK FOR HEAD GASKET FAILURES later in this Group.

[1]If gauge does not hold pressure, replace radiator cap.
[2] Test pressures recommended are for all Deere OEM cooling systems. On specific vehicle applications, test cooling system and pressure cap according to the recommended pressure for that vehicle.

DPSG,RG40854,11 -19-15MAY08-1/1

Pressure Test EGR Cooler for Air Leaks

NOTE: The EGR cooler can be pressure checked for leaks at a radiator shop.

1. Remove EGR cooler from engine.
2. Block off cooler openings.
3. Attach shop air and regulator to cooler and submerse cooler in water.
4. Apply 248 kPa (2.5 bar)(36 psi) air pressure to cooler and watch for air bubbles indicating leaks.

RE38635,0000014 -19-27MAY05-1/1

Charge Air System Diagnostic

NOTE: A failing Variable Geometry Turbocharger (VGT) or charge air system (for example, air leakage from the charge air cooler system) will result in black exhaust smoke and low power.

Continued on next page

RE38635,000005E -19-13SEP07-1/6

Air Filter Inspection

Procedure	Result
1. . Inspect air filter for damage or blockage that would restrict air flow, or feed dirt into the engine. 2. Remove inlet air pipes, and check for: damaged or loose clamps, and dirt tracks from unfiltered air.	**YES:** Notify customer to repair identified problems. After problem(s) repaired, GO TO 2.
Was damage, blockage, or dirt tracks found?	**NO:** GO TO 2.

RE38635,000005E -19-13SEP07-2/6

VGT Compressor

Procedure	Result
1. Without removing VGT, examine compressor housing and blades for damage. (See TURBOCHARGER INSPECTION, Section 02, Group 080 in base engine manual.) 2. Remove the compressor outlet tube to the charge air cooler. Check for debris from the compressor housing and blades, and for oil leaking from the seal of compressor housing shaft.	**YES:** GO TO 3.
Was damage, debris, or leaking oil found?	**NO:** GO TO 4.

RE38635,000005E -19-13SEP07-3/6

VGT Diagnostics

Procedure	Result
1. Remove turbocharger. (See REMOVE TURBOCHARGER in section 02, Group 080 of base engine manual.) 2. Inspect for debris or oil. (See TURBOCHARGER INSPECTION in Section 02, Group 080 of base engine manual.)	**YES:** : Replace turbocharger. (See INSTALL TURBOCHARGER in section 02, Group 080 of base engine manual.) Then remove, clean, and reinstall charge air cooler, and GO TO 4.
Was there debris or oil in the compressor outlet to the charge air cooler?	**NO:** GO TO 4.

RE38635,000005E -19-13SEP07-4/6

Charge Air Cooling System Check

Procedure	Result
NOTE: This procedure requires fabrication of caps for the inlet and outlet of charge air cooler outlet. Constructions of one of the caps requires the ability to receive and seal a supply air line, 1. At the intake manifold, remove charge air cooler outlet tube, and cap it. 2. At the turbocharger, remove charge air cooler inlet tube, and cap it. 3. Install a supply air line to the charge air system. 4. Slowly pressurize the charge air system to 206.85 kPa (30 psi), and maintain this pressure. 5. Using soapy water, check the charge air system joints for air leaks.	**YES:** Repair leaks and GO TO 5.
Were any joint leaks found?	**NO:** GO TO 5.

Continued on next page

RE38635,000005E -19-13SEP07-5/6

Charge Air Cooler Check

	1. Without removing the supply air line (added in step 3 of previous procedure), shut the air supply off. 2. Time how long measured air pressure takes to reach 0 kPa (psi).	**YES:** Reassemble the charge air system, including the turbocharger and supply air system, then GO TO E5 - ENGINE EMITS BLACK OR GRAY EXHAUST SMOKE, earlier in this group.
	Was the time to reach 0 kPa (psi) greater than 60 seconds?	**NO:** Replace charge air cooler.

RE38635,000005E -19-13SEP07-6/6

Check for Head Gasket Failures

Head gasket failures generally fall into three categories:

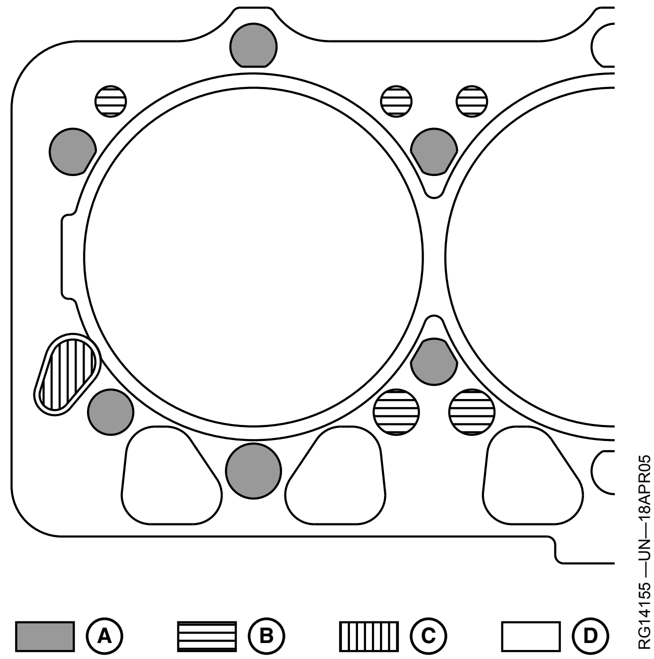
- Combustion seal failures
- Coolant seal failures
- Oil seal failures

Combustion seal failures occur when combustion gases escape between cylinder head and head gasket combustion flange, or between combustion flange and cylinder liner. Leaking combustion gases may vent to an adjacent cylinder, to a coolant or oil passage, or externally.

Coolant or oil seal failures occur when oil or coolant escapes between cylinder head and gasket body, or between cylinder block and gasket body. The oil or coolant may leak to an adjacent coolant or oil passage, or externally. Since oil and coolant passages are primarily on right hand (camshaft) side of the engine, fluid leaks are most likely to occur in that area.

Follow these diagnostic procedures when a head gasket joint failure occurs, or is suspected.

1. Start and warm up engine if it can be safely operated. Examine all potential leakage areas again as outlined previously. Using appropriate test and measurement equipment, check the following:
   - White smoke, excessive raw fuel, or moisture in exhaust system.
   - Rough, irregular exhaust sound, or misfiring.
   - Air bubbles, gas trapped in radiator/overflow tank.
   - Loss of coolant from overflow.
   - Excessive cooling system pressure.
   - Coolant overheating.
   - Low coolant flow.
   - Loss of cab heating (air lock)
2. Shut engine down. Recheck crankcase, radiator, and overflow tank for any significant differences in fluid levels, viscosity, or appearance.
3. Compare your observations from above steps with the diagnostic charts on the following pages. If diagnostic evaluations provide conclusive evidence of combustion gas, coolant, or oil leakage from head gasket joint, the cylinder head must be removed for inspection and repair of gasket joint components.



9 L Head Gasket

A—Cylinder Head Bolts
B—Coolant Passages
C—Oil Passage (supply)
D—Push Rod & Oil Drain

COMBUSTION SEAL LEAKAGE

Symptoms:

- Exhaust from head gasket crevice.
- Air bubbles in radiator/overflow tank.
- Coolant discharge from overflow tube.
- Engine overheating.
- Power loss.
- Engine runs rough.
- White exhaust smoke.
- Loss of cab heat.
- Gasket section dislodged, missing (blown).
- Coolant in cylinder.
- Coolant in crankcase oil.
- Low coolant level.

Possible Causes:

- Insufficient liner standout.
- Excessive liner standout differential between cylinders.
- Low head bolt clamping loads.
- Rough/damaged liner flange surface.
- Cracked/deformed gasket combustion flange.
- Out-of-flat/damaged/rough cylinder head surface.
- Missing/mislocated gasket firing ring.
- Block cracked in liner support area.
- Excessive fuel delivery.
- Advanced injection pump timing.
- Hydraulic or mechanical disturbance or combustion seal.

NOTE: Cracked cylinder head or liners may also allow combustion gas leakage into coolant.

If above symptoms are found, see <u>HEAD GASKET INSPECTION AND REPAIR SEQUENCE</u> in Section 02, Group 020 of this manual.

COOLANT SEAL LEAKAGE

Symptoms:

- Coolant discharge from head gasket crevice.
- Coolant in crankcase oil.

Continued on next page

RE38635,00000BA -19-18APR05-1/2

- Low coolant level.
- High oil level.
- Coolant discharge form crankcase vent.

Possible Causes:

- Excessive liner standout.
- Excessive liner standout differential between cylinders.
- Low head bolt clamping loads.
- Out-of-flat/damaged/rough block surface.
- Out-of-flat/damaged/rough cylinder head surface.
- Oil or coolant overheating.
- Cracks/creases in gasket body surfaces.
- Damage/voids in elastomer beading.

If above symptoms are found, see <u>HEAD GASKET INSPECTION AND REPAIR SEQUENCE</u> in Section 02, Group 020 of this manual.

OIL SEAL LEAKAGE

Symptoms:

- Oil discharge from head gasket crevice.
- Oil in coolant.
- Low crankcase oil level.
- Reduced oil to rocker arms (noisy).

Possible Causes:

- Excessive liner standout
- Excessive liner standout differential between cylinders.
- Low head bolt clamping loads
- Out-of-flat/damaged/rough block surface.
- Out-of-flat/damaged/rough cylinder head surface.
- Oil or coolant overheating.
- Cracks/creases in gasket body surfaces.
- Damage/voids in elastomer beading.
- Damaged/missing O-ring seal at oil port to rocker arms.

If above symptoms are found, see <u>HEAD GASKET INSPECTION AND REPAIR SEQUENCE</u> in Section 02, Group 020 of this manual.

NOTE: Defective oil cooler may also allow oil leakage into coolant.

RE38635,00000BA -19-18APR05-2/2

Measure Intake Manifold Pressure (Turbo Boost)

With the addition of the exhaust gas recirculator (EGR) and variable geometry turbocharger (VGT) to the 9 L engine design, turbocharger boost values cannot be accurately predicted.

The engine controls system is targeting a given EGR percentage. Exhaust restrictions and charge air cooler temperature differential in turn affect the engines' temperature differential between the intake and exhaust manifolds. In a vehicle, if operating conditions do not match exactly conditions measured in the engine lab (intake restriction, pressure difference on charge air cooler, and exhaust restriction), then the engine will adjust the VGT to get the correct EGR percentage. Boost pressures vary depending on operating conditions of the engine. They may be higher or lower. Therefore, accurate boost pressure values cannot be predicted when the engine is in the field.

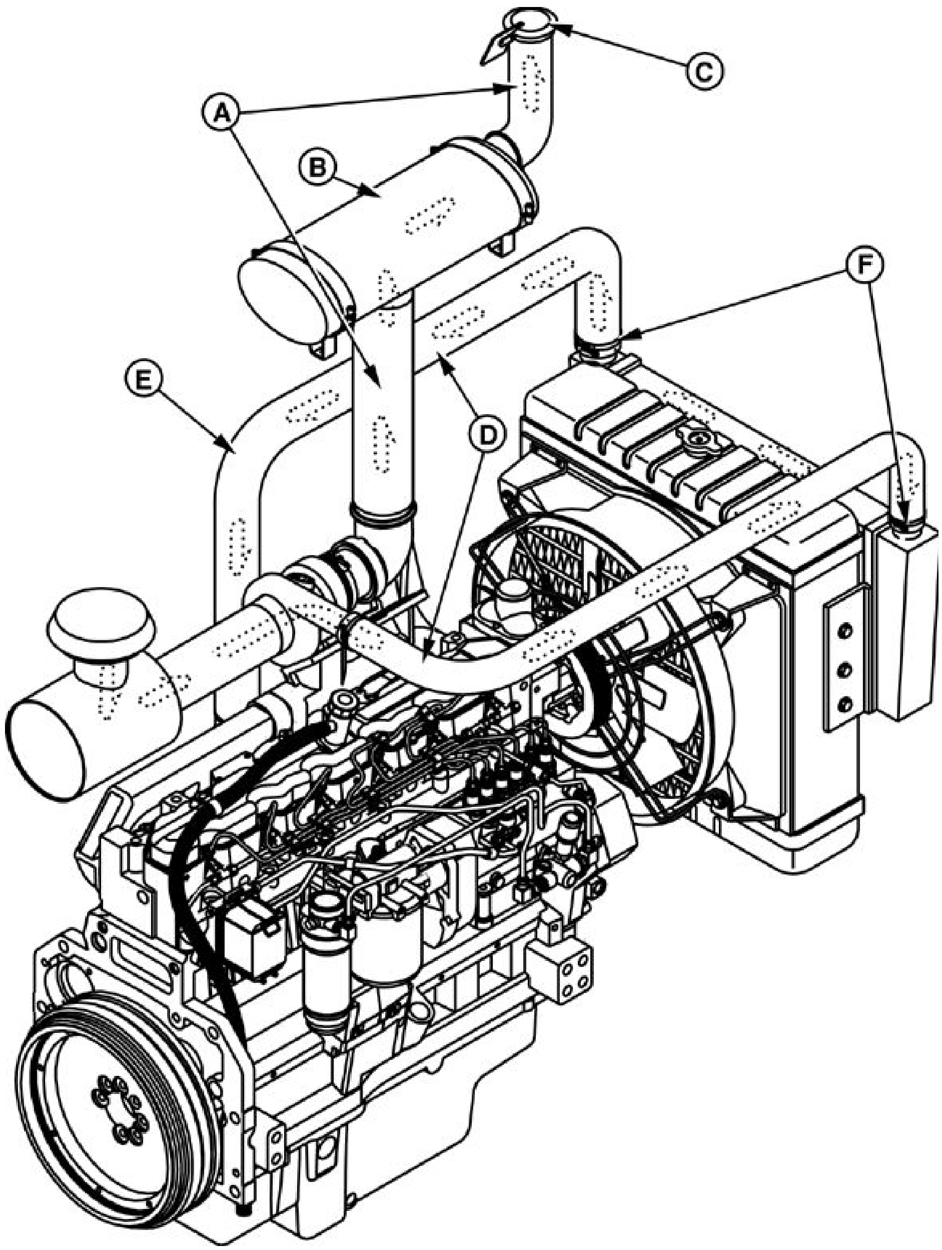
The engine has a Manifold Air Pressure Sensor that provides values to the ECU. Diagnostic procedures with Service Advisor can provide an accurate measurement of how well the engine is performing.

If boost pressure is suspected to be too low, check for the following:

- Restriction in air cleaner.
- Leak in air intake between turbocharger and cylinder head.
- Leak in exhaust manifold gasket.
- Restricted exhaust.
- Leak in fuel system piping.
- Restricted fuel filter elements.
- Incorrect injection pump timing.
- Low fuel injection pump delivery.
- Faulty fuel supply pump.
- Low cylinder compression pressure.
- Faulty fuel injection nozzles.
- Carbon build-up in turbocharger.
- Turbocharger compressor or turbine wheel rubbing housing.

RE38635,00000B3 -19-07APR05-1/1

Check for Intake and Exhaust Restrictions



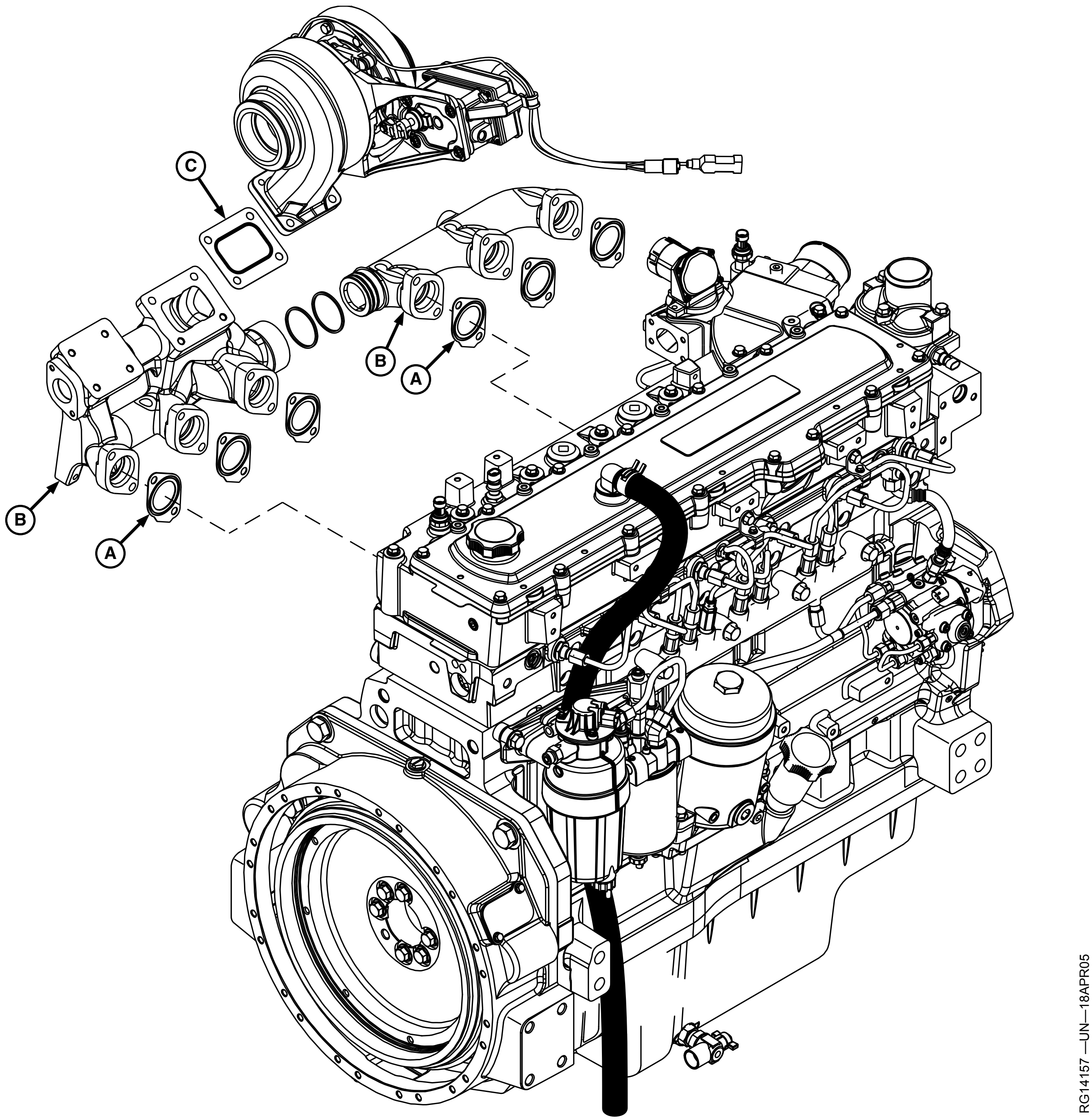
A—Exhaust Piping
B—Muffler
C—Rain Cap
D—Intake Piping
E—Elbows
F—Connections

Low power, low boost pressure, and excessive black exhaust smoke can be caused by an intake air or exhaust restriction.

1. Inspect the exhaust piping (A), the muffler (B), and the rain cap (C) for damage or any possible restrictions.
2. Inspect the intake piping (D), any elbows (E), and any connections (F). Look for collapsed pipes, dented pipes and loose connections. Replace components as needed.

DPSG,RG40854,14 -19-15MAY08-1/1

Check for Exhaust Air Leaks



Checking Exhaust Air Leaks

A—Exhaust Manifold Gasket **B—Exhaust Manifold** **C—Turbocharger Gasket**

Exhaust leaks, upstream of the turbocharger will cause the turbocharger turbine to rotate at a reduced speed resulting in low boost pressure, low power, and excessive black smoke.

Inspect the exhaust manifold gasket (A), the exhaust manifold (B), and the turbocharger gasket (C) for damage and any signs of leakage. Replace components as needed.

RE38635,0000097 -19-29MAR05-1/1

Section 05
Tools and Other Materials

Contents

Group 021 — Cylinder Head and Valves - Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

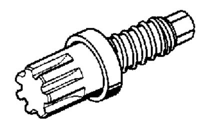
RE38635,000001D -19-01JUN05-1/11

Flywheel Turning Tool... JDG820

Used to rotate engine to check damper radial runout and time engine. JDE81-1 may be used also if JDG820 is not available.

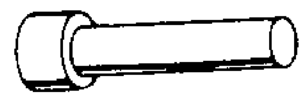
Timing Pin...JDE81-4

Lock engine at TDC when timing valve train, adjusting valve clearance, and installing fuel injection pump. Use with JDG820, JDE81-1 Flywheel Turning Tools.



RG7056 —UN—17JUN05

JDG820



RG5068

RG5068 —UN—05DEC97

JDE81-4

RE38635,000001D -19-01JUN05-2/11

Dial Indicator...(English, in.) D17526CI or (Metric, mm) D17527CI

Use with JDG451 to measure valve recess and cylinder liner height-to-cylinder block top deck.

RG6246

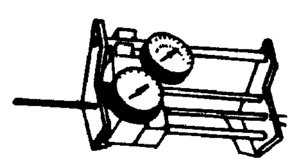
RG6246 —UN—05DEC97

D17526CI or D17527CI

RE38635,000001D -19-01JUN05-3/11

Spring Compression Tester D01168AA

Test valve spring compression.



RG5061

RG5061 —UN—05DEC97

D01168AA

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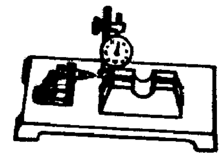
RE38635,000001D -19-01JUN05-4/11

Valve Inspection Center.................................... D05058ST

Check valves for out-of-round.



RG5062

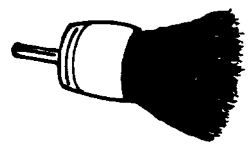
RG5062 —UN—05DEC97

D05058ST

RE38635,000001D -19-01JUN05-5/11

End Brush.. D17024BR

Clean valve seat and bores.



RG5063

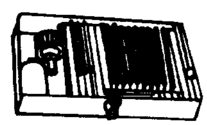
RG5063 —UN—05DEC97

D172024BR

RE38635,000001D -19-01JUN05-6/11

Valve Guide Knurler Kit JT05949

Knurl valve guides.



RG5064

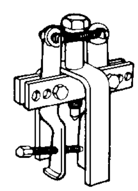
RG5064 —UN—05DEC97

JT05949

RE38635,000001D -19-01JUN05-7/11

Valve Seat Puller JDE41296

Remove valve seats.



RG5071

RG5071 —UN—05DEC97

JDE41296

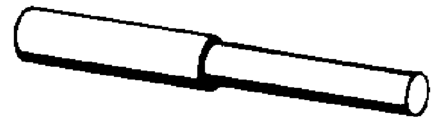
Continued on next page

RE38635,000001D -19-01JUN05-8/11

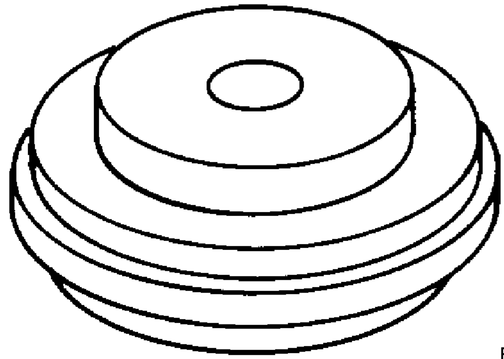
Valve Seat Pilot Driver JDE7

Install replacement valve seat inserts. Use with JDG605.
Valve Seat Installer JDG605

Install intake and exhaust valve seat inserts. Use with JDE7.



JDE7

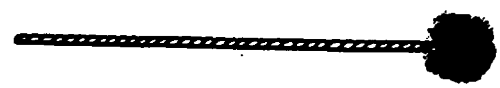


JDG10057

RE38635,000001D -19-01JUN05-9/11

Nozzle Threads Cleaning Brush D17030BR

Used to clean electronic injector bore.

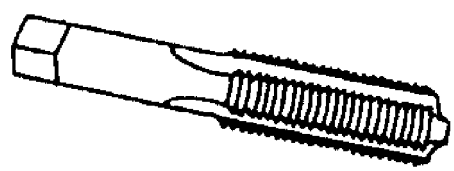


D17030BR

RE38635,000001D -19-01JUN05-10/11

Tap JDG681A

Used to restore threaded holes in cylinder block for cylinder head cap screws.



JDG681A

RE38635,000001D -19-01JUN05-11/11

Group 021 — Cylinder Head and Valves - Service Equipment and Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

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Continued on next page

RE38635,000001C -19-01JUN05-1/5

Valve Spring Compressor.....................................JDE138

Compress valve springs when removing and installing valves.

RE38635,000001C -19-01JUN05-2/5

Precision "Bevelled Edge" Straightedge........... D05012ST

Check cylinder head flatness.

RE38635,000001C -19-01JUN05-3/5

Eccentrimeter D11010KW

Measure valve seat-to-stem runout.

RE38635,000001C -19-01JUN05-4/5

Heavy-Duty Seat Grinder Set...............................JT05893

Grind valve seats.

RE38635,000001C -19-01JUN05-5/5

Group 021 — Cylinder Head and Valves - Other Materials

Number	Name	Use
AR44402 (U.S.)	Valve Stem Lubricant	Lubricate valve stems.
PT569 (U.S.)	NEVER-SEEZ® Compound	Turbocharger-to-exhaust manifold cap screws.

NEVER-SEEZ is a registered trademark of Emhart Chemical Group.

RE38635,000001B -19-01JUN05-1/1

Group 030 — Cylinder Block, Liners, Pistons, and Rods Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

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RE38635,0000019 -19-31MAY05-1/14

Dial Indicator...(English, in.) D17526CI or (Metric, mm) D17527CI

Use with JDG451 to measure valve recess and cylinder liner height-to-cylinder block top deck.

RG6246 —UN—05DEC97

RG6246

D17526CI or D17527CI

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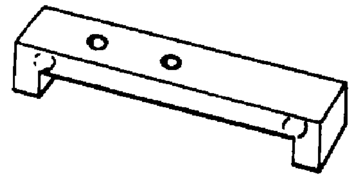
RE38635,0000019 -19-31MAY05-2/14

Piston and Liner Height Gauge JDG451

Use with dial indicator to measure piston and liner heights above cylinder block.

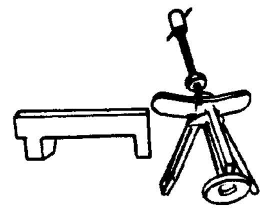


JDG451

RE38635,0000019 -19-31MAY05-3/14

Cylinder Liner Puller ....D01062AA orD01073AA.

Remove cylinder liners.

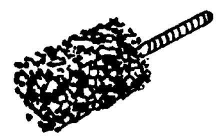


D01062AA or D01073AA.

RE38635,0000019 -19-31MAY05-4/14

Flexible Cylinder Hone D17005BR

Hone cylinder liners.

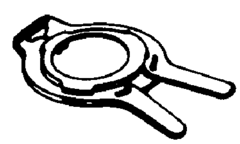


D17005BR

RE38635,0000019 -19-31MAY05-5/14

Piston Ring Expander..JDE93

Remove and install piston rings.

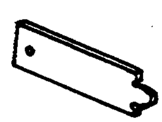


JDE93

RE38635,0000019 -19-31MAY05-6/14

No. 1 Ring Groove Wear Gauge JDE55

Check upper compression ring groove wear.



JDE55

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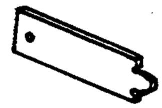
RE38635,0000019 -19-31MAY05-7/14

No. 2 Ring Groove Wear Gauge JDG852

Check lower compression ring groove wear.



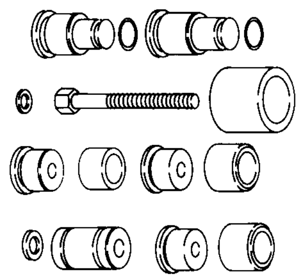
RG5076 —UN—23AUG88

JDG852

RE38635,0000019 -19-31MAY05-8/14

Connecting Rod Bushing Service Set JDE98A

Remove and install connecting rod bushings. Set consists of JDE98-1 Cup (1), JDE98-2 Driver (2), JDE98-3 Pilot (3), JDE98-4 Driver (4), JDE98-5 Driver (5), JDE98-6 Pilot (6), JDE98-7 Driver (7), JDE98-8 Cup (8), JDE98-9 Pilot (9), JDE98-10 Bushing Remover (10) and STD36104 Forcing Screw.



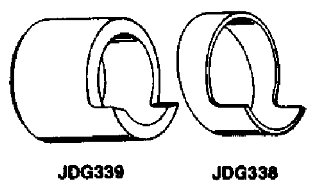
RG5078 —UN—16FEB94

JDE98A

RE38635,0000019 -19-31MAY05-9/14

Connecting Rod Bushing Service Set JDG337

Use with JDE98A Bushing Service Set to remove and install connecting rod bushings.



RG5079

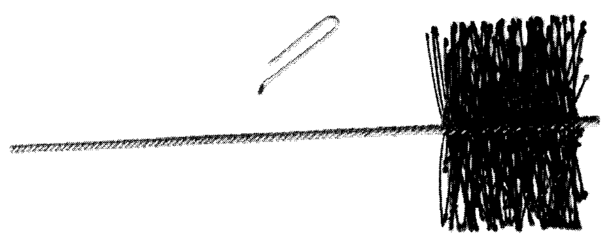
RG5079 —UN—07NOV97

JDG337

RE38635,0000019 -19-31MAY05-10/14

O-Ring Groove Cleaning Brush........................ D17015BR

Clean cylinder liner O-ring groove in block.



RG5075

RG5075 —UN—07NOV97

D17015BR

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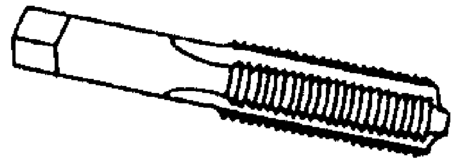
RE38635,0000019 -19-31MAY05-11/14

Tap.. JDG681

Used to restore threaded holes in cylinder block for cylinder head cap screws.



JDG681

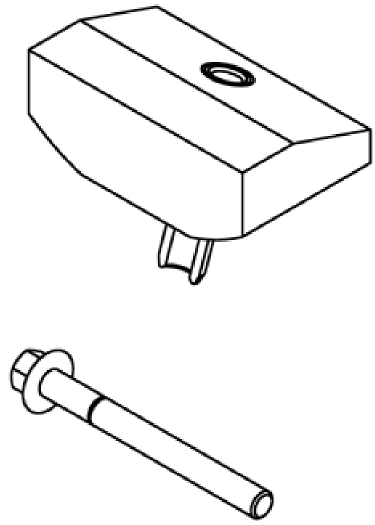
RE38635,0000019 -19-31MAY05-12/14

Piston Spray Jet Installation Tool........................ JDG1948

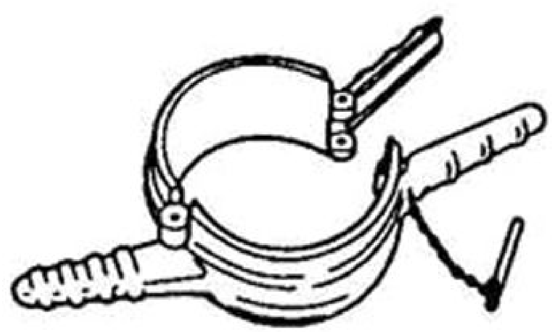
Install piston spray jet into main bearing web of cylinder block

Piston Ring Compressor..................................... JDG1963

Compress rings while installing pistons.



Piston Spray Jet Installer



Piston Ring Compressor

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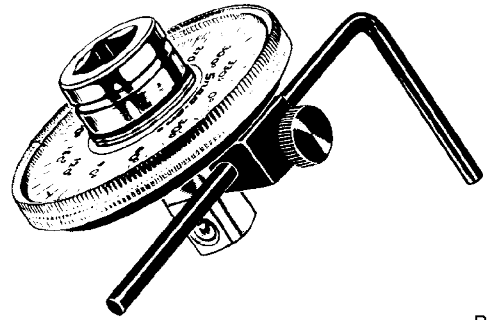
RE38635,0000019 -19-31MAY05-13/14

Torque Angle Gauge..JT05993

Used to TORQUE-TURN flanged-head cylinder head and connecting rod cap screws.



RG5698 RG5698 —UN—05DEC97

JT05993

RE38635,0000019 -19-31MAY05-14/14

Group 030 — Cylinder Block, Liners, Pistons, and Rods Other Materials

Number	Name	Use
	PLASTIGAGE®	Determine connecting rod bearing-to-journal oil clearance.
AR54749 (U.S.)	Soap Lubricant	Coat O-rings on cylinder liners.

PLASTIGAGE is a registered trademark of DANA Corp.

RG41183,000000C -19-03JAN01-1/1

Group 040 — Crankshaft, Main Bearings and Flywheel Essential Tools

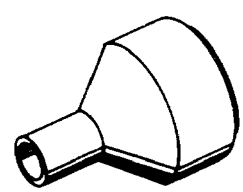
NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

RE38635,00000D1 -19-16JUN11-1/12

Seal Puller Adapter... JDG719

Used with a standout metal screw, JDE38-2 Shank, and JDE38-3 Slide Handle to remove front crankshaft oil seal with timing gear cover installed. Also used to remove rear crankshaft oil seal with seal housing installed.



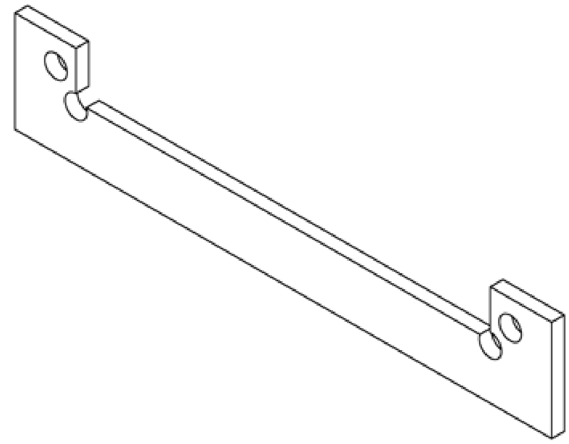
RG6214 RG6214 —UN—05DEC97

JDG719

Continued on next page RE38635,00000D1 -19-16JUN11-2/12

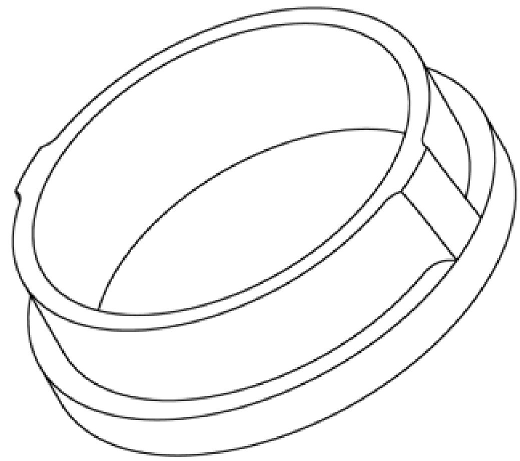
Seal and Wear Sleeve Installer JDG1952, JDG1953, JDG1954

Used to simultaneously install the new teflon unitized oil seal and wear sleeve on the rear crankshaft flange. Also use with JDG1953 & JDG1954 Alignment Tools to align and install rear oil seal housing, eliminating need for dial indicator to measure runout.



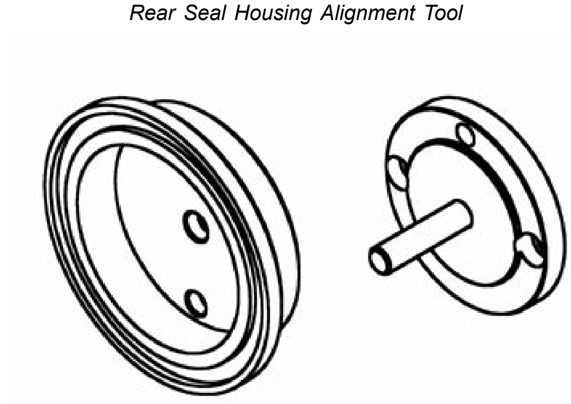
RG14223 —UN—31MAY05

Rear Crank Seal - Housing to Pan Rail Alignment



RG14222 —UN—28OCT05

Rear Seal Housing Alignment Tool



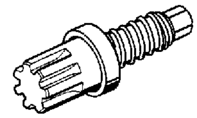
RG14221 —UN—31MAY05

Rear Seal & Wear Sleeve Installation Tool

Continued on next page RE38635,00000D1 -19-16JUN11-3/12

Flywheel Turning Tool.. JDG820

Used to rotate engine to check damper radial runout and time engine. JDE81-1 may be used also if JDG820 is not available.



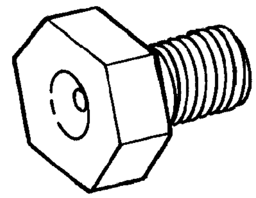
RG7056 —UN—17JUN05

JDG820

RE38635,00000D1 -19-16JUN11-4/12

Thread Protector.. JDG10545

Used with JDG721 Hub Puller Kit to remove vibration damper puller assembly. This thread protector is same as JDG787 except it has metric threads. Nose of tier 3 crank is tapped metric.Tool may be used with any puller set where limited space makes it difficult to use puller without a thread protector.



RG6429

RG6429 —UN—05DEC97

JDG10545

RE38635,00000D1 -19-16JUN11-5/12

Hub Puller Kit... JDG721

Used with JDG10545 Thread Protector to remove vibration damper pulley assembly.

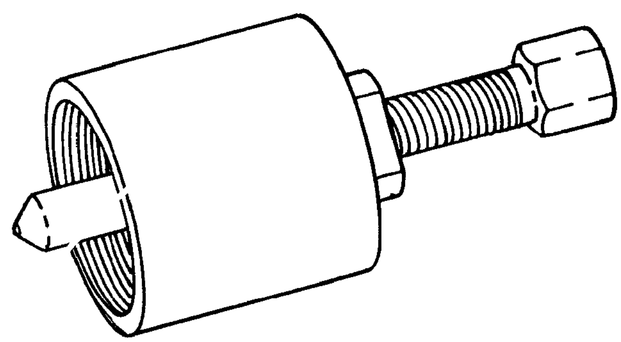
RG5763 —UN—05DEC97

JDG721

RE38635,00000D1 -19-16JUN11-6/12

Front Wear Sleeve Puller JDG786

Used to remove front crankshaft wear sleeve with timing gear cover installed.



RG6428

RG6428 —UN—05DEC97

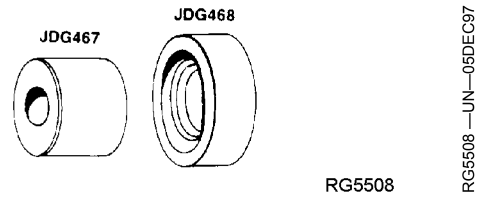
JDG786

Continued on next page

RE38635,00000D1 -19-16JUN11-7/12

Front Wear Sleeve Installer Set................................JDE3

Install front crankshaft wear sleeve.

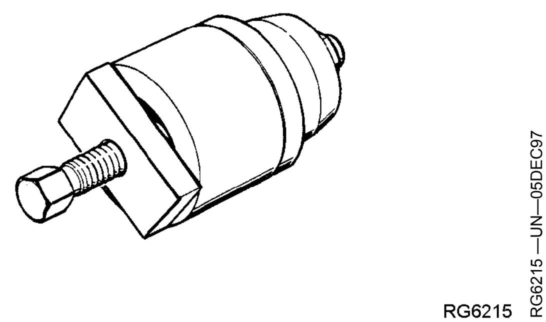


JDE3

RE38635,00000D1 -19-16JUN11-8/12

Seal Protector...JDG720A

Used to install front crankshaft oil seal with timing gear cover installed. Set consists of JDG10023 Forcing Screw, JDG720-2 Seal Protector, JDG720-5 Seal Installer and JDG720-4 Ring.

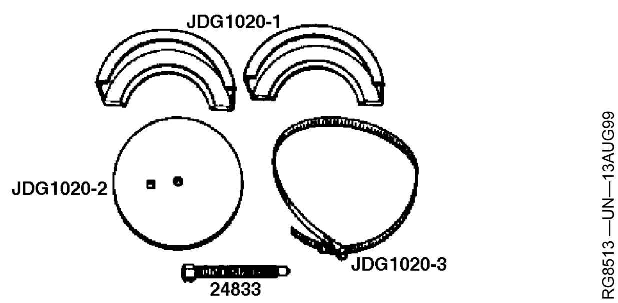


JDG720A

RE38635,00000D1 -19-16JUN11-9/12

Rear Wear Sleeve Puller Kit.............................. JDG1020

Used to remove rear wear sleeve with oil seal housing installed on Series 400, 450, and 500 Engines. Set consists of JDG1020-1 Collet Halves, 24833 Forcing Screw, JDG1020-2 Pulling Plate, JDG1020-3 Hose Clamp.

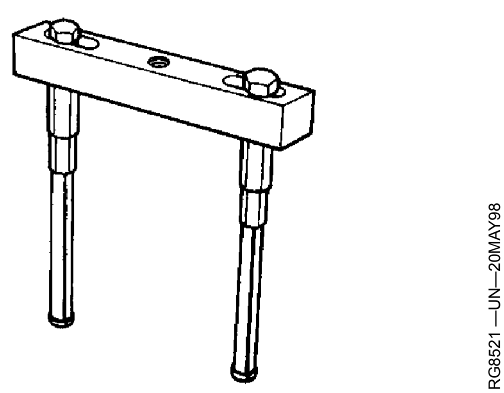


Rear Crankshaft Seal & Wear Sleeve Puller

RE38635,00000D1 -19-16JUN11-10/12

Main Bearing Cap Puller/Installer...................... JDG1069

Use to remove and install the main bearing caps. Due to wider bearing surface, these caps are installed with an increased interference fit.



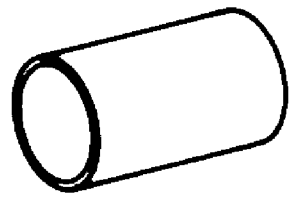
JDG1069

Continued on next page

RE38635,00000D1 -19-16JUN11-11/12

Gear Driver JDH7

Install crankshaft drive gear.



JDH7

RE38635,00000D1 -19-16JUN11-12/12

Group 040 — Crankshaft, Main Bearings and Flywheel Service Equipment and Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC). Some tools may be available from a local supplier.

SERVICEGARD is a trademark of Deere & Company

RG41183,000000E -19-03JAN01-1/3

Slide Hammer.. D01300AA

Use with JDG1069 to remove main bearing caps.

RG41183,000000E -19-03JAN01-2/3

[1]Puller D01251AA

Remove crankshaft gear.

[1]Part of D01047AA 17-1/2 and 30 Ton Puller Set

RG41183,000000E -19-03JAN01-3/3

Group 040 — Crankshaft, Main Bearings and Flywheel Other Materials

Number	Name	Use
TY15969 (U.S.) TY9479 (Canadian) 680 (LOCTITE®)	Retaining Compound (Maximum Strength)	Used to coat ID of new wear sleeve.
	PLASTIGAGE®	Check main bearing-to-crankshaft journal oil clearance during engine disassembly.
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Coat threads of flywheel mounting cap screws.
TY6333 or TY6347 (U.S.)	High Temperature Grease	Used to install timing gear cover tabs.
	Brake Kleen or Ignition Cleaner	Remove sealant from crankshaft flange.

LOCTITE is a registered trademark of Loctite Corp.
PLASTIGAGE is a registered trademark of DANA Corp.

RG41183,000000F -19-03JAN01-1/1

Group 050 — Camshaft and Timing Gear Train Essential Tools

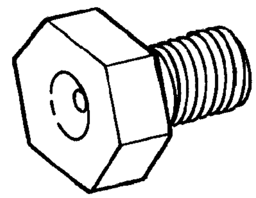
NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

DPSG,OUO1004,838 -19-27APR99-1/10

Thread Protector.. JDG787

Used with JDG721 Hub Puller Kit to remove vibration damper puller assembly.


RG6429

RG6429 —UN—05DEC97

JDG787

DPSG,OUO1004,838 -19-27APR99-2/10

Hub Puller Kit... JDG721

Used with JDG787 Thread Protector to remove vibration damper pulley assembly on some engine applications.

RG5763 —UN—05DEC97

JDG721

Continued on next page

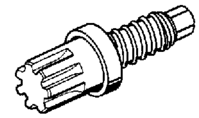
DPSG,OUO1004,838 -19-27APR99-3/10

Flywheel Turning Tool.. JDG820

Used to rotate engine to check damper radial runout and time engine. JDE81-1 may be used also if JDG820 is not available.

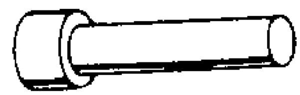
Timing Pin..JDE81-4

Lock engine at TDC when timing valve train, adjusting valve clearance, and installing fuel injection pump. Use with JDG820 and JDE81-1 Flywheel Turning Tools.



RG7056 —UN—17JUN05

JDG820



RG5068

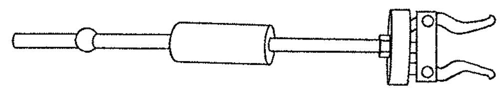
RG5068 —UN—05DEC97

JDE81-4

DPSG,OUO1004,838 -19-27APR99-4/10

Slide Hammer and Attachment......................... D01209AA

Used to remove auxiliary drive idler bushing/spacer from timing gear cover.



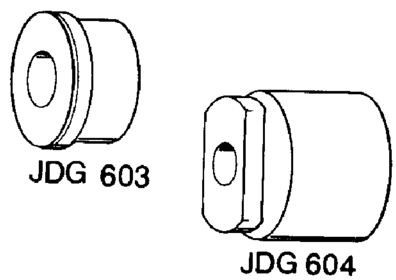
RG10060 —UN—10JUN99

D01209AA

DPSG,OUO1004,838 -19-27APR99-5/10

Camshaft Bushing Adapter Set JDG602

Used with JDE6 Camshaft Bushing Service Set to service camshaft bushings. JDG602 consists of JDG603 Driver and JDG604 Receiver Cup.



RG5336

RG5336 —UN—07NOV97

JDG602

DPSG,OUO1004,838 -19-27APR99-6/10

Camshaft Bushing Service Set.................................JDE6

Used with JDG602 Camshaft Bushing Adapter Set to service camshaft bushings. **JDG405 Service Set may be used along with JDG606 Adapter Set if JDE6 is not available.**

R26149N —UN—04DEC97

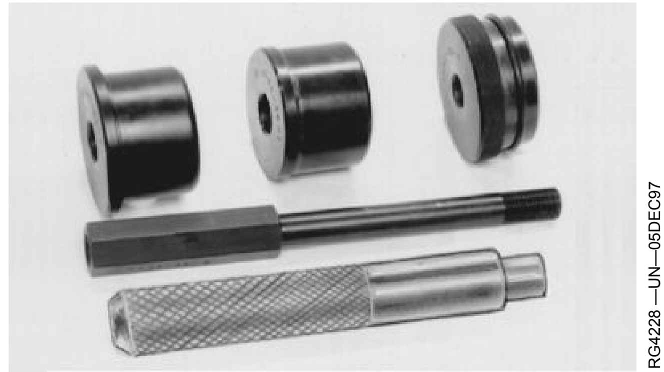
JDE6

Continued on next page

DPSG,OUO1004,838 -19-27APR99-7/10

Camshaft Bushing Service Set............................ JDG405

Used with JDG606 Camshaft Bushing Adapter Set and D102999AA Slide Hammer to service camshaft bushings. **JDE6 Service Set may be used along with JDG602 Adapter Set if JDG405 in not available.**

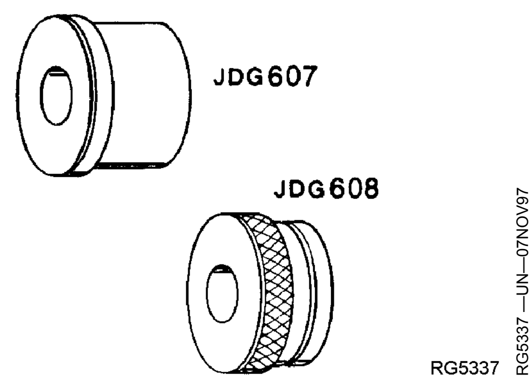


JDG405

DPSG,OUO1004,838 -19-27APR99-8/10

Camshaft Bushing Adapter Set JDG606

Used with JDG405 Camshaft Bushing Service Set and D01299AA Slide Hammer to service camshaft bushings. JDG606 consists of JDG607 Driver and JDG608 Pilot.



JDG606

DPSG,OUO1004,838 -19-27APR99-9/10

Slide Hammer... D01299AA

Used with JDG405 Camshaft Bushing Service Set and JDG606 Camshaft Bushing Adapter Set to service camshaft bushings.

D01299AA

DPSG,OUO1004,838 -19-27APR99-10/10

Group 050 — Camshaft and Timing Gear Train Other Materials

Number	Name	Use
51048 (LOCTITE®)	Moly Paste	Lubricate camshaft nose to provide lubrication to aid in camshaft gear installation.
TY6299 (U.S.)	PERMATEX® AVIATION (Form-A-Gasket No. 3)	Apply to camshaft bore steel cap plug.
TY6333 or TY6347 (U.S.)	High Temperature Grease	Used to lubricate camshaft lobes and thrust washer when installing camshaft.

LOCTITE is a registered trademark of Loctite Corp.
PERMATEX is a registered trademark of Loctite Corporation.

DPSG,OUO1004,840 -19-27APR99-1/1

Group 060 — Lubrication System Other Materials

Number	Name	Use
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Coat threads of oil filter adapter.
AVIATION (TY6299) (U.S.®)	Form-A-Gasket No. 3	Oil pan gasket surfaces.
TY9375 (U.S.) TY9480 (Canadian) 592 (LOCTITE®)	Pipe Sealant with TEFLON®	To seal oil pan elbow drain fitting.

LOCTITE is a registered trademark of Loctite Corp.
PERMATEX is a registered trademark of Loctite Corporation.
TEFLON is a registered trademark of Du Pont Co.

DPSG,OUO1004,846 -19-27APR99-1/1

Group 070 — Cooling System Other Materials

Number	Name	Use
TY6333 or TY6345 (U.S.)	High-Temperature Grease	Fan drive bearings.
TY9375 (U.S.) TY9480 (Canadian) 592 (LOCTITE®)	Pipe Sealant with TEFLON®	Coolant pump and block drain valves and coolant temperature switch.
T43512 (U.S.) TY9473 (Canadian) 242 (LOCTITE®)	Thread Lock and Sealer (Medium Strength)	Thermostat Housing-to-cylinder head cap screws.

LOCTITE is a registered trademark of Loctite Corp.
TEFLON is a registered trademark of Du Pont Co.

DPSG,OUO1004,849 -19-27APR99-1/1

Group 080 — Air Intake and Exhaust System Other Materials

Number	Name	Use
PT569 (U.S.)	NEVER-SEEZ® Compound	Turbocharger-to-exhaust manifold cap screws. Also apply to special flange head exhaust manifold cap screws when being reused.[1]

NEVER-SEEZ is a registered trademark of Emhart Chemical Group.

[1]Special flange head cap screws used on exhaust manifold have pre-applied anti-sieze compound. Reapply compound only when reusing cap screws.

DPSG,OUO1004,819 -19-21APR99-1/1

Group 100 — Starting and Charging Systems Essential Tools

NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

RE38635,0000017 -19-31MAY05-1/2

Starter Wrench JDG2046

Remove and install starter motor.

RG14234 —UN—31MAY05

Special Wrench - Starter Removal & Installation

RE38635,0000017 -19-31MAY05-2/2

Base Engine Diagnostic Tools

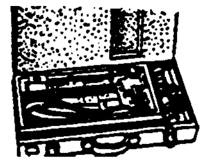
NOTE: Order tools according to information given in the U.S. SERVICEGARD™ Catalog or from the European Microfiche Tool Catalog (MTC).

SERVICEGARD is a trademark of Deere & Company

DPSG,OUO1004,201 -19-07JUL98-1/7

Compression Test Set JT01674
(formerly D14546BA or FKM10021)

Used to check cylinder compression pressure. Use adapter and gauge/hose assembly from set.

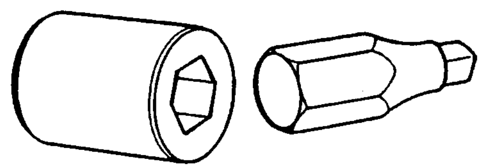


RG5161 —UN—23AUG88

DPSG,OUO1004,201 -19-07JUL98-2/7

Oil Galley Plug Tool JDG782

Used to remove and install oil galley plug when measuring engine oil pressure.

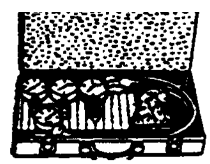


RG6612 —UN—29JAN93

DPSG,OUO1004,201 -19-07JUL98-3/7

Universal Pressure Test Kit JT05470
(formerly D15027NU or FKM10002)

Used for testing engine oil pressure, intake manifold pressure (turbo boost), and fuel supply pump pressure.



RG5162 —UN—23AUG88

DPSG,OUO1004,201 -19-07JUL98-4/7

Cooling System Pressure Pump....................... D05104ST

Used to pressure test radiator cap and cooling system.

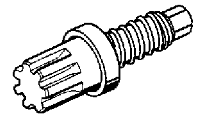
R26406N —UN—29NOV88

Continued on next page

DPSG,OUO1004,201 -19-07JUL98-5/7

Flywheel Turning Tool.. JDG820

Used to rotate engine flywheel to lock engine at "TDC" to check fuel injection pump timing. Use with JDE81-4 Timing Pin.

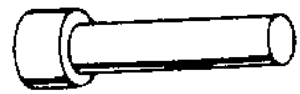


RG7056 —UN—17JUN05

DPSG,OUO1004,201 -19-07JUL98-6/7

Timing Pin..JDE81-4

Used to lock engine at "TDC". Use with JDG820 Flywheel Turning Tool.



RG5068

RG5068 —UN—05DEC97

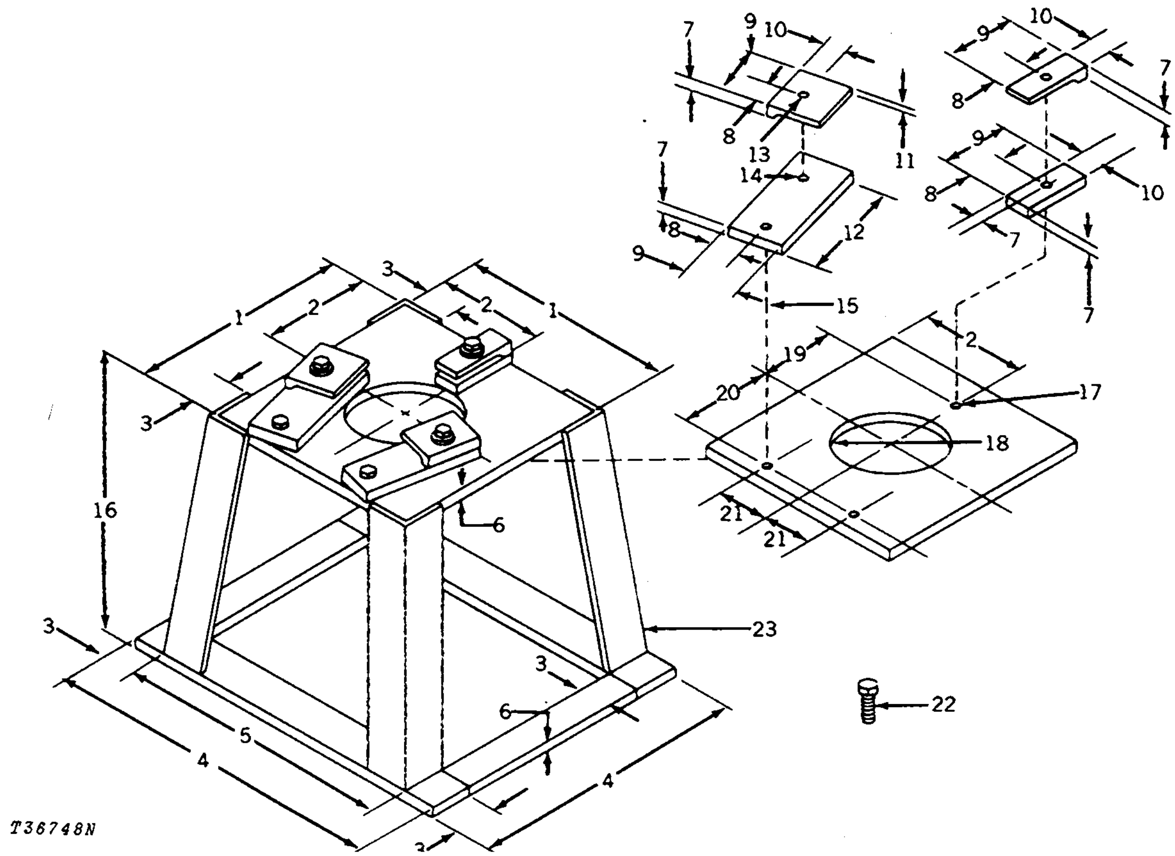
DPSG,OUO1004,201 -19-07JUL98-7/7

How to Make Tools

This tool can be made in a service shop using common shop tools and locally obtained materials.

RG,RG34710,1338 -19-11SEP08-1/1

DFRG3—Cylinder Liner Holding Fixture



Cylinder Liner Holding Fixture

1— 254.0 mm (10 in.)
2— 127.0 mm (5 in.)
3— 38.1 mm (1.5 in.)
4— 405.4 mm (16 in.)
5— 330.2 mm (13 in.)
6— 9.52 mm (0.38 in.)
7— 12.7 mm (0.5 in.)
8— 31.8 mm (1.25 in.)
9— 63.5 mm (2.5 in.)
10— 25.4 mm (1 in.)
11— 6.35 mm (0.25 in.)
12— 152.4 mm (6 in.)
13— 0.328 in. Drill Through
14— 5/16 in.—18 Tap
15— 2 used
16— 304.8 mm (12 in.)
17— 5/16 in.—18 Tap
18— 69.85 mm (2.75 in.) Radius
19— 101.6 mm (4 in.)
20— 111.25 mm (4.38 in.)
21— 60.45 mm (2.38 in.)
22— 5/16 in. x 1 in. Cap Screw
23— 38.1 mm (1.5 in.) Angle Iron

RG,RG34710,1339 -19-11SEP08-1/1

Section 06
Specifications

Contents

General OEM Engine Specifications

NOTE: For John Deere vehicle engines, see Machine Technical Manual.

ITEM	UNIT OF MEASURE	ENGINE MODEL 6090HF485
General Data		
Engine Type	——	In-line, 4 cycle diesel
Aspiration	——	Turbocharged and air-to-air after cooled
Number of Cylinders	——	6
Bore	mm (in.)	118.4 (4.66)
Stroke	mm (in.)	136.0 (5.35)
Displacement	L (cu in.)	9.0 (549)
Combustion System	——	Direct Injection
Compression Ratio	——	16:1
Physical Dimensions:		
Width	mm (in.)	630 (24.8)
Height	mm (in.)	1113 (43.8)
Length	mm (in.)	1210 (47.6)
Basic Dry Weight	kg (lb)	901 (1986)
Performance Data (Industrial Applications)		
Low Idle Speed	rpm	800
Fast Idle Speed	rpm	2180 OR 2380
Rated Speed	rpm	2000 or 2200
Performance Data (Generator Applications)		
Low Idle Speed	rpm	—
Fast Idle Speed	rpm	1590 or 1890
Rated Speed	rpm	1500 or 1800
Lubrication System		
Oil Pressure at Rated rpm	kPa (bar) (psi)	290 (2.9) (42)
Oil Pressure at Low Idle	kPa (bar) (psi)	170 (1.7) (25)
In-Crankcase Oil Temp at Rated rpm	°C (°F)	115°C (240°F)
Cooling System (Liquid, pressurized with centrifugal pump)		
Recommended Pressure Cap	kPa (psi)	100 (14.5)
Coolant Temperature Operating Range	°C (°F)	82°-94°C (180°-202F°)
Coolant Capacity	Liters (Qts)	16 (17)
Valve Actuation		
Valve Clearance (cold)		
Intake	mm (inch)	0.18 (.007)
Exhaust	mm (inch)	0.64 (.025)
Fuel System		
Injector Opening Pressure	kPa (psi)	ECU Programmed
Electrical System	**UNIT OF MEASURE**	**ENGINE MODEL 6090HF485**
Battery Capacity (minimum) - 12 Volt System	CCA	1100
Reserve Capacity - 24 Volt System	Minutes	250
Battery Capacity (minimum) - 24 Volt System	CCA	750
	Minutes	275

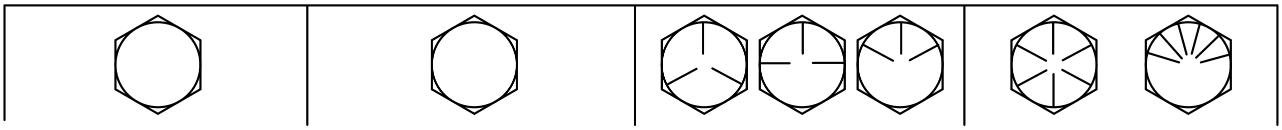
Continued on next page RE38635,00000E0 -19-12AUG11-1/2

ITEM	UNIT OF MEASURE	ENGINE MODEL 6090HF485
Air System		
Maximum Air Intake Restriction	in. H2O (kPa) (bar) (psi)	25 (6.25) (0.06) (1.0)

RE38635,00000E0 -19-12AUG11-2/2

Unified Inch Bolt and Screw Torque Values

TS1671 —UN—01MAY03



Bolt or Screw Size	SAE Grade 1				SAE Grade 2[a]				SAE Grade 5, 5.1 or 5.2				SAE Grade 8 or 8.2			
	Lubricated[b]		Dry[c]		Lubricated[b]		Dry[c]		Lubricated[b]		Dry[c]		Lubricated[b]		Dry[c]	
	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.
1/4	3.7	33	4.7	42	6	53	7.5	66	9.5	84	12	106	13.5	120	17	150
													N·m	lb.-ft.	N·m	lb.-ft.
5/16	7.7	68	9.8	86	12	106	15.5	137	19.5	172	25	221	28	20.5	35	26
									N·m	lb.-ft.	N·m	lb.-ft.				
3/8	13.5	120	17.5	155	22	194	27	240	35	26	44	32.5	49	36	63	46
			N·m	lb.-ft.	N·m	lb.-ft.	N·m	lb.-ft.								
7/16	22	194	28	20.5	35	26	44	32.5	56	41	70	52	80	59	100	74
	N·m	lb.-ft.														
1/2	34	25	42	31	53	39	67	49	85	63	110	80	120	88	155	115
9/16	48	35.5	60	45	76	56	95	70	125	92	155	115	175	130	220	165
5/8	67	49	85	63	105	77	135	100	170	125	215	160	240	175	305	225
3/4	120	88	150	110	190	140	240	175	300	220	380	280	425	315	540	400
7/8	190	140	240	175	190	140	240	175	490	360	615	455	690	510	870	640
1	285	210	360	265	285	210	360	265	730	540	920	680	1030	760	1300	960
1-1/8	400	300	510	375	400	300	510	375	910	670	1150	850	1450	1075	1850	1350
1-1/4	570	420	725	535	570	420	725	535	1280	945	1630	1200	2050	1500	2600	1920
1-3/8	750	550	950	700	750	550	950	700	1700	1250	2140	1580	2700	2000	3400	2500
1-1/2	990	730	1250	930	990	730	1250	930	2250	1650	2850	2100	3600	2650	4550	3350

Torque values listed are for general use only, based on the strength of the bolt or screw. DO NOT use these values if a different torque value or tightening procedure is given for a specific application. For plastic insert or crimped steel type lock nuts, for stainless steel fasteners, or for nuts on U-bolts, see the tightening instructions for the specific application. Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical grade.

Replace fasteners with the same or higher grade. If higher grade fasteners are used, tighten these to the strength of the original. Make sure fastener threads are clean and that you properly start thread engagement. When possible, lubricate plain or zinc plated fasteners other than lock nuts, wheel bolts or wheel nuts, unless different instructions are given for the specific application.

[a] *Grade 2 applies for hex cap screws (not hex bolts) up to 6 in. (152 mm) long. Grade 1 applies for hex cap screws over 6 in. (152 mm) long, and for all other types of bolts and screws of any length.*

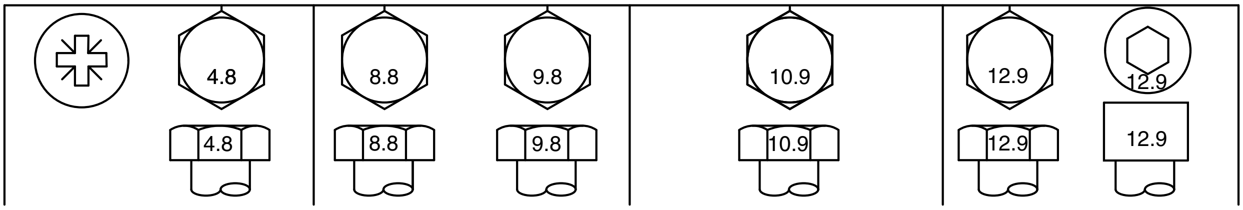
[b] *"Lubricated" means coated with a lubricant such as engine oil, fasteners with phosphate and oil coatings, or 7/8 in. and larger fasteners with JDM F13C, F13F or F13J zinc flake coating.*

[c] *"Dry" means plain or zinc plated without any lubrication, or 1/4 to 3/4 in. fasteners with JDM F13B, F13E or F13H zinc flake coating.*

DX,TORQ1 -19-12JAN11-1/1

Metric Bolt and Screw Torque Values

TS1670 —UN—01MAY03



Bolt or Screw Size	Class 4.8				Class 8.8 or 9.8				Class 10.9				Class 12.9			
	Lubricated[a]		Dry[b]		Lubricated[a]		Dry[b]		Lubricated[a]		Dry[b]		Lubricated[a]		Dry[b]	
	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.	N·m	lb.-in.
M6	4.7	42	6	53	8.9	79	11.3	100	13	115	16.5	146	15.5	137	19.5	172
									N·m	lb.-ft.	N·m	lb.-ft.	N·m	lb.-ft.	N·m	lb.-ft.
M8	11.5	102	14.5	128	22	194	27.5	243	32	23.5	40	29.5	37	27.5	47	35
			N·m	lb.-ft.	N·m	lb.-ft.	N·m	lb.-ft.								
M10	23	204	29	21	43	32	55	40	63	46	80	59	75	55	95	70
	N·m	lb.-ft.														
M12	40	29.5	50	37	75	55	95	70	110	80	140	105	130	95	165	120
M14	63	46	80	59	120	88	150	110	175	130	220	165	205	150	260	190
M16	100	74	125	92	190	140	240	175	275	200	350	255	320	235	400	300
M18	135	100	170	125	265	195	330	245	375	275	475	350	440	325	560	410
M20	190	140	245	180	375	275	475	350	530	390	675	500	625	460	790	580
M22	265	195	330	245	510	375	650	480	725	535	920	680	850	625	1080	800
M24	330	245	425	315	650	480	820	600	920	680	1150	850	1080	800	1350	1000
M27	490	360	625	460	950	700	1200	885	1350	1000	1700	1250	1580	1160	2000	1475
M30	660	490	850	625	1290	950	1630	1200	1850	1350	2300	1700	2140	1580	2700	2000
M33	900	665	1150	850	1750	1300	2200	1625	2500	1850	3150	2325	2900	2150	3700	2730
M36	1150	850	1450	1075	2250	1650	2850	2100	3200	2350	4050	3000	3750	2770	4750	3500

Torque values listed are for general use only, based on the strength of the bolt or screw. DO NOT use these values if a different torque value or tightening procedure is given for a specific application. For stainless steel fasteners or for nuts on U-bolts, see the tightening instructions for the specific application. Tighten plastic insert or crimped steel type lock nuts by turning the nut to the dry torque shown in the chart, unless different instructions are given for the specific application.

Shear bolts are designed to fail under predetermined loads. Always replace shear bolts with identical property class. Replace fasteners with the same or higher property class. If higher property class fasteners are used, tighten these to the strength of the original. Make sure fastener threads are clean and that you properly start thread engagement. When possible, lubricate plain or zinc plated fasteners other than lock nuts, wheel bolts or wheel nuts, unless different instructions are given for the specific application.

[a] *"Lubricated" means coated with a lubricant such as engine oil, fasteners with phosphate and oil coatings, or M20 and larger fasteners with JDM F13C, F13F or F13J zinc flake coating.*

[b] *"Dry" means plain or zinc plated without any lubrication, or M6 to M18 fasteners with JDM F13B, F13E or F13H zinc flake coating.*

DX,TORQ2 -19-12JAN11-1/1

Group 020 — Cylinder Head and Valves Repair Specifications

Item	Measurement	Specification
Intake Valve Clearance Check & Adjust (Rocker Arm-to-Valve Bridge With Engine Cold)	Clearance	0.13—0.23 mm (0.005—0.009 in.)
Exhaust Valve Clearance Check & Adjust (Rocker Arm-to-Valve Bridge With Engine Cold)	Clearance	0.58—0.69 mm (0.023—0.027 in.)
Valve Adjusting Screw Lock Nut	Torque	27 N•m (20 lb-ft)
Solenoid Wire Retaining Nuts	Torque	2.25 N•m (1.29 lb-ft)
Rocker Arm Cover Cap Screws	Torque	35 N•m (26 lb-ft)
Intake Valve	Lift	6.00—14.00 mm (0.250—0.550 in.) at 0.00 mm (in.)
Exhaust Valve	Lift	6.00—14.00 mm (0.250—0.550 in.) at 0.00 mm (in.)
Exhaust Valve	Recess	1.20—1.80 mm (0.047—0.071 in.) below cylinder head
Intake Valve	Recess	1.20—1.80 mm (0.047—0.071 in.) below cylinder head
Intake Valve Spring	Height	32.91 mm (1.30 in.)@728—804 N (160—177 lb-force) with valve open
	Height	45.0 mm (1.77 in.)@320—353 N (70—78 lb-force) with valve closed
Exhaust Valve Spring	Height	32.91 mm (1.30 in.)@728—804 N (160—177 lb-force) with valve open
	Height	45.0 mm (1.77 in.)@320—353 N (70—78 lb-force) with valve closed
Intake Valve Stem	OD	7.967—7.993 mm (0.3134—0.3145 in.)
Exhaust Valve Stem	OD	7.967—7.993 mm (0.3134—0.3145 in.)
Intake Valve Head	OD	39.87—40.13 mm (1.570—1.580 in.)
Exhaust Valve Head	OD	39.87—40.13 mm (1.570—1.580 in.)
Valve Face	Runout	0.05 mm (0.002 in.) maximum permissible
Valve Face (Intake and Exhaust)	Angle	29.25° ± 0.25°
Cylinder Head Plugs	Torque	60 Ṅ•m (44 lb-ft)
Cylinder Head	Maximum Acceptable Out-of-Flat Over Entire Length or Width	0.08 mm (0.003 in.)
	Straightness Per Any 305 mm (12 in.) Length	Within 0.025 mm (0.001 in.)
Cylinder Head	Thickness	105 nominal mm (4.134 in)
	Wear Limit	not available

Continued on next page

RE38635,000004F -19-23SEP09-1/2

Item	Measurement	Specification
	Combustion Face Surface Finish (Surface Mill Only to AA Finish)	1.5—2.8 micrometers (60—110 micro-in.)
	Maximum Wave Depth	0.012 mm (0.0005 in.)
Valve Guide	ID	8.017—8.043 mm (0.3156—0.3167 in.) in new head
New Guide-to-Exhaust Valve Stem	Clearance	0.050—0.076 mm (0.002—0.003 in.)
New Guide-to-Intake Valve Stem	Clearance	0.050—0.076 mm (0.002—0.003 in.)
Valve Seat	Angle	30° ± 0.50°
	Maximum Runout	0.065 mm (0.0025 in.)
Exhaust Valve Seat	Width	1.98—2.61 mm (0.080—0.103 in.)
Intake Valve Seat	Width	1.98—2.61 (0.080—0.103 in.)
Valve Seat Grinding	Angle	30° ± 0.25°
	Exhaust Width	1.98—2.61 mm (0.080—0.103 in.)
	Intake Width	1.98—2.61 mm (0.080—0.103 in.)
	Maximum Seat Runout	0.051 mm (0.0020 in.)
Oversize Inserts	not available	na
Liner	Height Above Block	0.051—0.127 mm (0.002—0.005 in.) above block
Cylinder Head Flanged-Head “SPECIAL” Cap Screws (No Washers)	Initial Torque	80 N•m (60 lb-ft)
Cylinder Head Flanged-Head “SPECIAL” Cap Screws (No Washers)	Final Torque	See Torque-to-Yield Procedure in this Group for Final Torque Specifications and Sequence
Initial Rocker Arm Pedestal-to-Cylinder Head Cap Screw	Torque	20 N•m (15 lb-ft)
Final Rocker Arm Pedestal-to-Cylinder Head Cap Screw	Torque Turn	Loosen one cap screw at a time 90° minimum, then torque to 40 N•m + additional 120° (30 lb-ft + 120°)
Rocker Arm Cover-to-Cylinder Head Cap Screw	Torque	35 N•m (26 lb-ft)
Intake Manifold-to-Cylinder Head	Torque	35 N•m (26 lb-ft)
Exhaust Manifold-to-Cylinder Head	Torque	70 N•m (52 lb-ft)
Turbocharger Cap Screws	Torque	40 N•m (30 lb-ft)
Turbocharger Oil Return Line-to-Turbocharger Cap Screws	Torque	35 N•m (26 lb-ft)

RE38635,000004F -19-23SEP09-2/2

Group 030 — Cylinder Block, Liners, Pistons and Rods Repair Specifications

Item	Measurement	Specification
Cylinder Liner Cap Screws (For Checking Standout)	Torque	68 N·m (50 lb-ft)
Cylinder Liners	Standout (Height Above Block)	0.051—0.127 mm (0.002—0.005 in.)
Maximum Piston Protrusion Above Block	Protrusion	0.051—0.787 mm (0.002—0.031 in.)
No. 1 Piston Compression Ring	End Gap	0.35—0.55 mm (0.014—0.021 in.)
No. 2 Piston Compression Ring	End Gap	0.73—0.99 mm (0.030—0.039 in.)
Piston Oil Control Ring-to-Groove	New Part Clearance	0.064—0.102 mm (0.0025—0.0040 in.)
	Maximum Serviceable Clearance	0.165 mm (0.0065 in.)
Cylinder Liner	Thickness	4.765—4.925 mm (0.188—0.194 in.)
	Packing Step Dimension	1.45—1.55 mm (0.057—0.061 in.)
Piston Skirt	OD 15.16 mm (0.597 in.) from Bottom of Piston	118.320—118.350 mm (4.658—4.659 in.)
Cylinder Liner	ID	118.390—118.410 mm (4.6610—4.6618 in.)
	OD (Coolant Jacket Area)	127.94—128.24 mm (5.037—5.049 in.)
	OD (At Upper Bore)	129.08—129.14 mm (5.082—5.084 in.)
	OD (At Lower Bore)	125.044—125.120 mm (4.923—4.926 in.)
	ID of Upper Bore in Block for Seating Liners	129.155—129.205 mm (5.085—5.087 in.)
	ID of Lower Bore in Block for Seating Liners	125.133—125.183 mm (4.9265—4.9285 in.)
	Liner-to-Block Clearance at Upper Bore	0.026—0.126 mm (0.001—0.005 in.)
	Liner-to-Block Clearance at Lower Bore	0.012—0.140 mm (0.0005—0.0055 in.)
	Maximum Out-of-Round	0.051 mm (0.0020 in.)
	Maximum Wear or Taper in Ring Travel Area	0.051 mm (0.0020 in.) maximum
Piston-to-Liner	New Part Clearance (At Bottom of Skirt)	0.076—0.124 mm (0.0030—0.0049 in.)
	Maximum Clearance	0.152 mm (0.0060 in.)
Cylinder Liner Flange	Thickness	11.989—12.039 mm (0.472—0.474 in.)
	OD	135.10—135.16 mm (5.319—5.321 in.)
Precision Joint™ Connecting Rod Cap Screw	Torque	95 N·m (71 lb-ft) plus 90–100° turn clockwise
Crankshaft Rod Journal	OD	83.482—83.508 mm (3.2867—3.2878 in.)
Assembled Connecting Rod Bearing	ID	83.537—83.589 mm (3.2889—3.2909 in.)
Connecting Rod Bearing-to-Journal (New Parts)	Oil Clearance	0.0254—0.102 mm (0.001—0.004 in.)
Connecting Rod Bore (Without Bearings)	ID	87.487—87.513 mm (3.444—3.445 in.)

Continued on next page RE38635,00000E1 -19-12AUG11-1/2

Item	Measurement	Specification
Connecting Rod Bore	Maximum Out-of-Round	0.025 mm (0.0010 in.)
Centerline of Piston Pin Bore-to-Crankshaft Bore	Dimension	217.95—218.05 mm (8.581—8.585 in.)
Piston Pin	OD	47.602—47.608 mm (1.8740—1.8743 in.)
Piston Pin Bore in Piston	ID	47.655—47.675 mm (1.8760—1.8770 in.)
Connecting Rod Pin-to-Bushing	Oil Clearance	0.042—0.084 mm (0.0017—0.0033 in.)
	Wear Limit	0.102 mm (0.0040 in.)
Connecting Rod Pin Bore	Diameter without Bushing	52.354—52.380 mm (2.0612—2.0622 in.)
Connecting Rod Pin Bore-to-Bushing	Press Fit	0.084—0.135 mm (0.0033—0.0053 in.)
Installed Service Connecting Rod Pin Bushing (Before Boring)	ID	47.58—47.63 mm (1.8732—1.8751 in.)
Installed Service Connecting Rod Pin Bushing (After Boring)	ID	47.655—47.681 mm (1.8762—1.8772 in.)
Cylinder Block Flange Counterbore	Depth	11.913—11.963 mm (0.469—0.471 in.)
Crankshaft Main Bearing	Bore ID without Bearing	101.651—101.67 mm (4.0020—4.0030 in.)
	Surface Width	36.28—36.78 mm (1.428—1.448 in.)
Crankshaft Thrust Bearing	Bore ID without Bearing	101.651—101.67 mm (4.0020—4.0030 in.)
	Surface Width (No. 5 Main)	37.44—37.54 mm (1.474—1.478 in.)
	Overall Cap Width	41.81—42.31 mm (1.646—1.666 in.)
Camshaft Follower	Bore ID in Block	27.550—28.600 mm (1.0846—1.1260 in.)
	Follower OD (New)	28.495—28.521 mm (1.1212—1.1229 in.)
	Follower-to-Bore Clearance	0.105 mm (0.004 in.)
Camshaft Bushing	Installed ID	67.064—67.114 mm (2.640—2.642 in.)
	Bushing Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
	Minimum Runout of Bore in Block	0.038 mm (0.0015 in.)
	Bushing-to-Journal Clearance	0.063—0.115 mm (0.0025—0.0045 in.)
Cylinder Block Top Deck	Maximum Out-of-Flat	0.10 mm (0.004 in.) over entire length or width
	Straightness	0.025 mm (0.001 in.) per any 305 mm (12.0 in) of Length
	Maximum Wave Depth	2.0 micrometers (79 micro-inch)
	Main Bearing Bore Centerline-to-Top Deck Distance	352.35—352.50 mm (13.872—13.878 in.)
Piston Cooling Orifice into Cylinder Block	Torque	16 Ṅ•m (12 lb-ft)

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Item	Measurement	Specification
Cylinder Liner Shim	not available	na

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RE38635,00000E1 -19-12AUG11-3/2

Group 040 — Crankshaft, Main Bearings and Flywheel Repair Specifications

Item	Measurement	Specification
Vibration Damper	Maximum Radial Runout	1.02 mm (0.040 in.)
Crankshaft	End Play	0.038—0.380 mm (0.0015—0.0150 in.)
Crankshaft Pulley	ID	47.594—47.630 mm (1.8738—1.8752 in.)
Crankshaft	OD for Front Pulley	47.650—47.676 mm (1.8759—1.8770 in.)
Crankshaft Front Oil Seal Bore in Timing Gear Cover	Maximum Radial Runout	0.254 mm (0.010 in.) Maximum
Front Oil Seal Installed Below Front Face of Seal Bore	Distance	8.9 mm (0.35 in.)
Flywheel Housing Face	Runout	0.20 mm (0.008 in.) Maximum Variation
Flywheel Face	Flatness	0.23 mm (0.009 in.) Maximum Variation
	Flatness	0.013 mm (0.0005 in.) Maximum Variation per 25 mm (1.0 in.) of Travel
Flywheel Pilot Bearing Bore	Concentricity	0.127 mm (0.005 in.) Maximum Variation
Crankshaft Dowel Pin	Protrusion	13.5—14.5 mm (0.53—0.57 in.) From Crankshaft Rear Flange
Crankshaft Main Bearing-to-Journal	Oil Clearance	0.030—0.107 mm (0.0012—0.0042 in.)
Crankshaft Main Bearing	ID With Bearing	95.270—95.320 mm (3.7508—3.7528 in.)
	ID Without Bearing	101.651—101.677 mm (4.0020—4.0030 in.)
Crankshaft Main Journal	OD	95.196—95.222 mm (3.7479—3.7490 in.)
Crankshaft Main Journal	Taper per 25.4 mm (1.0 in.) length	0.0025 mm (0.0001 in.)
	Out-of-Roundness	0.025 mm (0.0010 in.)
Crankshaft Main Bearing Cap	Surface Width	36.28—36.78 mm (1.428—1.448 in.)
Main Bearing Cap Bore	ID Without Bearings (Standard)	101.651—101.677 mm (4.0020—4.0030 in.)
	Diameter Variation	0.013 mm (0.0005 in.) maximum
	Diameter Taper	0.008 mm (0.0003 in.) maximum
	Straightness Variation (Any Bore-to-Adjacent Bore)	0.038 mm (0.0015 in.) maximum
	Straightness Variation (5 Center Bore-to-End Bore	0.076 mm (0.0030 in.) maximum
	Centerline of Bore-to-Top Deck	352.35—352.50 mm (13.872—13.878 in.)
Thrust Bearing Cap	Surface Width	37.44—37.54 mm (1.474—1.478 in.)
Thrust Bearing Cap	Overall Width	41.81—42.31 mm (1.646—1.666 in.)
Thrust Bearing Surface	Maximum Runout	0.25 mm (0.0010 in.)
Undersized Main Bearings Available	not available	na

Continued on next page RE38635,00000AB -19-05APR05-1/3

Item	Measurement	Specification
Undersized Rod (Pin) Journal Bearings Available	not available	N\A
Oversize Thrust Washer Available	not available	N\A
Crankshaft	End Play	0.038—0.380 mm (0.0015—0.0150 in.)
Piston Cooling Orifices into Cylinder Block	Torque	16 N•m (12 lb-ft.)
Crankshaft Main Bearing Cap Screws	Initial Torque	122 N•m (90 lb-ft)
Crankshaft Main Bearing Cap Screws	Final Torque Turn	Additional 120°
Oil Pump Drive Gear-to-Crankshaft	Backlash Clearance	0.38 mm (0.015 in.)
Crankshaft Rear Oil Seal Housing ID	Maximum Runout	0.100 mm (0.004 in.)
Rear Oil Seal Housing-to-Oil Pan Rail	Recess	0.000—0.050 mm (0.000—0.002 in.) Inside Block Oil Pan Rail
Rear Crankshaft Oil Seal Housing	Torque	27 N•m (20 lb-ft)
Rear Oil Seal & Wear Sleeve Assembly	Torque	2 N•m (1.5 lb-ft)
Timing Gear Cover-to-Cylinder Block Cap Screws[1]	Torque M8 Cap Screws	25 N•m (19 lb-ft)
	Torque M10 Cap Screws	41 N•m (30 lb-ft)
Injection Pump Gear Cover-to-Timing Gear Cover	Torque	31 N•m (23 lb-ft)
Coolant Pump Cover-to-Timing Gear Cover		
M8 Cap Screws	Torque	32 N•m (24 lb-ft)
M10 Cap Screws	Torque	47 N•m (35 lb-ft)
Front Oil Seal Installed Below Front Lip of Seal Bore	Recess	8.9 mm (0.35 in.)
Vibration Damper-to-Crankshaft Cap Screws	Torque	230 N•m (170 lb-ft)
Crankshaft Pulley-to-Damper Cap Screws (Single Dampers for Gen-Set Applications)	Torque	61 N•m (45 lb-ft)
Crankshaft Pulley-to-Damper Cap Screws (All Other Applications)	Torque	70 N•m (52 lb-ft)
Drive Hub-to-Flywheel Cap Screws	Torque	115 N•m (85 lb-ft)
Flywheel-to-Crankshaft Cap Screws (With Rear PTO)	Torque	162 N•m (120 b-ft)
SAE 2 (w/o Rear PTO) and SAE 3 Flywheel Housing-to-Cylinder Block Cap Screws	Torque	365 N•m (269 lb-ft)
SAE 3 Flywheel Housing-to-Oil Pan M12 Cap Screws	Torque	129 N•m (95 lb-ft)
SAE 3 Flywheel Housing-to-Oil Pan M10 Cap Screws	Torque	47 N•m (35 lb-ft)

Continued on next page

Item	Measurement	Specification
SAE 1 Flywheel Housing-to-Cylinder Block Cap Screws	Torque	365 N•m (269 lb-ft)

[1]*See INSTALL TIMING GEAR COVER, later in this group, for proper cap screw tightening sequence.*

RE38635,00000AB -19-05APR05-3/3

Group 050 — Camshaft and Timing Gear Train Repair Specifications

Item	Measurement	Specification
Intake Valve	Lift	13.53—13.71 mm (0.533—0.540 in.) at 0.00 mm (in.) clearance
	Wear Limit	12.65 mm (0.498 in.) at 0.00 mm (in.) clearance
Exhaust Valve	Lift	14.52—14.70 mm (0.572—0.579 in.) at 0.00 mm (in.) clearance
	Wear Limit	13.64 mm (0.537 in.) at 0.00 mm (in.) clearance
Camshaft	End Play	0.013—0.500 mm (0.0005—0.0200 in.) new
	Wear Limit	0.65 mm (0.0260 in.) maximum allowable
Camshaft Drive Gear-to-Crankshaft Gear	Backlash	0.076 mm (0.003 in.) min.
Auxiliary Drive Cover Cap Screws	Torque	47 N·m (35 lb-ft)
Auxiliary Drive Idler Housing-to-Timing Gear Cover (3/8 in.)	Torque	41 N·m (30 lb-ft)
Auxiliary Drive Idler Housing-to-Cylinder Block (3/8 in.)	Torque	41 N·m (30 lb-ft)
Auxiliary Drive Idler Housing-to-Cylinder Block (1/2 in.)	Torque	127 N·m (94 lb-ft)
Auxiliary Drive Idler Shaft Button Head Cap Screw	Torque	150 N·m (110 lb-ft)
Auxiliary Drive Idler Housing-to-Idler Bearing (5/16 in.)	Torque	27 N·m (20 lb-ft)
Auxiliary Drive Idler Gear-to-Crankshaft Gear	Backlash	0.11—0.7 mm (0.004—0.028 in.)
Camshaft Gear-to-Injection Pump Drive Gear Backlash	Backlash	0.051 mm (0.0020 in.) minimum
Thrust Washer	Thickness	2.24—2.34 mm (0.088—0.092 in.)
Camshaft Follower	OD	17.33—17.35 mm (0.682—0.683 in.)
Camshaft Follower Bore in Block	ID	17.384—17.440 mm (0.6845—0.6865 in.)
Camshaft Journal	OD	66.987—67.013 mm (2.6373—2.6383 in.) new
Camshaft Bushing	I.D.	67.076—67.102 mm (2.6408—2.6418 in.) new
Intake Camshaft Lobe	Lift	7.69—7.79 mm (0.303—0.307 in.)
	Wear Limit	7.19 mm (0.283 in.)
Exhaust Camshaft Lobe	Lift	8.25—8.35 mm (0.325—0.329 in.)
	Wear Limit	7.75 mm (0.305 in.)
Camshaft Gear Thrust Surfaces	Runout	0.10 mm (0.004 in.) maximum

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Item	Measurement	Specification
Camshaft Bushing	ID	67.076—67.102 mm (2.6408—2.6418 in.)
	Bore in Block	69.987—70.013 mm (2.7554—2.7564 in.)
Camshaft Bore	Runout	0.038 mm (0.0015 in.) maximum
Camshaft Journal	OD	66.987—67.013 mm (2.6373—2.6383 in.)
Camshaft Bushing-to-Journal	Oil Clearance	0.063—0.115 mm (0.0025—0.0045 in.)
Timing Gear Cover-to-Cylinder Block Cap Screws	Torque	27 N·m (20 lb-ft)
Coolant Pump Cover-to-Timing Gear Cover		
5/16-in. Cap Screws	Torque	27 N·m (20 lb-ft)
3/8-in. Cap Screws	Torque	47 N·m (35 lb-ft)
Injection Pump Drive Gear Cover	Torque	27 N·m (20 lb-ft)

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Group 060 — Lubrication System Repair Specifications

Item	Measurement	Specification
Engine Oil Pressure[1]	Oil Pressure - Low Idle	170 (1.7 bar) (25 psi)
	Oil Pressure - 2200 rpm (Tractors = 2100) Rated Speed Full Load	290 (2.9 bar) (42 psi)
Oil Filter Adapter-to-Cylinder Block (Top Load Oil Filter)	Initial Torque	5 Ṅ•m (4 lb-ft)
	Final Torque	36 N•m (27 lb-ft)
Oil Filter Bypass Valve Plug	Torque	23 N•m (17 lb-ft)
Oil Pressure Regulating Valve Plug	Torque	100 N·m (74 lb-ft)
Oil Cooler Adapter Cap Screws	Torque	47 N·m (35 lb-ft)
Oil Cooler Cover-to-Cylinder Block Cap Screws[2]	Torque	37 N·m (27 lb-ft)
Oil Pressure Regulating Valve	Operating Pressure (Starts to Operate)	340 kPa (3.4 bar) (49 psi)
Oil Filter Bypass Valve Spring	Compressed Length	30.0 mm (1.18 in.) @ 64—78 N (14—18 lb-force)
	Free Length	44.0 mm (1.73 in.)
Oil Filter Bypass Valve Plug	Torque	100 N·m (74 lb-ft)
Oil Filter Bypass Valve	Operating Pressure	220 kPa (2.20 bar) (32 psi)
Oil Cooler Bypass Valve Spring	Compressed Length	30.0 mm (1.18 in.) @ 64—78 N (14—18 lb-force)
	Free Length	44.0 mm (1.73 in.)
Oil Cooler Bypass Valve Plug	Torque	100 N·m (74 lb-ft)
Oil Cooler Bypass Valve	Operating Pressure	220 kPa (2.20 bar) (32 psi)
Crankshaft Spur Gear-to-Oil Pump Drive Gear	Backlash	0.10 mm (0.004 in.) minimum
Oil pump gear-to-crankshaft throw	Clearance	0.38 mm (0.0015 in.)
Oil Pump Drive Shaft	Maximum End Play	0.15 mm (0.006 in.)
Oil Pump Drive Shaft	Maximum Side Movement	0.17 mm (0.0065 in.)
Oil Pump Drive Gear	Backlash	0.33—2.00 mm (0.013—0.079 in.)
Oil Pump Cover-to-Housing	Torque	41 N•m (30 lb-ft)
Oil Pump Set Screw Lock Nut	Torque	8 N·m (6 lb-ft)
Oil Pump Intake (Pickup) Tube-to-Cover	Torque	41 N•m (30 lb-ft)
Oil Pump Housing-To-Cylinder Block	Torque	73 N•m (54 lb-ft)
Oil Pump Drive Gear Retaining Nut	Torque	54 N·m (40 lb-ft)
Oil Pump Outlet and Oil Cooler Cross-Over Tube-to-Cylinder Block Adapter (Internal)	Torque	54 N·m (40 lb-ft)
Turbo Oil Supply Line Brackets to Intake Manifold	Torque	35 N•m (26 lb-ft)
Oil Supply Line P Clamps	Torque	15 N•m (11 lb-ft)

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Item	Measurement	Specification
Oil Supply Line to Oil Filter Adapter	Torque	24 N•m (18 lb-ft)
Oil Pan M12 Cap Screws[3]	Torque	130 N•m (96 lb-ft)
Oil Pan M10 Cap Screws[3]	Torque	73 N•m (54 lb-ft)
Oil Pan Drain Plug Aluminum Pans	Torque	101 N•m (75 lb-ft)
Oil Pan Elbow Lock Nut	Torque	81 N•m (60 lb-ft)
Front Frame/Oil Sump (8030 Tractors) M12 Cap Screws[4]	Torque	133 N·m (98 lb-ft)
Front Frame/Oil Sump (8030 Tractors) M10 Cap Screws[4]	Torque	58 N·m (43 lb-ft)
Oil Pan Drain Plug Cast Iron Pans (Sumps)	Torque	47 N·m (35 lb-ft)

[1]Oil pressure with oil sump temperature of 105° C (220° F).
[2]Refer to REMOVE, INSPECT AND INSTALL ENGINE OIL COOLER, later in this group for cap screw tightening sequence.
[3]See INSTALL ENGINE OIL PAN later in this group, for cap screw tightening sequence.
[5]See TIGHTEN CAP SCREWS ON FRONT FRAME/OIL SUMP (8000 SERIES TRACTORS) later in this group, for cap screw tightening sequence.

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Group 070 — Cooling System Repair Specifications

Item	Measurement	Specification
Adjustable Fan Drive Housing	ID	71.999—72.025 mm (2.8346—2.8356 in.)
Adjustable Fan Drive Shaft	OD	35.001—35.017 mm (1.3780—1.3786 in.)
Adjustable Fan Drive Bearing	ID.	34.987—35.013 mm (1.3774—1.3785 in.)
	OD	71.987—72.013 mm (2.8341—2.8351 in.)
Adjustable Fan Drive Shaft	End Play	0.10 mm (0.004 in.)
Adjustable Fan Drive Housing Seal	Depth	Flush-to-0.50 mm (0.020 in.) below housing face
Fan/Hub Pulley-to-Fan Spacer Cap Screws	Torque	60 N·m (45 lb-ft)
Fan Hub/Pulley-to-Fan Shaft	Torque	80 N·m (60 lb-ft)
Fan Drive Support Plate-to-Engine		
M8 Mounting Cap Screws (To Injection Pump Access Cover)	Torque	24 N·m (18 lb-ft)
M8 Mounting Cap Screws (All Others)	Torque	35 N·m (26 lb-ft)
M10 Mounting Cap Screws	Torque	61 N·m (45 lb-ft)
M12 Mounting Cap Screws	Torque	101 N·m (74 lb-ft)
Thermostat Housing-Mounted Fixed Fan Drive Specifications		
Fixed Fan Drive Shaft	OD	25.387—25.400 mm (0.9995—1.0000 in.)
Fixed Fan Drive Bearing	OD	47.612—47.625 mm (1.8745—1.8750 in.)
Fixed Fan Drive Pulley (Bearing End)	ID	47.576—47.612 mm (1.8731—1.8745 in.)
[1]Fixed Fan Drive Pulley (Fan Spacer End)	ID	49.485—49.518 mm (1.9482—1.9495 in.)
[2]Fan Spacer	O.D.	49.457—49.483 mm (1.9471—1.9481 in.)
Fixed Fan Drive Manifold	I.D.	25.336—25.362 mm (0.9975—0.9985 in.)
Fixed Fan Drive Shaft (Installed)	Dimension From Manifold Mounting Face to End of Shaft	25.51—25.77 mm (1.004—1.015 in.)
Adjustable Fan Drive Housing Seal	Depth	Flush-to-0.50 mm (0.020 in.) below housing face
Fixed Fan Drive Bearing Shaft	Depth	33.31—33.57 mm (1.311—1.322 in.) below manifold mounting surface

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Item	Measurement	Specification
Fixed Fan Drive (Thermostat Housing Mounted) Cap Screws	Torque	60 N·m 45 (lb-ft)
Belt Tensioner Spring	Tension	24-28 N·m (17-21 lb-ft)
Fan-to-Fan Hub/Pulley	Torque	47 N•m (35 lb-ft)
Coolant Pump Cover Mounting Cap Screws		
M8 Mounting Cap Screw	Torque	32 N•m (24 lb-ft)
M10 Cap Screws	Torque	47 N•m (35 lb-ft)
Thermostat 82°C (180°F)	Opening Temperature	80—84°C (175—182°F)
Aluminum Thermostat Cover-to-Cylinder Head	Torque	30 N•m (22 lb-ft)
Thermostat Housing-to-Cylinder Head Cap Screws	Torque	61 N•m (45 lb-ft)
Coolant Temperature Sensor	Torque	40 N•m (30 lb-ft)

[1]*Units with press-fit fan spacer only.*
[2]*Units with press-fit fan spacer only.*

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Group 080 — Air Intake and Exhaust System Repair Specifications — PowerTech PSX

Item	Measurement	Specification
Turbocharger Shaft	Radial Bearing Clearance (Allowable Movement)	0.13—0.18 mm (0.005—0.007 in.)
Turbocharger Shaft	Axial Bearing End Play	0.064—0.114 mm (0.0025—0.0045 in.)
Turbocharger-to-Exhaust Manifold Cap Screws	Torque	40 N•m (30 lb-ft)
Turbocharger Oil Return Line	Torque	34 N·m (25 lb-ft)
Exhaust Manifold-to-Cylinder Head Cap Screws	Torque	70 N•m (52 lb-ft)
Intake Manifold-to-Cylinder Head	Torque	35 N•m (26 lb-ft)

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Group 081 — Air Intake and Exhaust System Repair Specifications — PowerTech PVX

Item	Measurement	Specification
Turbocharger Shaft	Radial Bearing Clearance (Allowable Movement)	0.13—0.18 mm (0.005—0.007 in.)
Turbocharger Shaft	Axial Bearing End Play	0.064—0.114 mm (0.0025—0.0045 in.)
Turbocharger-to-Exhaust Manifold Cap Screws	Torque	40 N•m (30 lb-ft)
Oil Supply Fitting	Torque	25 N•m (19 lb-ft)
Turbocharger Oil Return Line	Torque	35 N•m (25 lb-ft)
Exhaust Manifold-to-Cylinder Head Cap Screws	Torque	70 N•m (52 lb-ft)
Intake Manifold-to-Cylinder Head	Torque	35 N•m (26 lb-ft)
Intake Manifold-to-Cylinder Head - Short Cap Screws - 2nd Torque	Torque	45 N•m (33 lb-ft)

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OEM Starting and Charging Systems

Item	Measurement	Specification
Wiring Harness Adapter to Alternator Nut	Torque	2 N•m (1.47 lb-ft)
Alternator Mounting Cap Screw (lower cap screw)	Torque	50 N•m (37 lb-ft)
Alternator Strap to Alternator (upper cap screw)	Torque	50 N•m (37 lb-ft)
Alternator Strap to Thermostat Housing	Torque	35 N•m (26 lb-ft)
Starter Motor to Cylinder Block	Torque	47.5 N•m (35 lb-ft)

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Base Engine Diagnostic Specifications (Includes Dynamometer Specifications (OEM) and Turbocharger Boost Specifications)

Engine Compression Pressure

NOTE: Pressure should be checked on a cylinder to cylinder comparison basis, not as an absolute value per cylinder as done with older engine series. Refer to Service Advisor relative compression test for cylinder to cylinder test criteria.

Oil Pressure

	Specification
OIL PRESSURE SPECIFICATIONS—Minimum No Load at 800 rpm (Slow Idle)	170 kPa (1.70 bar) (25 psi)
Maximum Full Load at 2200 rpm (Rated Speed)	290 kPa (2.9 bar) (42 psi)

Thermostat

THERMOSTAT TEST SPECIFICATIONS

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

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Dynamometer Test Specifications

Power ratings for various injection pump options are provided for OEM applications on the charts that follow. For Construction Equipment applications, refer to SP458 Specifications Handbook. For North American Agricultural applications, refer to DB1216 Specifications Handbook.

NOTE: The power specifications shown apply to Waterloo-built OEM engines. Specifications are subject to change. Refer to factory DTAC for assistance.

Engine speeds listed are as preset to factory specification. In most cases, slow idle speed will be reset depending upon specific vehicle application requirements. Refer to your machine technical manual for engine speeds that are different from those preset at the factory.

Power ratings specify flywheel power without fan or accessories such as air compressor.

If specifications are not listed in handbooks, refer to factory DTAC for assistance.

POWER RATINGS ON DYNAMOMETER FOR OEM ENGINES[1]

Engine Model	Injection Pump Option Code	Rated Speed[2] (rpm)	Fast Idle[3] (rpm)	Slow Idle (rpm)	Power Rating kW (BHP)
6090HF485 Industrial Units	166L	2000	2180	800	168 (225)
	166M	2000	2180	800	168 (225)
	166N	2000	2180	800	168 (225)
	166P	2000	2180	800	168 (225)
	166R	2000	2180	800	168 (225)
	166S	2000	2180	800	168 (225)
	166T	2000	2180	800	168 (225)
	166U	2000	2180	800	168 (225)
	16GA	2200	2380	800	187 (250)
	16GB	2200	2380	800	187 (250)
	16GC	2200	2380	800	187 (250)
	16GD	2200	2380	800	187 (250)
	16JA, 16JB, 16JC, 16JD	2200 2200	2180 2380	800 800	205 (275)[4] 205 (275)[4]
		2200 2000	2180 2380	800 800	224 (300)[4] 224 (300)
		2000 2200	2180 2380	800 800	242 (325)[4] 242 (325)
		2000 2200	2180 2380	800 800	261 (350)[4] 261 (350)
		2200	2380	800	280 (375)
		2200	2380	800	298 (400)
Generator Sets					
6090HF485 Emission Non-Certified	1624	1500	1590		257 (345)
		1500	1590		288 (386)
6090HF485 Emission Certified		1800	1890		345 (462)

[1] Engine speeds listed are preset to factory specification for application. Therefore, speeds may vary depending upon specific vehicle application requirements. Refer to your machine operator's manual for engine speeds that are different from those preset at the factory.

[2] Generator set engines (3-5% governor) usually run at 1500 rpm (50 Hz) or 1800 (60 Hz) when operating under load depending on cycles of AC current.

[3] For engines with standard governor, fast idle is 7-10% above rated speed. For engines with generator set governors, fast idle is 3-5% above rated speed.

[4] These engines have a 7% power bulge which allows for INTERMITTENT operation of 7% above rated power.

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Intake Manifold Pressure (Turbocharger Boost) Specifications

TURBO BOOST PRESSURES (JOHN DEERE OEM/OUTSIDE EQUIPMENT MANUFACTURERS)			
Engine Number	**Rated Power at Full Load High Speed kW (hp)**	**Full Speed rpm**	**Turbo Boost Pressure at Full Load Full Speed kPa (bar) (psi)**
6090HF485 (Gen Set)	229 (307)	1800	186—200 kPa (1.86—2 bar) (27—29 psi)
	258 (346)	1800	225—244 kPa (2.25—2.44 bar) (33—35 psi)
	287 (385)	1800	246—256 kPa (2.46—2.56 bar) (36—37 psi)
	315 (422)	1800	256 (2.56) (37)
6090HF475 (Gen Set)	253 (339)	1500	169 (1.69) (25) (Standby)
	304 (408)	1500	214 (2.14) (31) (Standby)
6090HCQ01 (9670 STS)	227 (305)	2200	173 (1.73) (25)
6090HCQ01 (9770 STS)	268 (360)	2200	227 (2.27) (33)
6090HTJ03 (Feller Buncher)	213 (289)	2000	186 (1.86) (27)
6090HTJ03 (Feller Buncher)	230 (313)	2000	206 (2.06) (30)

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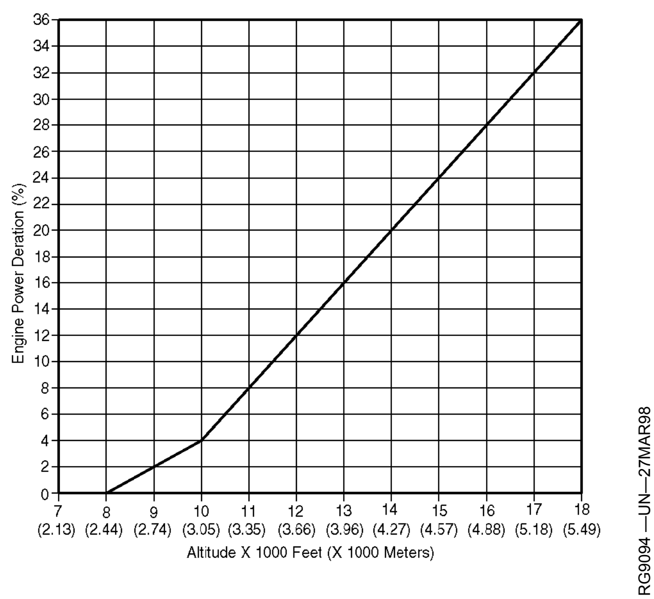
Effects of Altitude and Temperature on Engine Performance

Altitude, fuel temperature, air temperature, and humidity may affect engine performance. As a general rule, atmospheric changes will usually cause a decrease in engine power by the percentages shown in chart below.

ATMOSPHERIC CHANGE	% POWER DECREASE
Fuel Temperature Rise of 1°C (1.8°F) above 40° C (104°F)	0.29
Air Temperature Rise of 5.5°C (10°F) above 25°C (77°F)	0.50
Naturally Aspirated Engines: Altitude Rise of 300 m (1000 ft) above 180 m (600 ft)	3.00
Turbocharged Engines: Altitude Rise of 300 m (1000 ft) above 180 m (600 ft)	0.50
Relative Humidity Rise of 10% above 0%	0.07



Turbocharged Engines

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