# PowerTech Plus™ 9.0 L Tier 3/Stage IIIA OEM Diesel Engines Base Engine

## TECHNICAL MANUAL

## PowerTech Plus™ 9.0 L Tier 3/Stage IIIA OEM Diesel Engines — Base Engine

**CTM400 26APR06 (ENGLISH)**

**For complete service information also see:**

| | |
|---|---|
| **PowerTech Plus™ 9.0 L Diesel Engines— Level 14 Diagnostics - Electronic Fuel Systems with Denso HPCR. . . . . . . . . . . . . . .** | **CTM385** |
| **Alternators and Starting Motors . . . . . . . . . .** | **CTM77** |
| **OEM Engine Accessories . . . . . . . . . . . . . . . .** | **CTM67** |

TP-6458 4/06

**John Deere Power Systems**

LITHO IN U.S.A.

# Introduction

## Foreword

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

This manual (CTM400) covers only the base engine. It is one of three volumes on 9.0 L engines. The following two companion manuals cover fuel system repair and diagnostics:

- CTM385—Level 14 Diagnostics & Electronic Fuel Systems for Denso HPCR
- CTM77—Alternators & Starting Motors

Other manuals will be added in the future to provide additional information on electronic fuel systems as needed.

This manual covers the base engine for all 9.0 L engines.

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.

Use this component technical manual in conjunction with the machine technical manual. An application listing in the introduction identifies engine-models/applications. See the machine technical manual for information on engine removal and installation, and gaining access to engine components.

Information is organized in sections and groups for the various components requiring service instruction. At the end of the book are summary listings of all applicable essential tools, service equipment, and other materials needed to do the job, service parts kits, specifications, wear tolerance, and torque values.

Before beginning repair on an engine, clean the engine and mount on a repair stand. (See CLEAN ENGINE in Group 010 and see MOUNT ENGINE ON REPAIR STAND in Group 010..)

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.

Some components of this engine may be serviced without removing the engine from the machine. Refer to the specific machine technical manual for information on components that can be serviced without removing the engine from the machine and for engine removal and installation procedures.

Read each block of material completely before performing service to check for differences in procedures that apply to the engine model number you are working on. If only one procedure is given, that procedure applies to all the engines in the manual.

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 types 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.**

RE38635,0000075 –19–08FEB06–1/1

## 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—Base Engine
- CTM385—Level 14 Electronic Fuel Systems
- CTM77—Electrical (Starter & 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 03, GROUP 120 (Base Engine Operation)**

- 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 *POWERTECH*® 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.

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

- **CTM385 — 8.1 L Diesel Engines— Level 14Electronic Fuel Systems with Denso High Pressure Common Rail**

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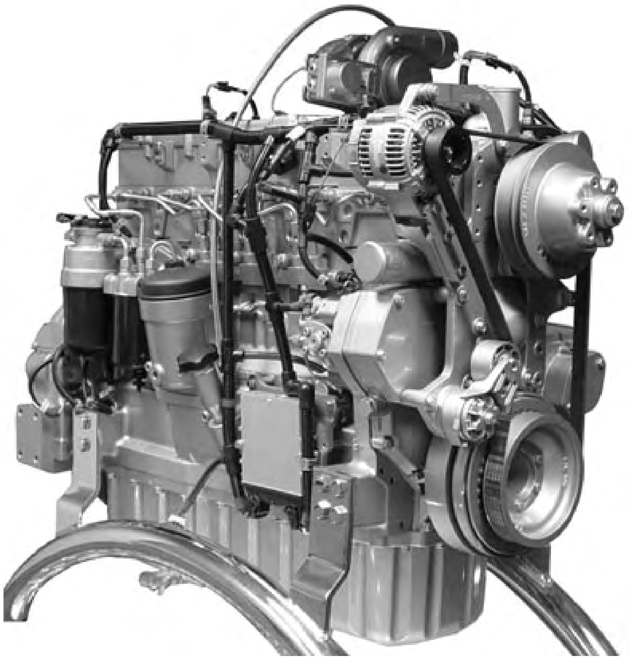
RE38635,0000076 –19–15MAR05–1/1

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

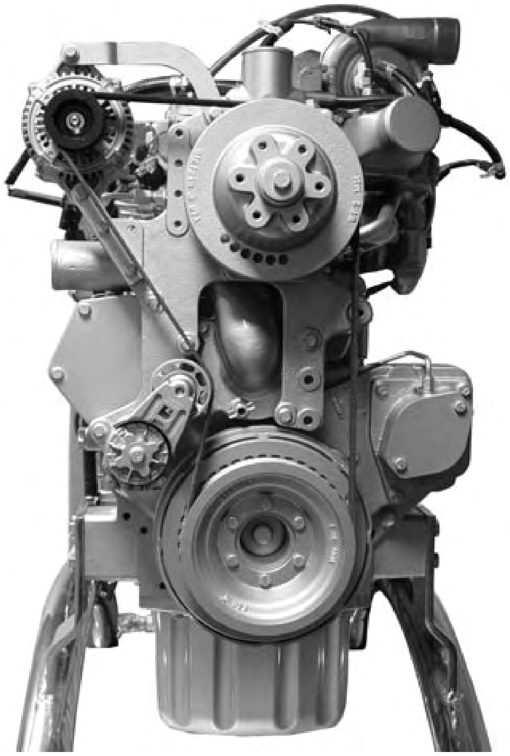


RG13848 –UN–24JAN05

9.0 L Diesel Engine Right Front View

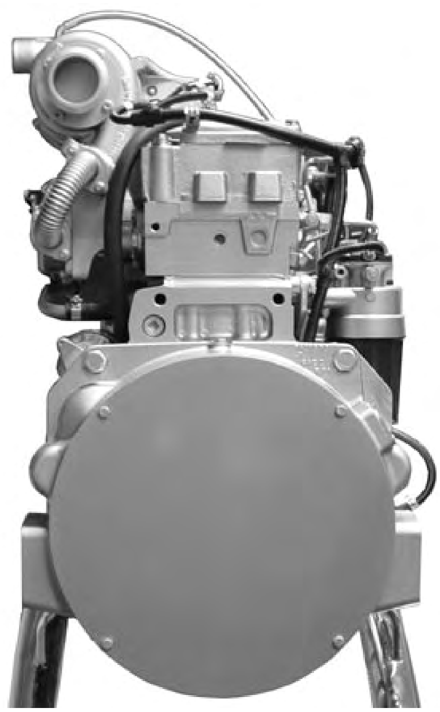
RG13847 –UN–24JAN05

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

RE38635,0000077 –19–01FEB06–1/1

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*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.*

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INDX

# Section 01
# General

## Contents

## Handle Fluids Safely—Avoid Fires

TS227 –UN–23AUG88

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.

DX,FLAME –19–29SEP98–1/1

## Handle Starting Fluid Safely

TS1356 –UN–18MAR92

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.

DX,FIRE3 –19–16APR92–1/1

01
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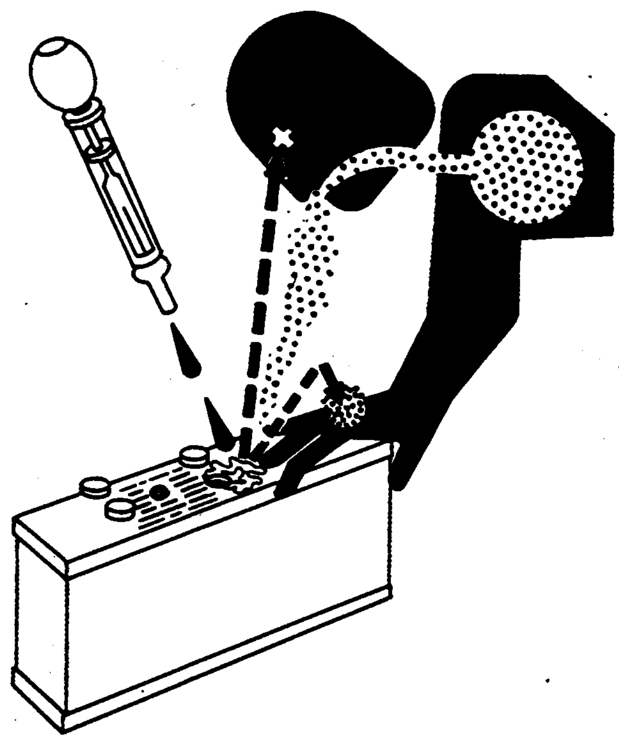
2

## Handling Batteries Safely


TS204 –UN–23AUG88


TS203 –UN–23AUG88

Continued on next page DPSG,OUO1004,2758 –19–22DEC05–1/2

**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.**

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

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

**Avoid the hazard by:**

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

**If you spill acid on yourself:**

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

**If acid is swallowed:**

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

**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.**

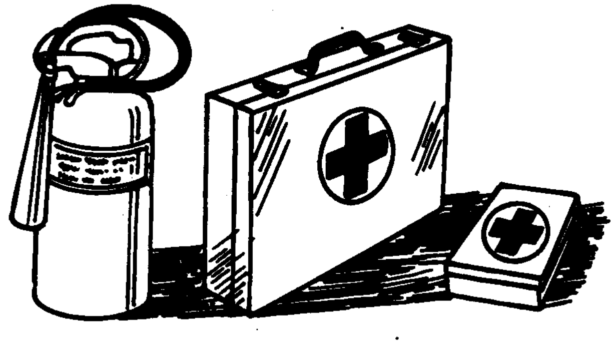
DPSG,OUO1004,2758 –19–22DEC05–2/2

## 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

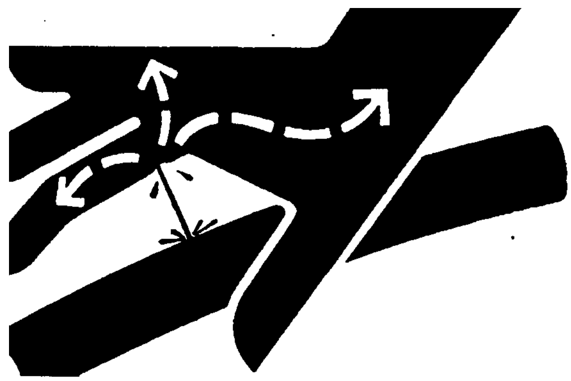
## Avoid High-Pressure Fluids

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.

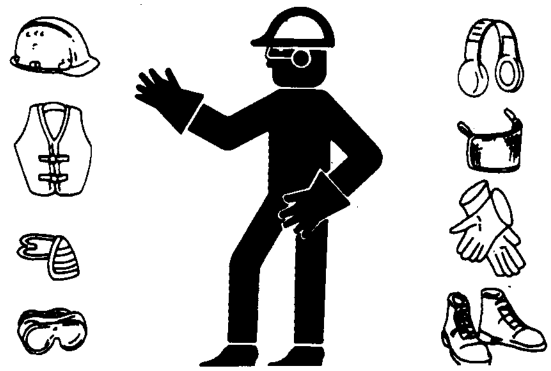
If an accident occurs, see a doctor immediately. Any fluid injected into the skin must be surgically removed within a few hours or gangrene may result. Doctors unfamiliar with this type of injury should reference a knowledgeable medical source. Such information is available from Deere & Company Medical Department in Moline, Illinois, U.S.A.



X9811 –UN–23AUG88

DX,FLUID –19–03MAR93–1/1

## Wear Protective Clothing



TS206 –UN–23AUG88

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

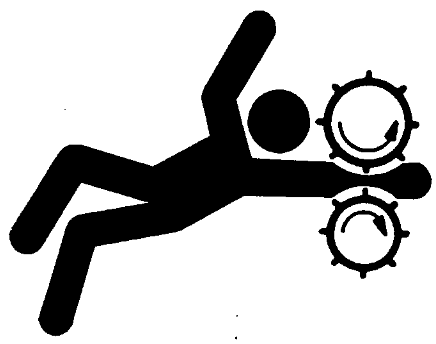
Prolonged exposure to loud noise can cause impairment or loss of hearing.

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.

DX,WEAR –19–10SEP90–1/1

## Service Machines Safely



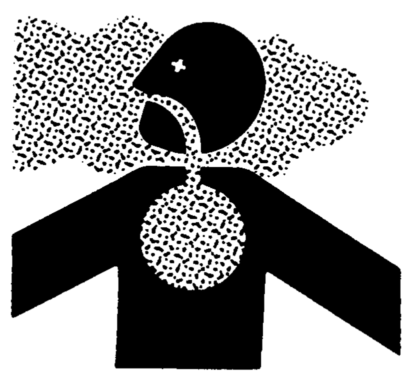
TS228 –UN–23AUG88

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.

DX,LOOSE –19–04JUN90–1/1

## Work In Ventilated Area



TS220 –UN–23AUG88

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.

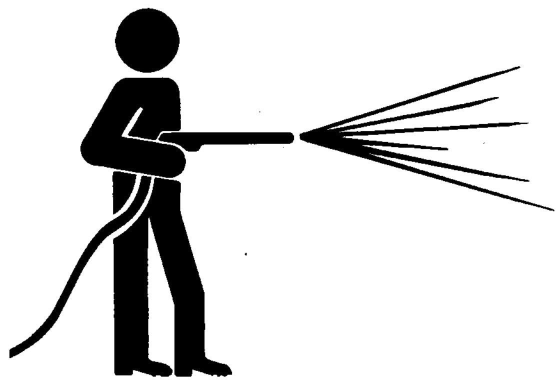
If you do not have an exhaust pipe extension, open the doors and get outside air into the area

DX,AIR –19–17FEB99–1/1

## 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.



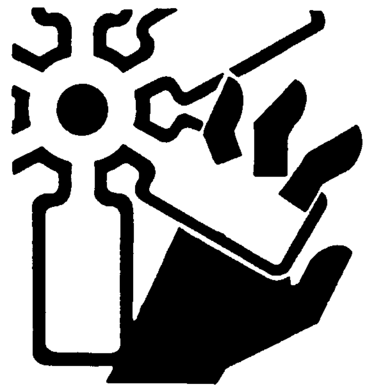
T6642EJ –UN–18OCT88

DX,CLEAN –19–04JUN90–1/1

## Install Fan Guards

Rotating cooling system fans can cause serious injury.

Keep fan guards in place at all times during engine operation. Wear close fitting clothes. Stop the engine and be sure fan is stopped before making adjustments or connections, or cleaning near the front of the engine.



*Rotating Fan*

TS677 –UN–21SEP89

OUOD006,000009D –19–04DEC02–1/1

## Avoid Hot Parts

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

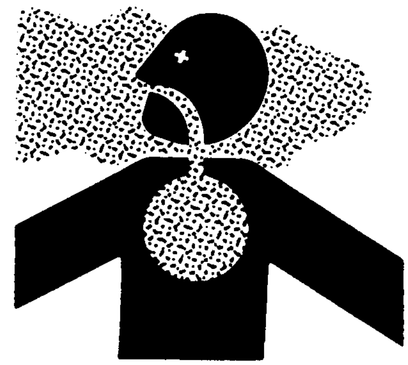
External dry exhaust parts become very hot during operation. Turbochargers may reach temperatures as high as 500°C (932°F) under full load, and naturally aspired exhaust manifolds may reach 600°C (1112°F) under full load. This may ignite paper, cloth or wooden materials. Parts on engines that have been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

*Hot Surface*

TS271 –UN–23AUG88

OUOD006,000009E –19–04DEC02–1/1

## Remove Paint Before Welding or Heating



TS220 –UN–23AUG88

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.

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

## Avoid Heating Near Pressurized Fluid Lines

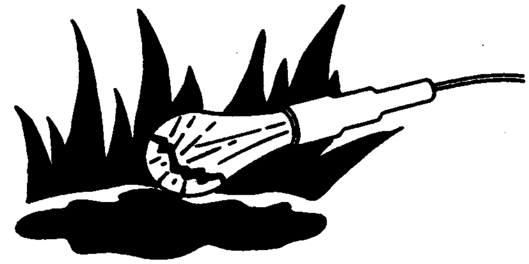
TS953 –UN–15MAY90

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.

DX,TORCH –19–10DEC04–1/1

## 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.



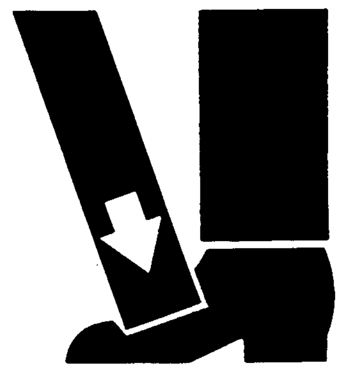
TS223 –UN–23AUG88

DX,LIGHT –19–04JUN90–1/1

## 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.



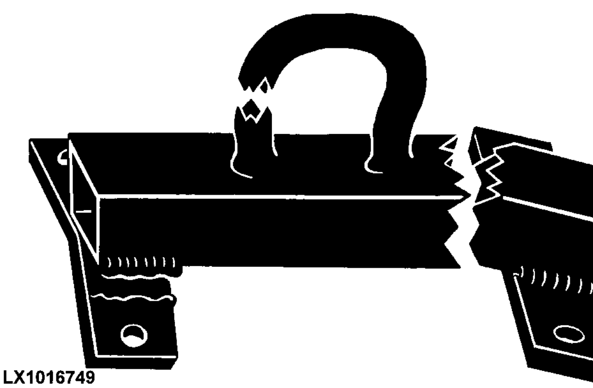
TS226 –UN–23AUG88

DX,LIFT –19–04JUN90–1/1

## Construct Dealer-Made Tools Safely

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.




*Construct Dealer-Made Tools Safely*

LX1016749 –UN–01JUL97

DPSG,OUO1004,899 –19–19MAY99–1/1

## 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

## Use Proper Tools

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

Use power tools only to loosen threaded parts and fasteners.

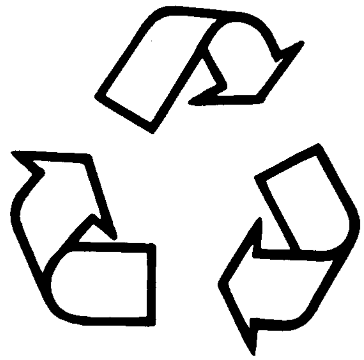
For loosening and tightening hardware, use the correct size tools. DO NOT use U.S. measurement tools on metric fasteners. Avoid bodily injury caused by slipping wrenches.

Use only service parts meeting John Deere specifications.

TS779 –UN–08NOV89

DX,REPAIR –19–17FEB99–1/1

## 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

## Live With Safety


TS231 –19–07OCT88

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

DX,LIVE –19–25SEP92–1/1

## Engine Model Designation

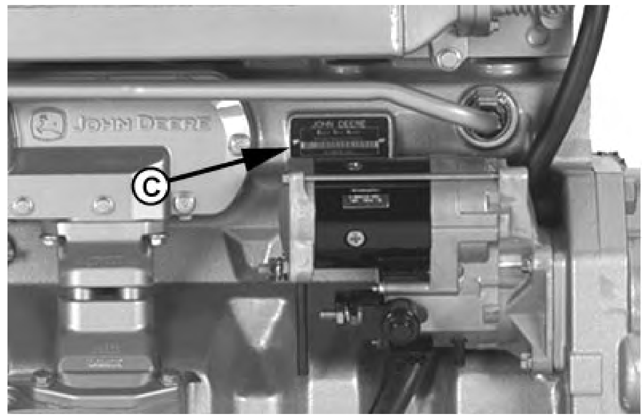
JOHN DEERE ENGINE MODEL—6090

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 ENGINE APPLICATION CHART, later in this Group


RG13814 –UN–11JAN05

*Engine Serial Number Plate*




RG13813 –UN–11JAN05

*Serial Number Plate Location*

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

RE38635,00000B5 –19–11APR05–1/1

## 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.**

### 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 ENGINE MODEL DESIGNATION.)
**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. SeeENGINE APPLICATION CHART later in this group.

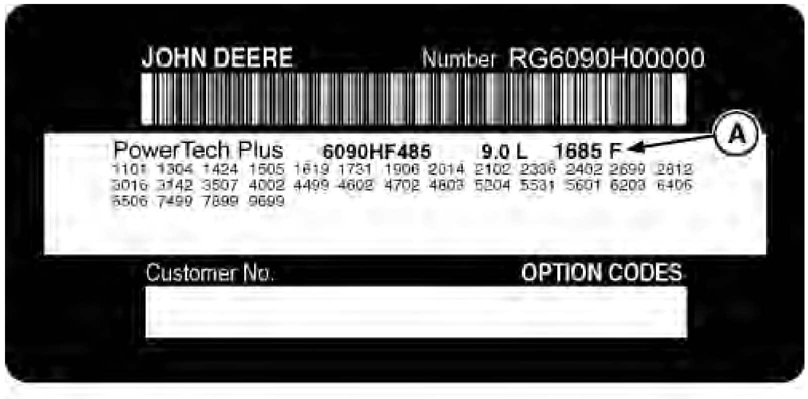

RG13814 –UN–11JAN05

*Engine Serial Number Plate*

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

RE38635,00000B6 –19–11APR05–1/1

## Engine Option Code Label




RG13820 –UN–11JAN05

*Option Code Label*

**A—Engine Base Code (Shown on Engine Option Code Label)**

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

RE38635,0000016 –19–31MAY05–1/1

## Engine Application Chart (Agricultural Equipment)

| Machine Model | Engine Model |
|---|---|
| **WATERLOO—TRACTORS** | |
| 8130MFWD | 6090HRW01, 06 |
| 8230MFWD/8330MFWD | 6090HRW02 |
| 8430MFWD | 6090HRW04 |
| 8430/8530 | 6090HRW08 |
| 8130ILS | 6090HRW10 |
| 8230/8339ILS | 6090HRW11 |
| 8430/8530ILS | 6090HRW13 |
| **HARVESTER—COMBINES** | |
| 9760STS/9780CTSE | 6090HH001 |
| 9660STS/9660E | 6090HH002 |
| 9660STS/9760STS | 6090HH005 |
| **DES MOINES - SPRAYERS** | |
| 4930 | 6090HN001 |

RE38635,0000079 –19–23SEP05–1/1

## Engine Application Chart (Construction & Forestry Equipment

**Machine Model** **Engine Model**

**DUBUQUE/DAVENPORT**

850H/850J Crawler Dozer .................................................. 6090HT001
330CLC/370C Excavator ............. 6090HT002
724/744/824 Wheel Loader .......... 6090DW03
1470 Harvester ............................ 6090HTJ05

RE38635,000007A –19–01FEB06–1/1

## Engine Application Chart (OEM) (Outside Equipment Manufacturers)

**Application** **Engine Model**

OEM Engine (Tier 3 / Stage IIIA) ...................................... 6090HF485

RE38635,00000B9 –19–11APR05–1/1

## 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 5°C (40°F), winter grade fuel (Grade No. 1-D fuel 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 temperature at which fuel begins to thicken and becomes more resistant to flow through fuel pumps and lines.

*NOTE: On an average, winter grade 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 to aid cold weather starting.

**CAUTION: Do not use any starting fluid with an air intake heater.**

**Starting Fluid**

A starting fluid port on the intake is available to aid cold weather starting.

**CAUTION: Do not use any starting fluid with an engine equipped with glow plugs**

**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 ion the expected air temperature range between oil changes and proper concentration of low silicate antifreeze as recommended. (See DIESEL ENGINE OIL and ENGINE COOLANT requirements this section.)

**Diesel Fuel Flow Additive**

Use John Deere Premium Diesel Fuel Conditioner (Winter) or equivalent to treat fuel during the cold weather season. This winter formulation is a combination diesel fuel conditioner and anti-gel additive.

**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.**

**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.

Continued on next page

DX,FUEL10 –19–16DEC05–1/2

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 –19–16DEC05–2/2

## Diesel Engine Oil and Filter Service Intervals

The oil and filter service intervals in the table below should be used as guidelines. Actual service intervals also depend on operation and maintenance practices. It is suggested to use oil analysis to determine the actual useful life of the oil and to aid in selection of the proper oil and filter service interval.

Oil and filter service intervals are based on a combination of oil pan capacity, type of engine oil and filter used, and sulfur content of the diesel fuel.

| Engine Oil and Filter Service Intervals | | |
|---|---|---|
| | **Standard Drain Oil Pan** | **Extended Drain Oil Pan** |
| **Fuel Sulfur** | Less than 0.05% (500 ppm) | |
| Standard Oil | 250 hours | 250 hours |
| Premium Oil | 375 hours | 500 hours |
| **Fuel Sulfur** | 0.05 to 0.50% (500 to 5000 ppm) | |
| Standard Oil | 150 hours | 150 hours |
| Premium Oil | 275 hours | 400 hours |
| **Fuel Sulfur** | 0.50% to 1.00% (5000 ppm to 10 000 ppm) | |
| Standard Oil | 125 hours | 125 hours |
| Premium Oil | 187 hours | 250 hours |

Diesel fuel sulfur level will affect engine oil and filter service intervals. Higher fuel sulfur levels reduce oil and filter service intervals as shown in the table.

- Use of diesel fuel with sulfur content less than 0.10% (1000 ppm is strongly recommended.)
- Use of diesel fuel with sulfur content 0.10% (1000 ppm) to 0.50% (5000 ppm) may result in REDUCED oil and filter change intervals as shown in the table.
- BEFORE using diesel fuel with sulfur content greater than 0.50% (5000 ppm), contact your John Deere dealer.

**Oil types** (premium or standard) in the table include:

- “Premium Oils” include John Deere PLUS-50™, ACEA E7, or ACEA E6 oils.
- “Standard Oils” include John DeereTORQ-GARD SUPREME™, API CI-4 PLUS, API CI-4, API CH-4, ACEA E5, or ACEA E4, or ACEA E3 oils.

The 500 hour extended oil and filter change interval is only allowed if all of the following conditions are met:

- Engine equipped with an extended drain interval oil pan
- Use of diesel fuel with sulfur content less than 0.05% (500 ppm)
- Use of premium oil John Deere PLUS-50, ACEA E7 or ACEA E6 and approved John Deere oil filter

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

DX,ENOIL12 –19–19DEC05–1/1

## 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.

**Required fuel properties**

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

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

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

**Fuel lubricity** should pass a minimum level of 3100 grams as measured by ASTM D6078 or maximum scar diameter of 0.45 mm as measured by ASTM D6079 or ISO 12156-1.

**Sulfur content:**

- Diesel fuel quality and fuel sulfur content must comply with all existing emissions regulations for the area in which the engine operates.
- Use of diesel fuel with sulfur content less than 0.10% (1000 ppm) is STRONGLY recommended.
- Use of diesel fuel with sulfur content 0.10% (1000 ppm to 0.50% (5000 ppm) may result in REDUCED oil and filter change intervals.
- BEFORE using diesel fuel with sulfur content greater than 0.50% (5000 ppm), contact your John Deere dealer.
- DO NOT use diesel fuel with sulfur content greater than 1.0%.

**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 –19–17NOV05–1/1

## Testing Diesel Fuel

DIESELSCAN™ is a John Deere fuel analysis program that can be used to monitor the quality of your fuel. The DIESELSCAN analysis verifies fuel type, cleanliness, water content, suitability for cold weather operation, and whether the fuel meets specifications.

Check with your John Deere dealer for availability of DIESELSCAN kits.

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DX,FUEL6 –19–14NOV05–1/1

## Bio-Diesel Fuel

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

Bio-diesel fuels may be used ONLY if the bio-diesel fuel properties meet the latest edition of ASTM PS121, DIN 51606 or equivalent specification.

It has been found that bio-diesel fuels may improve lubricity in concentrations up to a 5% blend in petroleum diesel fuel.

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

**IMPORTANT: Raw pressed vegetable oils are NOT acceptable for use for fuel in any concentration in John Deere engines.**

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

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

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

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

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

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## Handling and Storing Diesel Fuel

**CAUTION: 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 bio-diesel 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 –19–19DEC03–1/1

## 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 minimum load level of 3100 grams as measured by ASTM D6078 or 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 PREMIUM DIESEL FUEL CONDITIONER (or equivalent) at the specified concentration.

DX,FUEL5 –19–27OCT05–1/1

## Diesel Engine Break-In Oil

New engines are filled at the factory with John Deere ENGINE BREAK-IN OIL. During the break-in period, add John Deere ENGINE BREAK-IN OIL as needed to maintain the specified oil level.

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

After engine overhaul, fill the engine with John Deere ENGINE BREAK-IN OIL.

If John Deere ENGINE BREAK-IN OIL is not available, use a diesel engine oil meeting one of the following during the first 100 hours of operation:

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

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

**IMPORTANT: Do not use PLUS-50 oil or engine oils meeting any of the following during the first 100 hours of operation of a new or rebuilt engine:**

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

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

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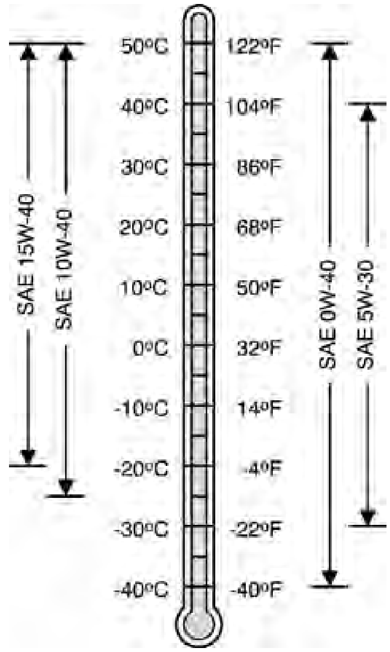
DX,ENOIL4 –19–19DEC05–1/1

## Diesel Engine Oil




TS1675 –UN–31OCT03

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

**John Deere PLUS-50™ oil is preferred.**

Oil meeting one of the following specifications are also recommended:

- ACEA Oil Sequence E7
- ACEA Oil Sequence E6
- ACEA Oil Sequence E5
- ACEA Oil Sequence E4

Extended service intervals may apply when John Deere PLUS-50™, ACEA E7, ACEA E6, ACEA E5, or ACEA E4 engine oils are used. Consult your John Deere dealer for more information.

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

- John Deere TORQ-GARD SUPREME™
- API Service Category CI-4 PLUS
- API Service Category CI-4
- API Service Category CH-4
- ACEA Oil Sequence E3

**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 1.0% (10 000 ppm).

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*TORQ-GARD SUPREME is a trademark of Deere & Company*

DX,ENOIL7 –19–23NOV05–1/1

## Extended Diesel Engine Oil Service Intervals

When John Deere PLUS-50™, ACEA E7, ACEA E6, ACEA E5, or ACEA E4 oils are used with specified John Deere filter, the service interval for engine oil and filter changes may be increased by 50% but not to exceed a maximum of 500 hours.

If John Deere PLUS-50, ACEA E7, ACEA E6, ACEA E5, or ACEA E4 oils are used with other than the specified John Deere filter, change the engine oil and filter at the normal service interval.

If John Deere TORQ-GARD SUPREME™, API CI-4 PLUS, API CI-4, API CH-4, or ACEA E3 oils are used, change the engine oil and filter at the normal service interval.

If API CG-4, API CF-4, or ACEA E2 oils are used, change the engine oil and filter at 50% of the normal service interval.

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*TORQ-GARD SUPREME is a trademark of Deere & Company*

DX,ENOIL6 –19–19DEC05–1/1

## 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 oils.

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

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## 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.

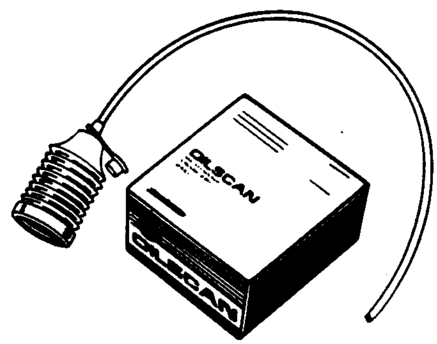
DX,LUBMIX –19–18MAR96–1/1

## OILSCAN® and CoolScan®

OILSCAN® and CoolScan® are John Deere sampling programs to help you monitor machine performance and identify potential problems before they cause serious damage.

Oil and coolant samples should be taken from each system prior to its recommended change interval.

Check with your John Deere dealer for the availability of OILSCAN® and CoolScan® kits.

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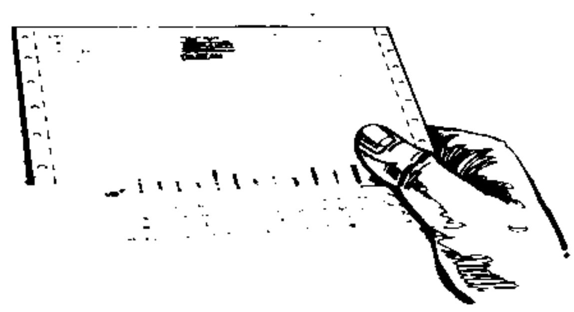

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*CoolScan is a registered trademark of Deere & Company.*

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## 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.**

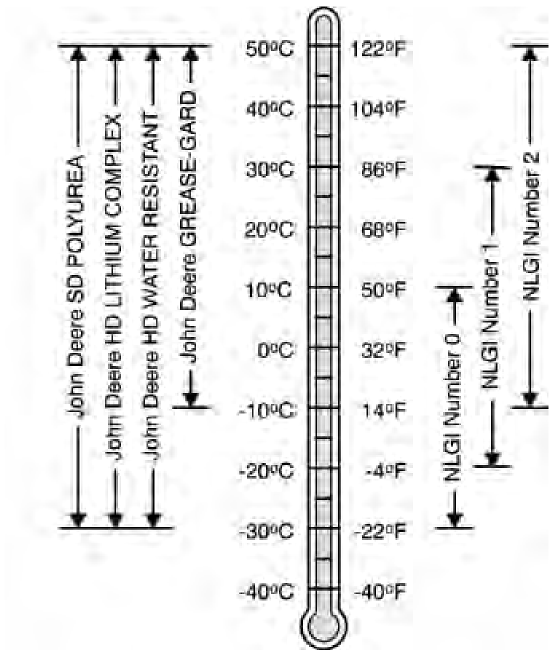
The following greases are also recommended

- John Deere HD LITHIUM COMPLEX GREASE
- John Deere HD WATER RESISTANT GREASE
- John Deere GREASE-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**

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*GREASE-GARD is a trademark of Deere & Company*

DX,GREA1 –19–07NOV03–1/1

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

**John Deere COOL-GARD™ Prediluted Coolant is preferred for service.**

John Deere COOL-GARD Prediluted Coolant is available in a concentration of either 50% ethylene glycol or 55% propylene glycol.

**Additional recommended coolants**

The following engine coolant is also recommended:

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

John Deere COOL-GARD coolants do not require use of supplemental coolant additives, except for periodic replenishment of additives during the drain interval.

**Other fully formulated coolants**

Other fully formulated low silicate ethylene or propylene glycol base coolants for heavy-duty engines may be used if they meet one of the following specifications:

- ASTM D6210 prediluted (50%) coolant
- ASTM D6210 coolant concentrate in a 40% to 60% mixture of concentrate with quality water

Coolants meeting ASTM D6210 do not require use of supplemental coolant additives, except for periodic replenishment of additives during the drain interval.

**Coolants requiring supplemental coolant additives**

Other low silicate ethylene glycol base coolants for heavy-duty engines may also be used if they meet one of the following specifications:

- ASTM D4985 ethylene glycol base prediluted (50%) coolant
- ASTM D4985 ethylene glycol base coolant concentrate in a 40% to 60% mixture of concentrate with quality water

Coolants meeting ASTM D4985 require an initial charge of supplemental coolant additives, formulated for protection of heavy duty diesel engines against corrosion and cylinder liner erosion and pitting. They also require periodic replenishment of additives during the drain interval.

**Other coolants**

It is possible that neither John Deere COOL-GARD nor coolants meeting one of the coolant standards listed above is available in the geographical area where service is performed. If these coolants are unavailable, use a coolant concentrate or prediluted coolant with a quality additive package that provides cylinder liner cavitation protection and 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% to 60%) coolant
- ethylene glycol or propylene glycol base coolant concentrate in a 40% to 60% mixture of concentrate with quality water

**Water quality**

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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,COOL3 –19–27OCT05–2/2

## Diesel Engine Coolants, Supplemental Additive Information

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

### Coolant Specifications

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

Some coolant concentrates, including John Deere COOL-GARD Coolant Concentrate, contain both ethylene glycol antifreeze and inhibiting coolant additives. Mix these products and quality water, but do not add an initial charge of supplemental coolant additives.

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

### Replenish Coolant Additives

The concentration of coolant additives is gradually depleted during engine operation. Periodic replenishment of inhibitors is required, even when John Deere COOL-GARD is used. Follow the recommendations in this manual for the use of supplemental coolant additives.

### Why Use Supplemental Coolant Additives?

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

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

### Avoid Automotive-Type Coolants

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

### Non-Aqueous Propylene Glycol

Non-aqueous propylene glycol should not be used with John Deere diesel engines. This coolant works best with coolant temperatures above the acceptable engine operating range. This could decrease engine life due to lower engine oil viscosity. In addition, electronically controlled engines could experience premature power de-rate due to high coolant temperature.

### Water Quality

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

| | |
|---|---|
| Chlorides | 40 mg/L or less |
| Sulfates | 100 mg/L or less |
| Total Dissolved Solids | 340 mg/L or less |
| Total Hardness | 170 mg/L or less |
| pH Level | 5.5 to 9.0 |

### Freeze Protection

The relative concentrations of ethylene glycol and water in the engine coolant determine its freeze protection limit. Refer to the chart on the following page.

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

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

DPSG,OUOD002,1835 –19–03AUG00–2/2

## 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.

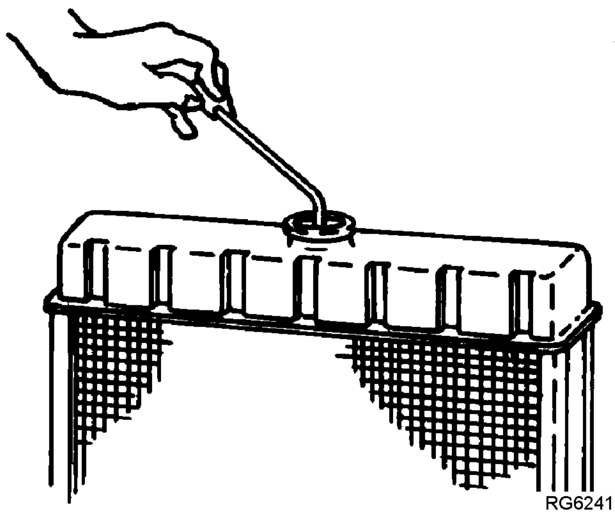
Compare the results to the supplemental coolant additive (SCA) chart to determine the amount of inhibiting additives in your coolant and whether more John Deere COOLANT CONDITIONER should be added.

**CoolScan**

For a more thorough evaluation of your coolant, perform a CoolScan analysis. See your John Deere dealer for information about CoolScan.

DPSG,OUOD002,1825 –19–02AUG00–1/1

## Replenishing Supplemental Coolant Additives (SCAs) Between Coolant Changes



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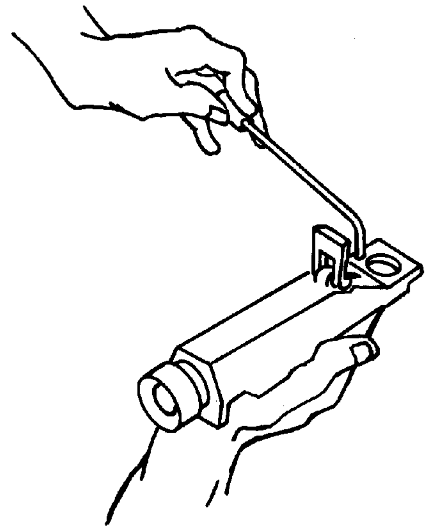

RG6262

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**IMPORTANT: Do not add supplemental coolant additives when the cooling system is drained and refilled with John Deere ANTIFREEZE/SUMMER COOLANT or John Deere COOL-GARD®.**

*NOTE: If a system is to be filled with coolant that does not contain SCAs, the coolant must be precharged. Determine the total system capacity and premix with 3% John Deere Coolant Conditioner.*

Through time and use, the concentration of coolant additives is gradually depleted during engine operation. Periodic replenishment of inhibitors is required, even when John Deere ANTIFREEZE/SUMMER COOLANT is used. The cooling system must be recharged with additional supplemental coolant additives available in the form of liquid coolant conditioner.

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

**John Deere LIQUID COOLANT CONDITIONER is recommended as a supplemental coolant additive in John Deere engines.**

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

Test the coolant solution at 600 hours or 12 months of operation using either John Deere coolant test strips or a COOLSCAN® analysis. If a COOLSCAN® analysis is not available, recharge system per instructions printed on label of John Deere Liquid Coolant Conditioner.

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*COOLSCAN is a registered trademark of Deere & Company.*

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RG,01,DT7035 –19–14NOV00–1/2

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

**If frequent coolant makeup is required, the glycol concentration should be checked with JT07298 Coolant/Battery Tester to ensure that the desired freeze point is maintained. Follow manufacturer's instructions provided with Coolant/Battery Tester.**

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

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

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

See DIESEL ENGINE COOLANTS, SUPPLEMENTAL ADDITIVE INFORMATION earlier in this group for proper mixing of coolant ingredients before adding to the cooling system.

RG,01,DT7035 –19–14NOV00–2/2

## 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.

**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.**

DX,COOL6 –19–18MAR96–1/1

## Flush and Service Cooling System

TS281 –UN–23AUG88

**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 cap completely.**

**IMPORTANT: Air must be expelled from cooling system when system is refilled. See CHECKING COOLING SYSTEM in operator's manual.**

The ethylene glycol base (antifreeze) can become depleted of SCAs allowing various acids to form that will damage engine components. In addition, heavy metals, such as lead, copper and zinc, accumulate in the ethylene glycol base. The heavy metals come from corrosion that occurs to some degree with in a cooling system. When a coolant is saturated to the point where it can no longer hold heavy metals and other dissolved solids, they settle out and act as abrasives on engine parts.

*NOTE: Refer to your operator's manual for a specific service interval. See LUBRICATION AND MAINTENANCE SERVICE INTERVAL CHART in operator's manual.*

Flush cooling system as described in your operator's manual. See FLUSHING COOLING SYSTEM in operator's manual. Clean cooling system with clean water and TY15979 John Deere Heavy-Duty Cooling System Cleaner or an equivalent cleaner such as FLEETGUARD® RESTORE™or RESTORE PLUS™. Follow the instructions provided with the cleaner. Refill cooling system with the appropriate coolant solution. See DIESEL ENGINE COOLANT, earlier in this group.

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*RESTORE is a trademark of FLEETGUARD.*
*RESTORE PLUS is a trademark of FLEETGUARD.*

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RG,01,DT7033 –19–29OCT97–1/2

**IMPORTANT: NEVER overfill the system. A pressurized system needs space for heat expansion without overflowing at the top of the radiator. Coolant level should be at bottom of radiator filler neck.**

**Air must be expelled from cooling system when system is refilled. Loosen plug in side of thermostat housing to allow air to escape when filling system. Retighten plug when all the air has been expelled.**

After adding new coolant solution, run engine until it reaches operating temperature. This mixes the coolant solution uniformly and circulates it through the entire system. After running engine, check coolant level and entire cooling system for leaks.

Contact your engine servicing dealer, if there are further questions.

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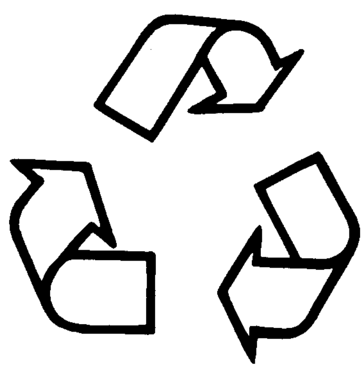
## Disposing of Coolant



TS1133 –UN–26NOV90

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

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.

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

RG,01,DT7032 –19–29OCT97–1/1

# Section 02
# Repair and Adjustments

## Contents



**Continued on next page**

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## 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.

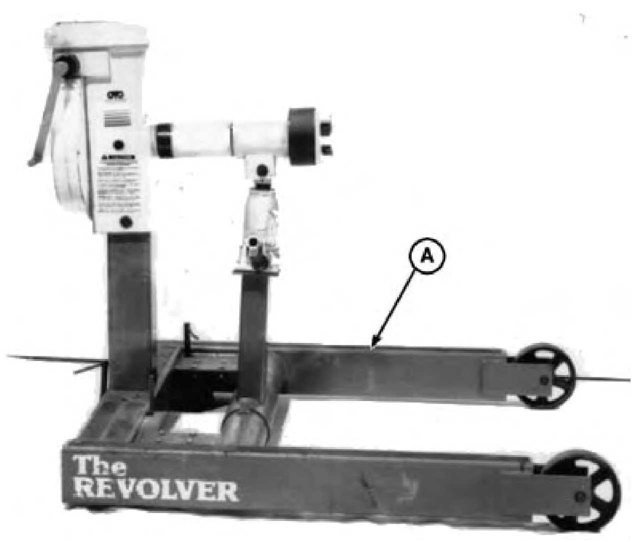
DPSG,OUO1032,3410 –19–15JUN00–1/1

## Engine Repair Stand

*NOTE: Only the 2722 kg (6000 lb) heavy-duty engine repair stand (A) No. 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.

**A—Engine Repair Stand**



RG4929 –UN–05DEC97

*Engine Repair Stand*

RG,RG34710,1043 –19–23OCT97–1/1

## 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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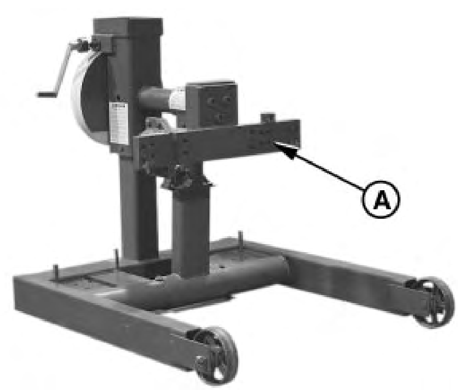
RG,RG34710,1044 –19–23OCT97–1/1

## 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*

RG,RG34710,1045 –19–23OCT97–1/1

## Install Engine Lift Straps

1. Using one cap screw, install lift strap to the right front side (A) of cylinder head.

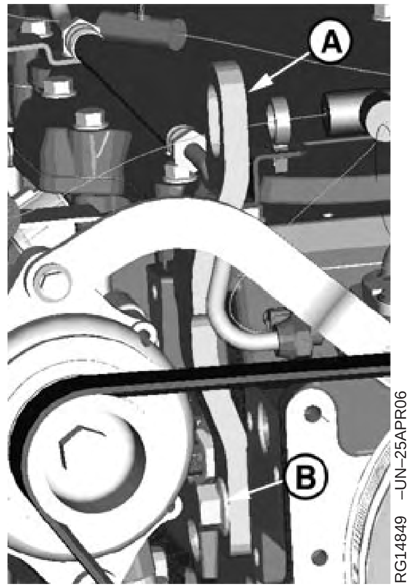
2. Using one cap screw, install lift strap to the left rear (C) of cylinder head.

3. Torque both cap screws to specification.

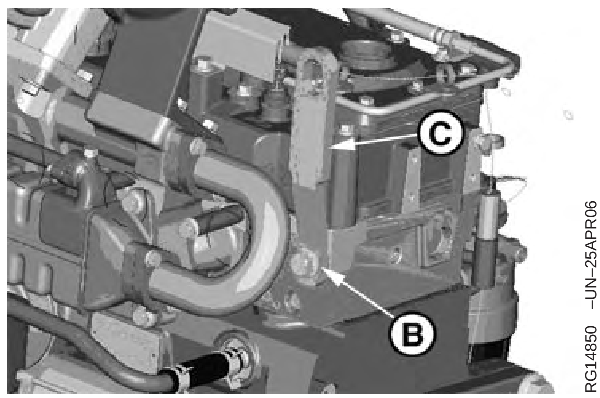
**Specification**

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**




*Right Front Lift Strap*



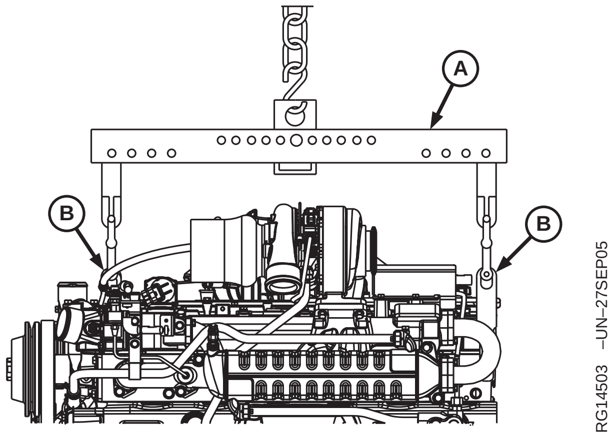

*Left Rear Lift Strap*

RE38635,000011C –19–25APR06–1/1

## Engine Lifting Procedure

**CAUTION: The only recommended method for lifting the 6090 engine is with JDG23 Engine Lifting Sling and safety approved lifting straps that come with engine or that are available as a service tool. 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**

1. Attach JDG23 Engine Lifting Sling (A) to engine 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.

*SERVICEGARD is a trademark of Deere & Company*

RE38635,000011D –19–25APR06–1/1

## 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

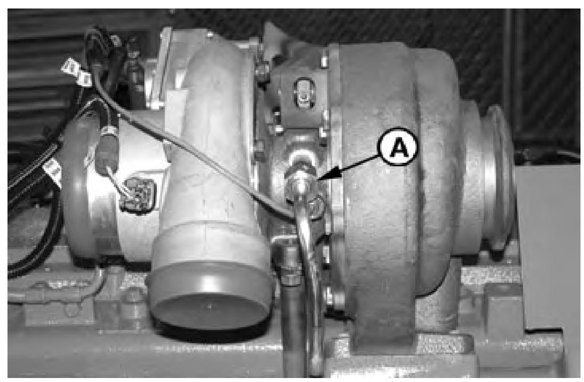
1. Drain all engine oil and coolant, if not previously done.

**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.




*Turbocharger Oil Supply Line*

**A—Oil Supply Line**

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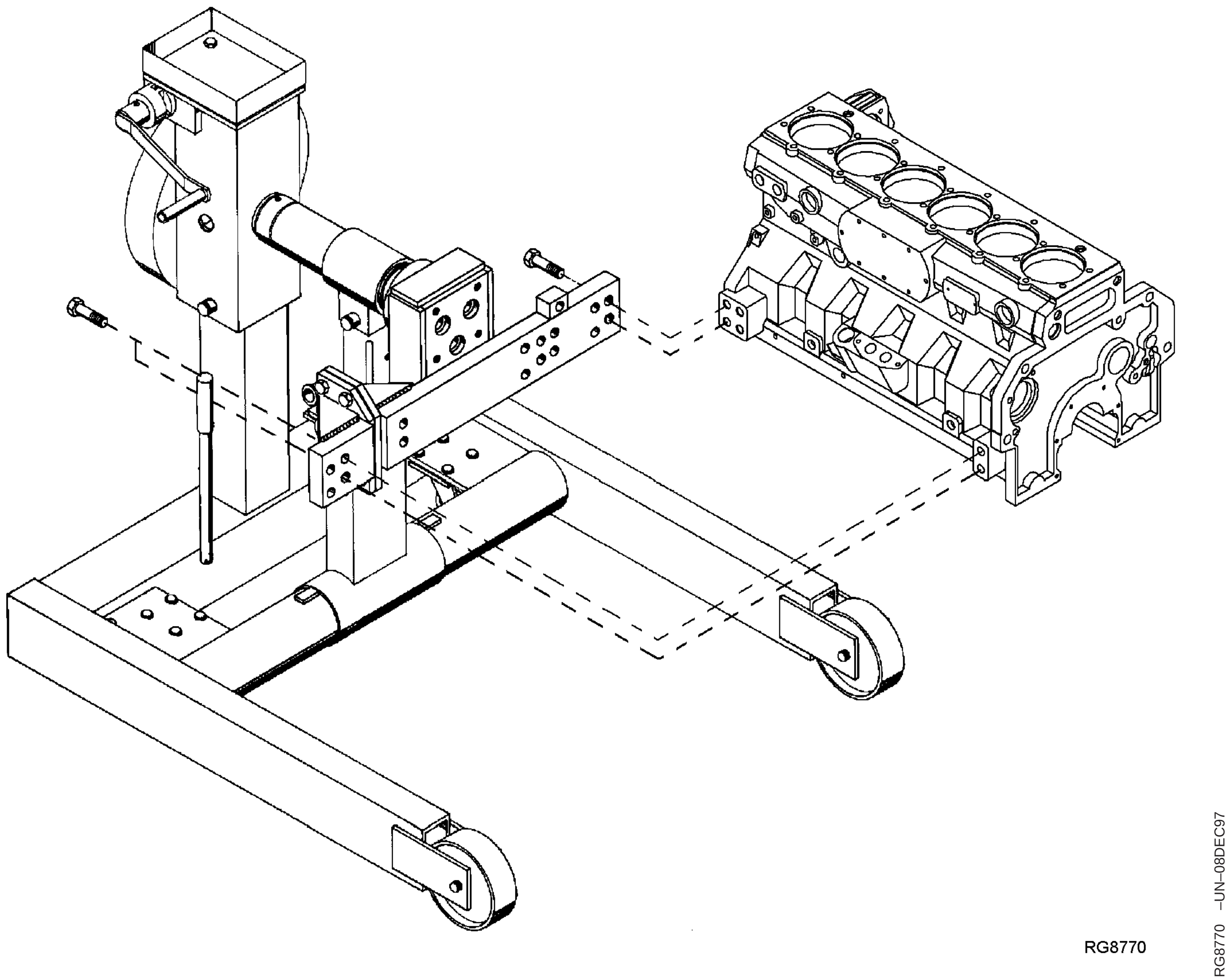
## Mount Engine on Repair Stand




*Mounting Engine on Repair Stand*

**Continued on next page** RE38635,0000025 –19–15DEC04–1/2

**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.*

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:

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

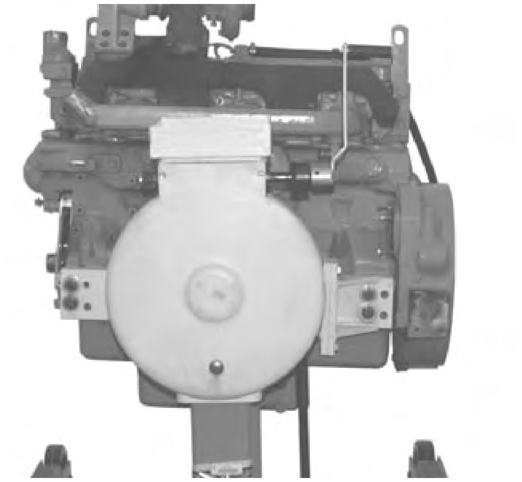
| | |
|---|---|
| 6090HRW01 ................................ | M16-2 X 110mm. |
| 6090HRW02 ................................ | M16-2 X 110mm |
| 6090HRW04 ................................ | M16-2 X 110mm |
| 6090HZ003 ................................. | M16-2 X 110mm. |
| 6090HT001R ............................... | 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 |

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.

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



RG10054 –UN–23JUN99

*Engine on Repair Stand*

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.

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.

*PLASTIGAGE is a registered trademark of DANA Corp.*

**Continued on next page**

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 –19–13JAN06–2/2

## 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.

*LOCTITE is a registered trademark of Loctite Corp.*
*SCOTCH-GRIP is a registered trademark of 3M Co.*
*TEFLON is a registered trademark of Du Pont Co.*
*NEVER-SEEZ is a registered trademark of Emhart Chemical Group.*

**Continued on next page**

RG,RG34710,1051 –19–23OCT97–1/2

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)



*LOCTITE is a registered trademark of Loctite Corp.*

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

RG,RG34710,1051 –19–23OCT97–2/2

## 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.

Continued on next page

RE38635,0000027 –19–15DEC04–1/2

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 –19–15DEC04–2/2



## 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.)

RE38635,0000029 –19–15DEC04–1/1

## Perform Engine Break-In

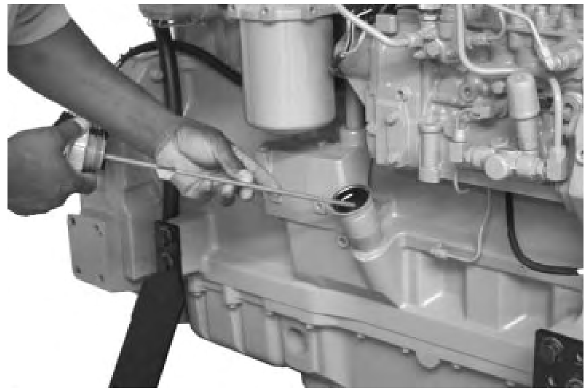
Use a dynamometer to perform the following preliminary break-in procedure. If necessary, preliminary engine break-in can be performed without a dynamometer if under controlled operating conditions.



**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.**



RG7359 –UN–20JUN00

*Check Engine Oil Level*

RG5895 –UN–13AUG91

*Engine Oil Level Dipstick*

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.

Continued on next page

RE38635,0000028 –19–15DEC04–1/3

**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.

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

**Continued on next page**

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.*

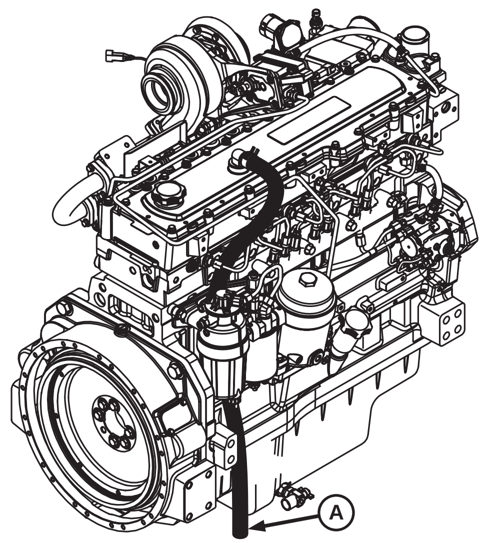
RE38635,0000028 –19–15DEC04–3/3

## 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

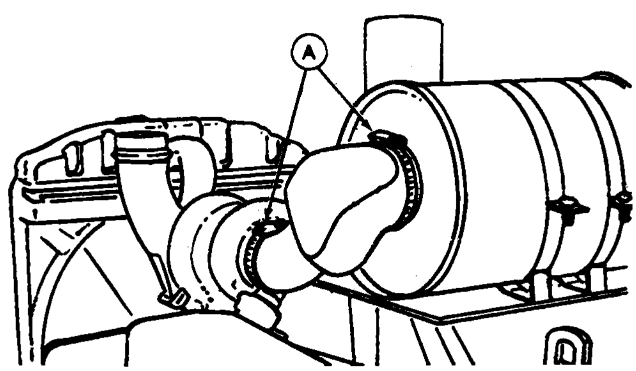
## Check Air Intake System

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

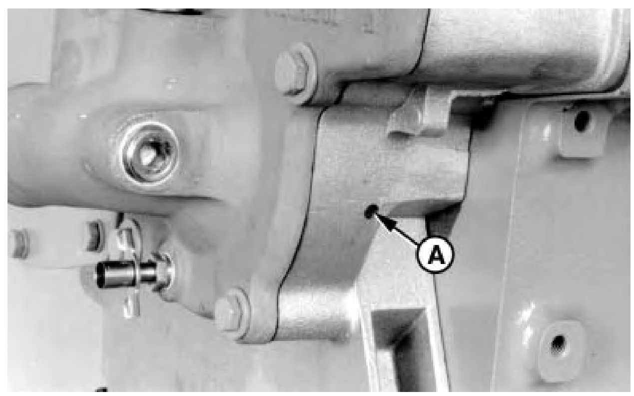
1. Remove trash that has accumulated on or near radiator.

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.

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




RG7061 –UN–26NOV97

*Cooling System Weep Hole with Foam Filter*

**A—Weep Hole**

**Continued on next page** RG,RG34710,1058 –19–23OCT97–1/2

**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.**


*Service Cooling System Safely*

**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.**

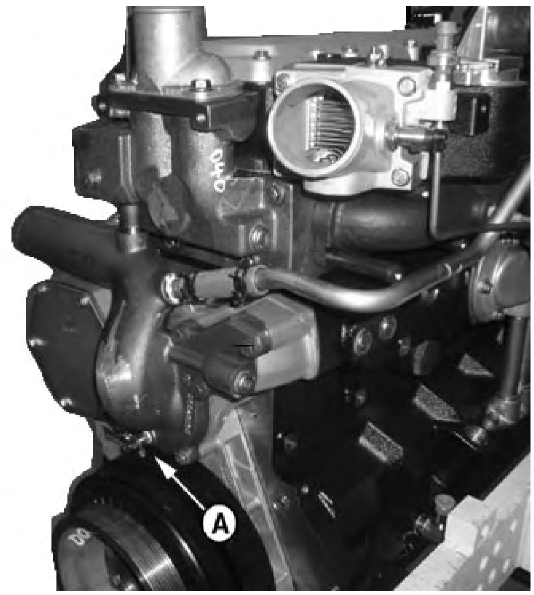
8. Fill cooling system with coolant. See DIESEL ENGINE COOLANT in Group 002.

9. Run engine until it reaches operating temperature. Check entire cooling system for leaks.

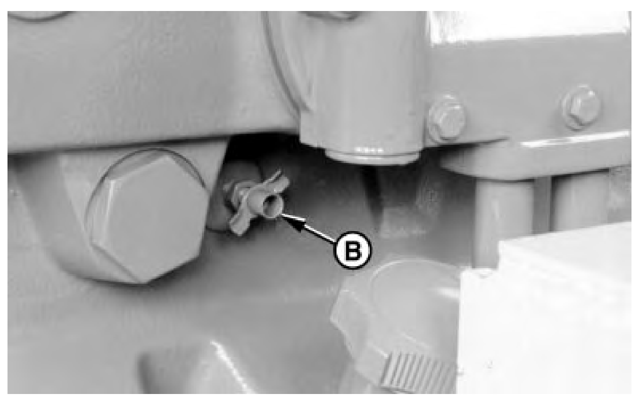
10. After engine cools, check coolant level.

*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.




*Coolant Pump Drain Valve*




*Cylinder Block Coolant Drain Valve*

**A—Coolant Pump Drain Valve**
**B—Block 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.

Continued on next page

RG,RG34710,1059 –19–23OCT97–1/2

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 –19–23OCT97–2/2

## 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

## Adjust Valve Clearance

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.



Continued on next page RE38635,0000030 –19–25APR06–1/6

**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.

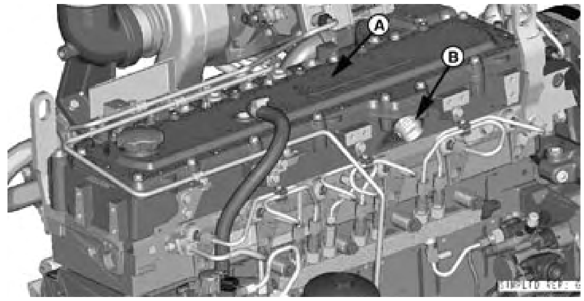
2. Remove rocker arm cover with vent tube (A).

**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.**

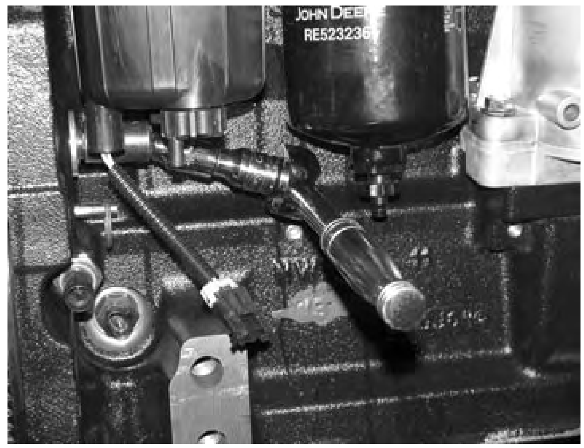
*NOTE: Use a flexible socket extension when rotating engine to avoid interference with fuel filter assembly, as shown.*

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




RG13925 –UN–29JAN05

*Rocker Arm Cover & Wiring Harness Attach*




RG13945 –UN–04FEB05

*JDG820 Flywheel Turning Tool*

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

**Continued on next page**

RE38635,0000030 –19–25APR06–2/6

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.

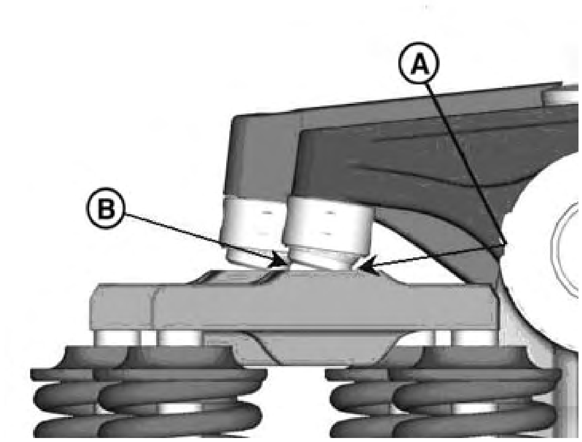
*NOTE: To assist in adjusting valve clearance, push the rocker arm foot forward (A) for easier feeler gauge access (B)*

**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.

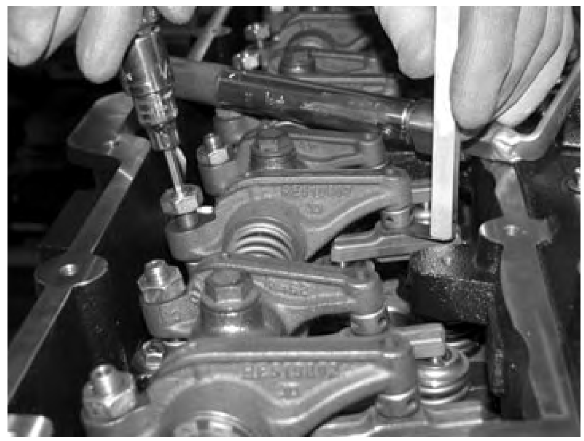
**Specification**

| | |
|---|---|
| Intake Valve Clearance Checking (Rocker Arm-to-Valve Tip With Engine Cold)—Clearance | 0.13—0.23 mm (0.005—0.009 in.) |
| Exhaust Valve Clearance Checking (Rocker Arm-to-Valve Tip 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) |

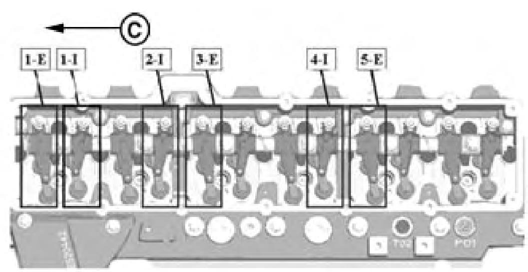


RG13842 –UN–07JAN05

*Valve Clearance Setting Procedure*


RG13946 –UN–04FEB05

*Checking Valve Clearance with Feeler Gauge*



RG13840 –UN–23FEB05

*Valve Checking Sequence - #1 TDC*

**C—Front of Engine**

Continued on next page

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



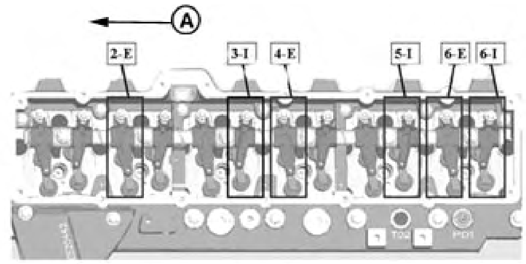
RE38635,0000030 –19–25APR06–4/6

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.




RG13839 –UN–29JAN05

*Valve Checking Sequence - #6 TDC*

**A—Front of Engine**

RE38635,0000030 –19–25APR06–5/6

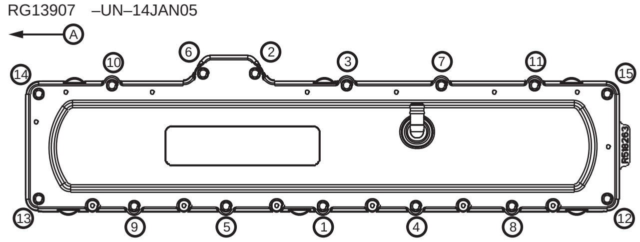
11. Install rocker arm cover with vent tube and tighten cap screws in sequence shown to specification.

**Specification**

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

12. Connect main engine wiring harness.

RG13907 –UN–14JAN05




*Rocker Arm Cover Torque Sequence*

**A—Front of Engine**

RE38635,0000030 –19–25APR06–6/6

## Check Valve Lift

**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

## Remove Cylinder Head

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.*

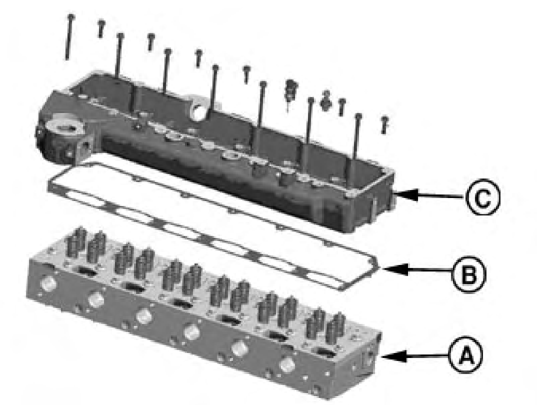
2. Remove thermostat housing and all coolant piping. See REMOVE THERMOSTAT HOUSING in Group 070.

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.




RG14121 —UN—29MAR05

*Removing Cylinder Head*

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

Continued on next page

RE38635,0000031 –19–07JAN05–1/4

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.



**Continued on next page** RE38635,0000031 –19–07JAN05–2/4

*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.

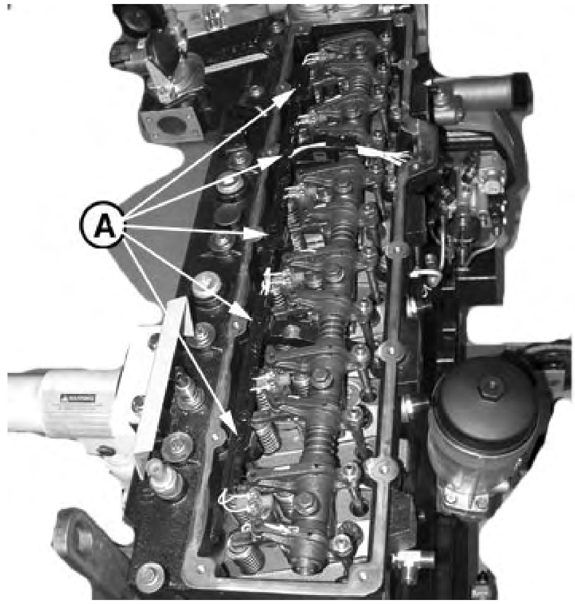
12. Remove push rods and identify for reassembly.

*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.

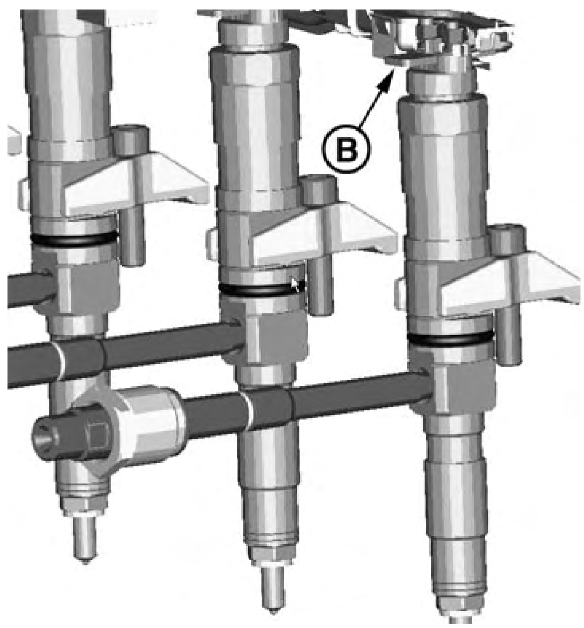
**IMPORTANT: DO NOT use screwdrivers or pry bars between cylinder block and cylinder head to loosen head-to-block gasket seal.**

14. Lift cylinder head from block. If cylinder head sticks, use a soft hammer to tap the cylinder head.




RG13916 –UN–19MAR05

*Injector Wiring Harness*




RG14398 –UN–08JUL05

*Injector QR Tab*

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

**Continued on next page**

RE38635,0000031 –19–07JAN05–3/4

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.*

RE38635,0000031 –19–07JAN05–4/4

## Diagnosing Head Gasket Joint Failures

Head gasket failures generally fall into three categories:

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

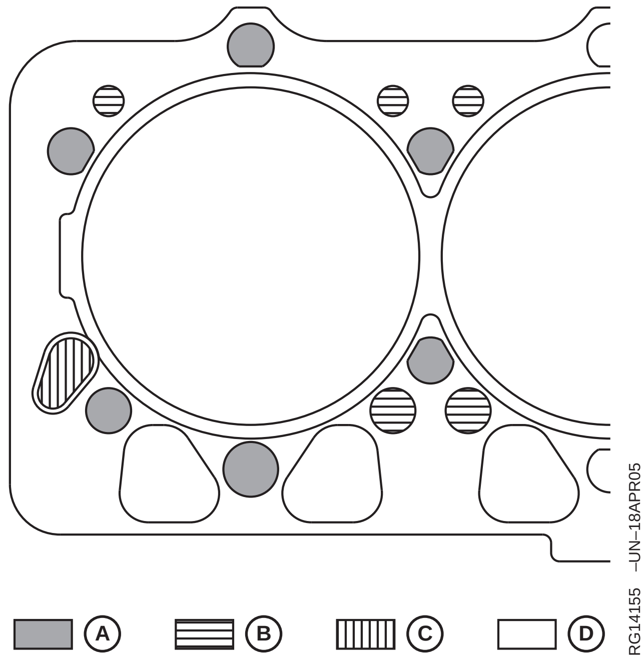
Combustion seal failures occur when combustion gases escape between cylinder head and head gasket combustion flange, or between combustion flange and cylinder liner. Leaking combustion gases may vent to an adjacent cylinder, to a coolant or oil passage, or externally.

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.

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.




*6090 Cylinder Head Gasket*

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

Continued on next page RE38635,0000032 –19–07JAN05–1/2

- 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 –19–07JAN05–2/2

## 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**

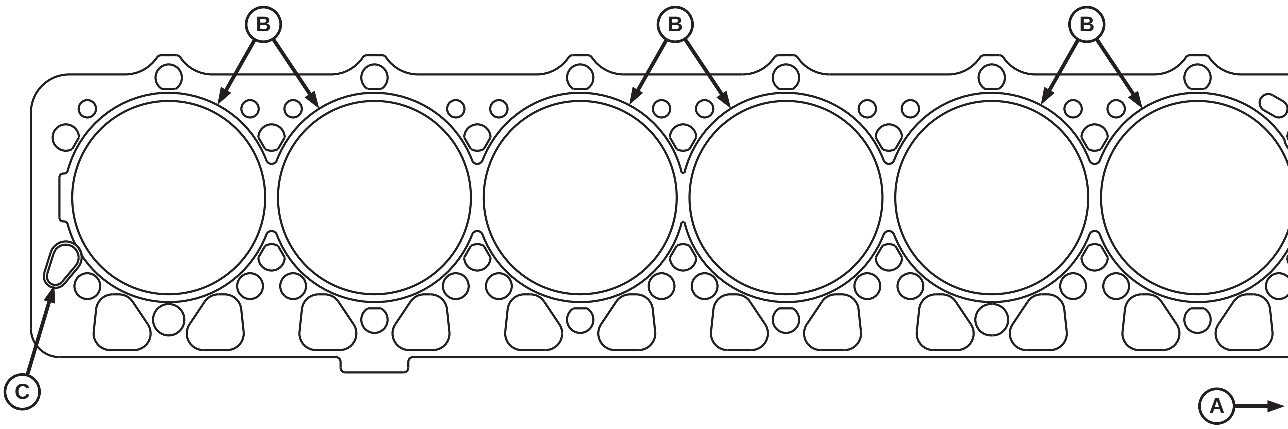
| Symptoms | Possible Causes |
|---|---|
| Coolant discharge from head gasket crevice | Excessive liner standout |
| Coolant in crankcase oil | Excessive liner standout differential between cylinders |
| Low coolant level | Low head bolt clamping loads |
| High oil level | Out-of-flat/damaged/rough block 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.)

Continued on next page

RE38635,00000BB –19–18APR05–1/2

- 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.

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

## Inspect Rocker Arm Assembly

RG13906 –UN–28MAY05

Rocker Arm Assembly

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. If rocker arms, snap rings, pedestal, or shaft are damaged, rocker arm assembly MUST BE replaced as an assembly.

3. Check rocker arm adjusting nut and screw for damage. Visually inspect rocker arm for hairline cracks. Replace if necessary.

4. 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.*

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

RE38635,0000034 –19–07JAN05–1/1

## Disassemble and Assemble Rocker Arm Assembly

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–28MAY05

*Rocker Arm Shaft Assembly*

RE38635,0000098 –19–29MAR05–1/1

## Measure Valve Recess

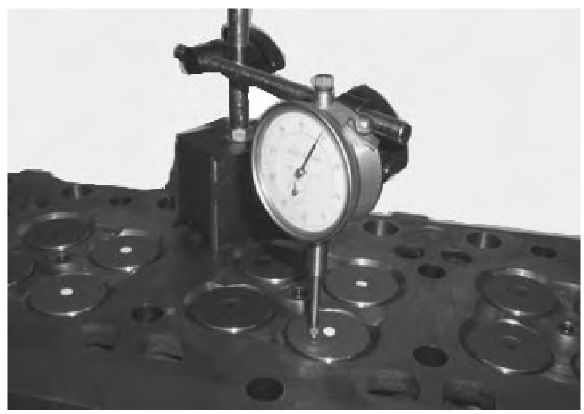
Measure and record valve recess dimensions for all valves using JDG451 Gauge with D17526CI (English, in.) or D17527CI (Metric, mm) Dial Indicator or KJD10123 Gauge. Compare measurements to specifications given below.

**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–28MAY05

*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

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021
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## Remove Valve Assembly

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

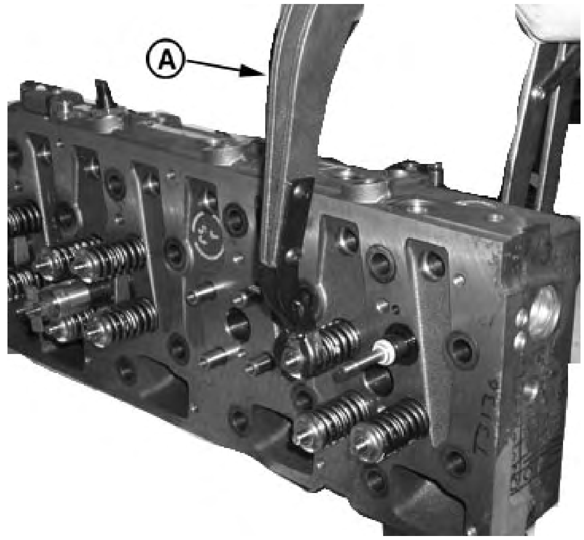
**IMPORTANT: Identify all usable parts for correct reassembly in same location as removed.**

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.*

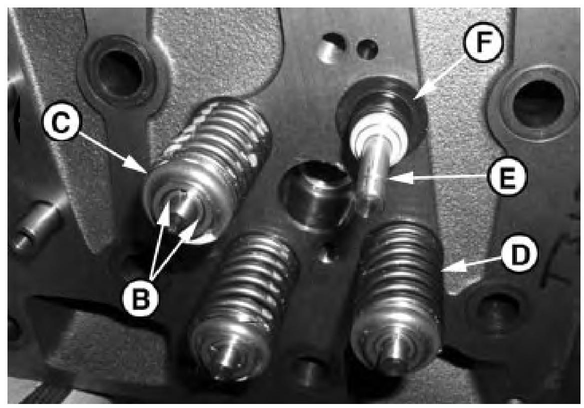
7. Repeat procedure on remaining valves.

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




RG14171 –UN–28MAY05

*Removing Valve Assemblies*




RG14172 –UN–28MAY05

*Valve Assemblies*

RE38635,0000099 –19–29MAR05–1/1

## Inspect and Measure Valve Springs

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–04DEC97

*Valve Spring*


T82054 –UN–08NOV88

*Checking Valve Spring Tension*

RE38635,000009A –19–29MAR05–1/1

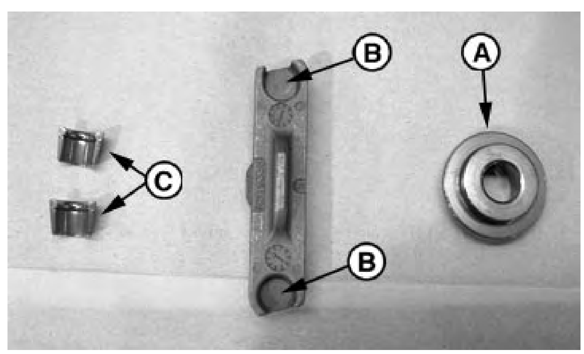
## Inspect Valve Retainer, Valve Bridges, and Valve Retainer Locks

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

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 –19–13JAN06–1/1

## Clean Valves

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

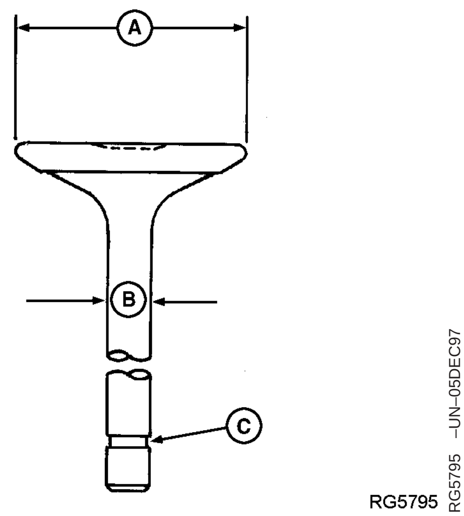
## Inspect and Measure Valves

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.) |




*Measuring Valves*

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

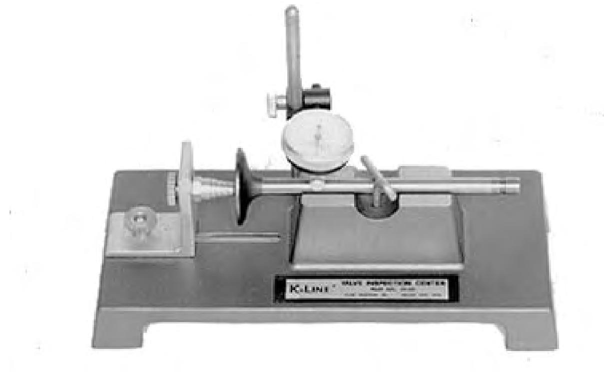
Continued on next page

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

## Grind (Reface) Valves

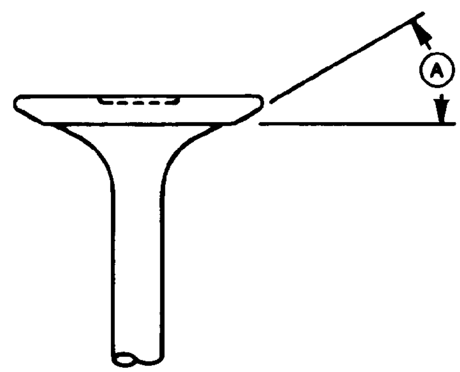
**IMPORTANT: Valve grinding should only be done by experienced personnel familiar with equipment and capable of maintaining required specifications.**

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.**




RG5247 –UN–05DEC97

*Valve Face Angle*

**A—Valve Face Angle**

RE38635,000009C –19–29MAR05–1/1

## Inspect and Clean Cylinder Head

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 –19–07JAN05–1/1

## Check Cylinder Head Combustion Face Flatness

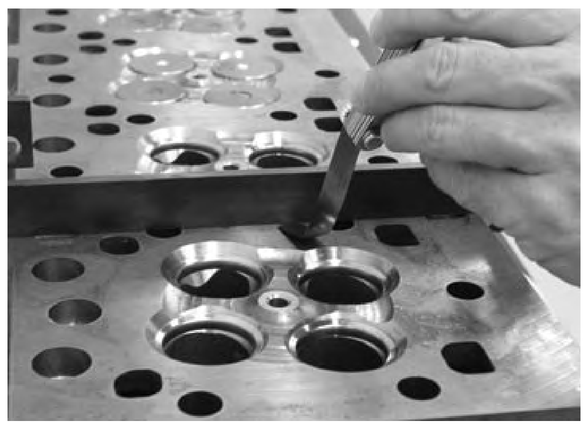
Check cylinder head flatness using D05012ST Precision Straightedge and feeler gauge. Check lengthwise, crosswise, and diagonally in several places.

*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)*

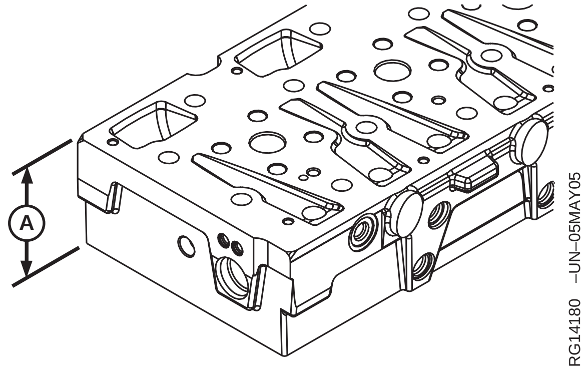
RE38635,0000002 –19–26APR05–1/1

## Measure Cylinder Head Thickness

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 |



*Cylinder Head Thickness*

**A—Head Thickness**

RE38635,0000008 –19–29APR05–1/1

## Clean Valve Guides

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

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## Measure Valve Guides

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.**


RG14177 –UN–28MAY05

*Measure Valve Guide ID*

RE38635,0000004 –19–27APR05–1/1

## Clean and Inspect 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.


RG14178 –UN–28MAY05

*Cleaning Valve Seats*

RE38635,0000005 –19–27APR05–1/1

## Measure Valve Seats

1. Measure valve seats for proper specifications listed below.

2. Using D11010KW Eccentrimeter, measure valve seat runout (D).

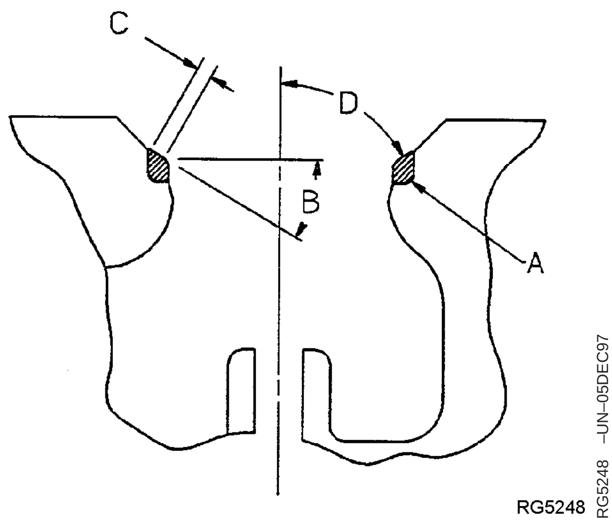
3. If valve seat is not within specification, recondition valve seat by grinding or replace valve seat inserts (A) if reconditioning is not possible. See GRIND VALVE SEATS, or see INSTALL VALVE SEAT INSERTS, later in this group.

**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.)




*Measuring Valve Seats*

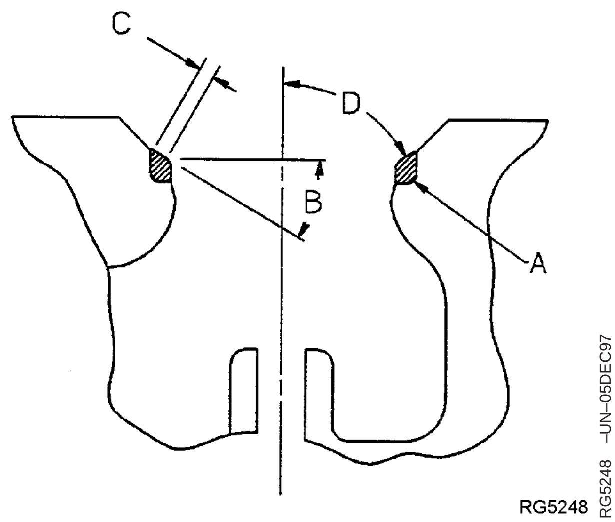
**A—Valve Seat Insert**
**B—Valve Seat Angle**
**C—Valve Seat Width**
**D—Valve Seat Runout**

RE38635,0000007 –19–27APR05–1/1

## Grind Valve Seats

**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 MEASURE VALVE RECESS SERIAL earlier in this group. Be sure valve guide bores are clean before grinding valve seats. See CLEAN VALVE GUIDES earlier in this group.)**




*Measuring Valve Seats*

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

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.*

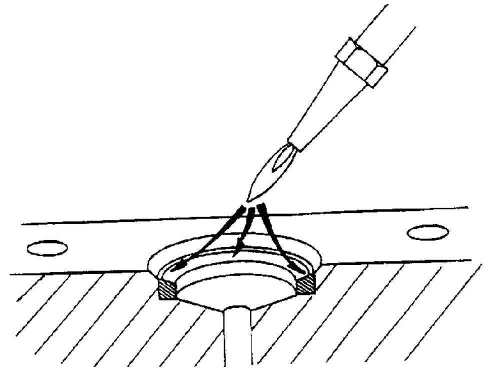
2. ALWAYS measure valve seat runout after grinding using D11010KW Eccentrimeter and check recess in cylinder head after grinding as described later.

**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

## Remove Valve Seat Inserts and Measure Bores in Cylinder Head



*Heating Valve Seat Inserts*

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.

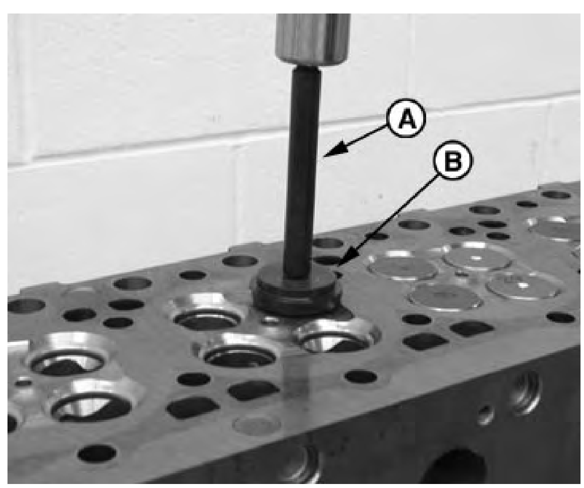
   Valve seat inserts may be also removed using the following method:

   - 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.

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

RE38635,000000A –19–29APR05–1/1

## Install Valve Seat Inserts



*Install Valve Seat Inserts*

1. Use the JDE7 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.

RE38635,000000B –19–29APR05–1/1

## Inspect and Clean Cylinder Head Nozzle Bore

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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

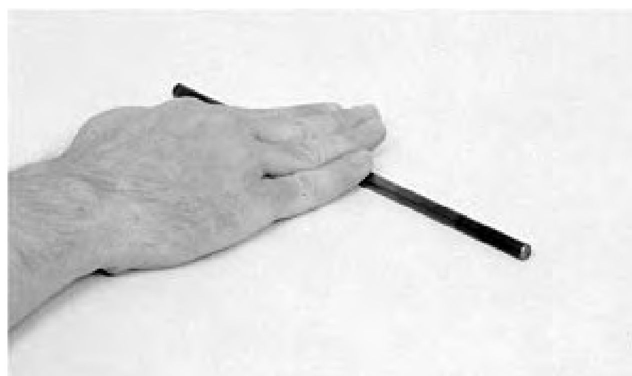
## Clean and Inspect Push Rods

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

## Clean and Inspect Top Deck of Cylinder Block

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

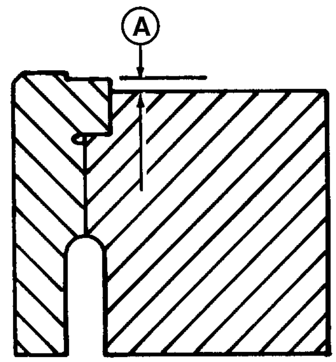
## Measure Cylinder Liner Standout (Height Above Block)

**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.**


*Bolting Down Cylinder Liners*

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.*




*Liner Height*

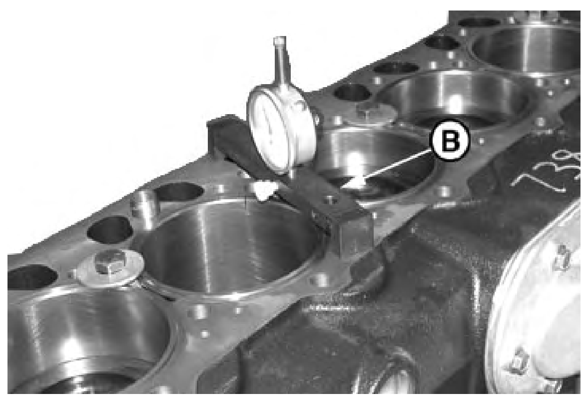
2. Using JDG451 Gauge (B) along with D17526CI (English) or D17527CI (Metric scale) Dial Indicator or KJD10123 Gauge, measure the height of bolted down liners that are not obviously defective before removal from block.

*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.




*Checking Cylinder Liner Height Above Block*

**B—JDG451 Gauge**

RE38635,000009E –19–29MAR05–1/1

## Assemble Valve Assembly

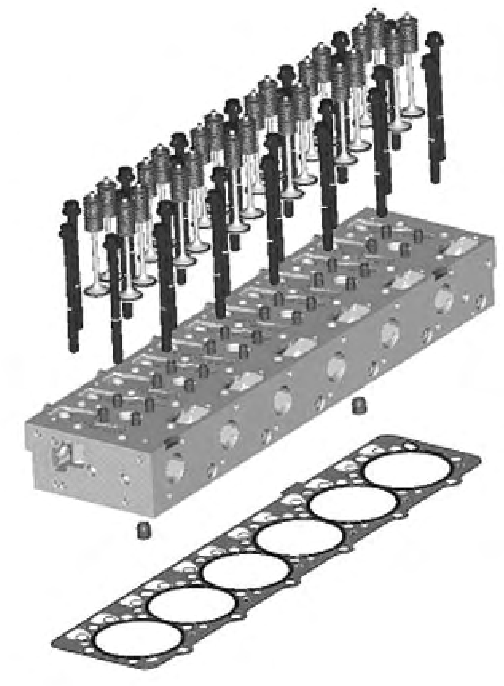
1. Apply AR44402 Valve Stem Lubricant or clean engine oil to valve stems and guides.

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.*

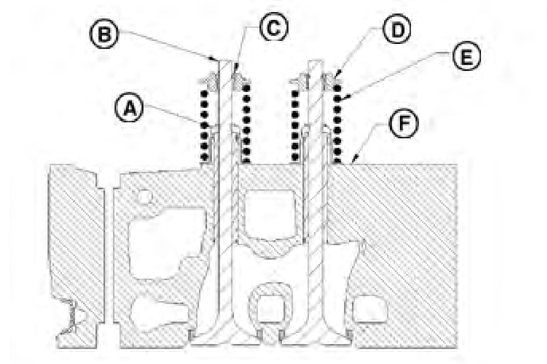
3. Install 24 valve stem seals (A) over guides in cylinder head (F).

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



RG13901 –UN–07JAN05

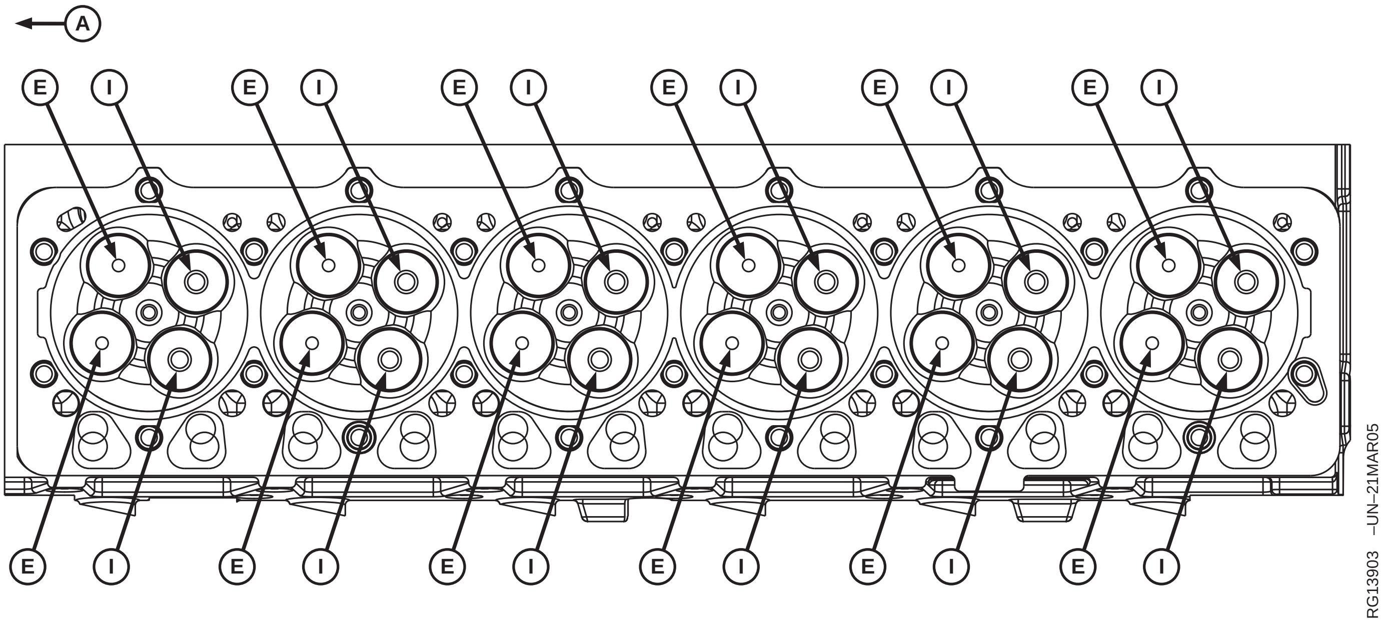
*Cylinder Head and Valve Assembly*




RG13902 –UN–08JAN05

*Valve Assembly*

**Continued on next page** 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

## Install Cylinder Head and Cap Screws

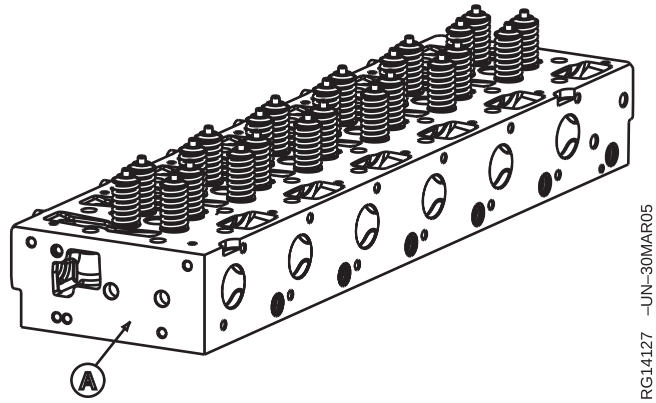
**IMPORTANT: ALWAYS thoroughly inspect new cylinder head gasket for possible manufacturing imperfections. Return any gasket that does not pass inspection.**

**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.**

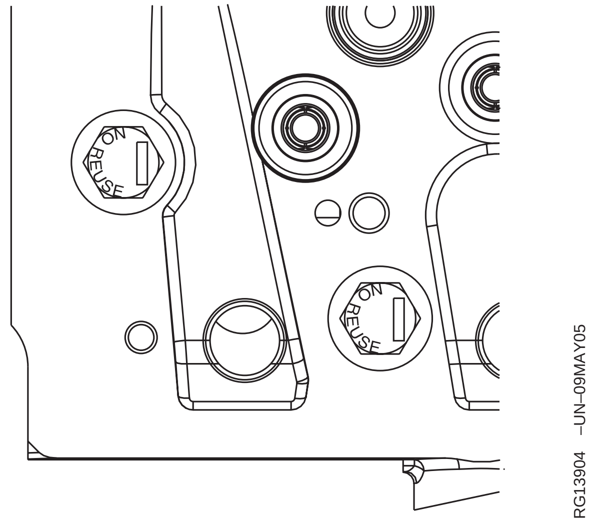
2. Lower cylinder head evenly to correct position on block using appropriate lifting equipment. Make sure that head is positioned correctly over dowels and sits flat on cylinder block top deck.



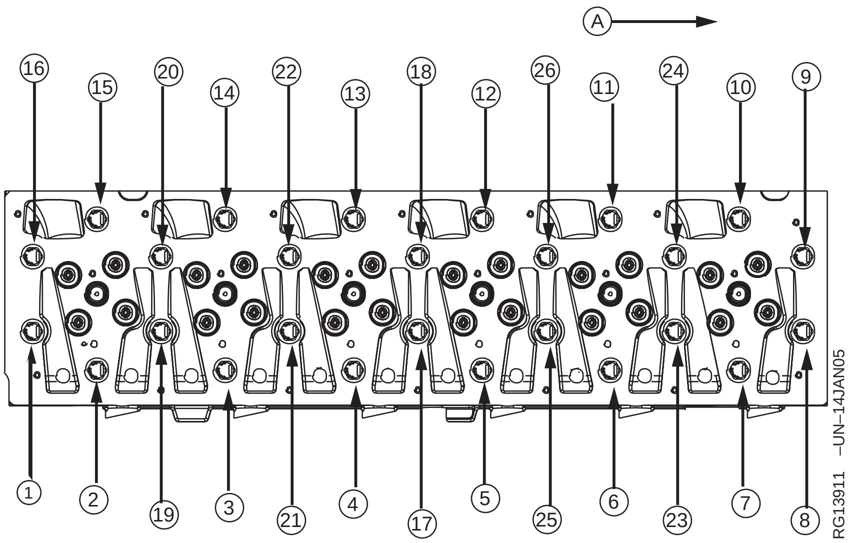

*Cylinder Head Assembly*

**A—Front Face of Cylinder Head**

**Continued on next page** RE38635,000009F –19–30MAR05–1/2




*Special Cap Screws for Cylinder Head*




*Head Cap Screw Locations*

**A—Front of Engine**

**IMPORTANT: Only ASTM Grade 180 Flanged-Head cap screws marked "NO REUSE" (upper illustration) 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.

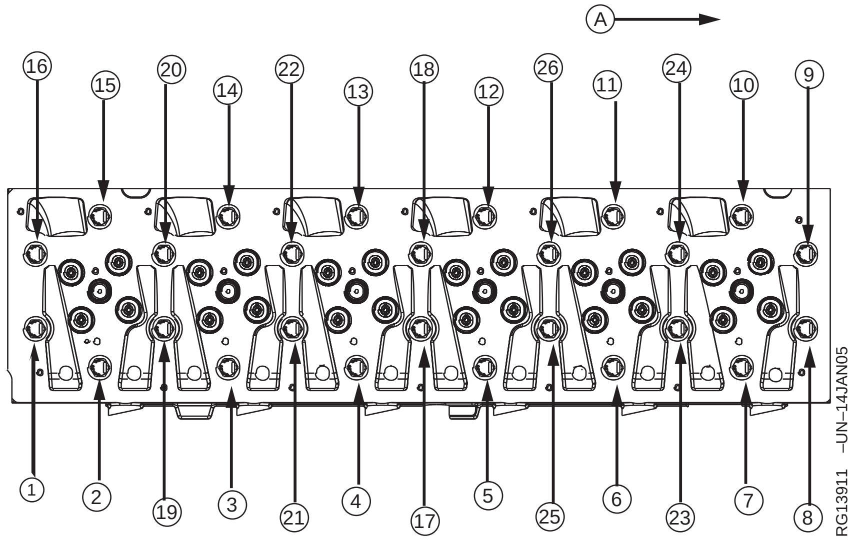
*NOTE: All cylinder head cap screws for the 6090 engine are same length.*

4. Install 26 special cap screws marked "NO REUSE" and tighten using the TORQUE-TO-YIELD tightening procedure, described next in this group. See TORQUE-TO-YIELD FLANGE-HEAD CAP SCREWS—GRADE 180 MARKED "NO REUSE" in this group.

   Arrow (A) points toward front of engine.

RE38635,000009F –19–30MAR05–2/2

## Torque-to-Yield Flanged-Head Cap Screws—Grade 180 Marked “NO REUSE”




*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

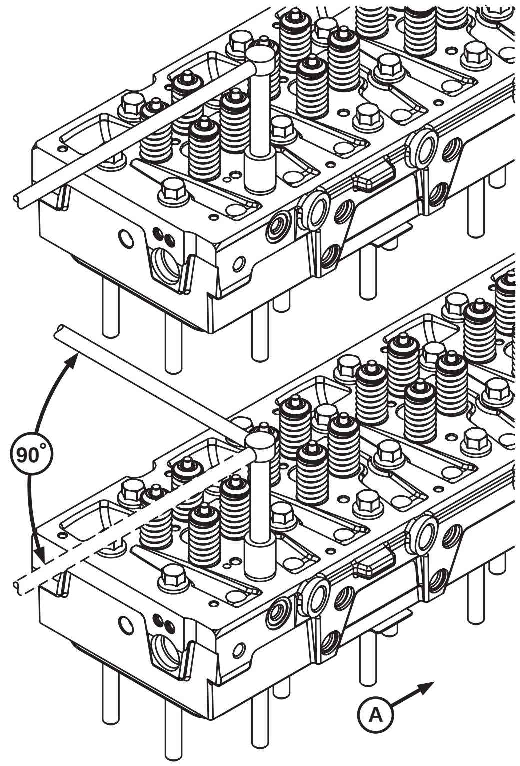
**IMPORTANT: If a cap screw is accidentally tightened more than 90° in any one sequence, DO NOT loosen cap screw but make adjustments in the next tightening sequence.**

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°.**




RG14067 –UN–29MAR05

*Torque-to-Yield Cylinder Head Cap Screws*

**A—Front of Engine**

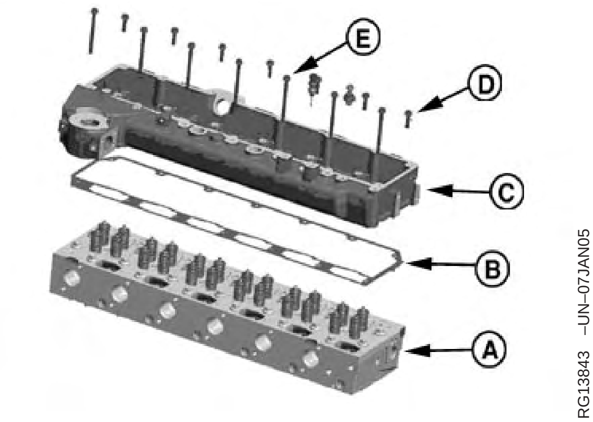
RE38635,00000A0 –19–30MAR05–2/2

## 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.

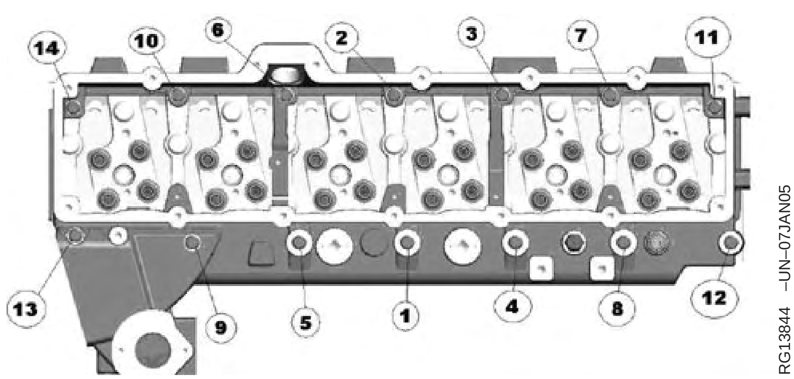
1. Install 2 guide pins in cylinder head (A) to align intake manifold gasket.
2. Install new intake manifold gasket (B) over guide pins
3. Install intake manifold (C) over guide pins and place on gasket and cylinder head.
4. Remove guide pins.
5. Install 7 short flange head cap screws (D) in right side 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).
7. Install 7 long flange head cap screws with lubricated washers in left side of intake manifold to cylinder head.




*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**

RE38635,00000A1 –19–30MAR05–1/2



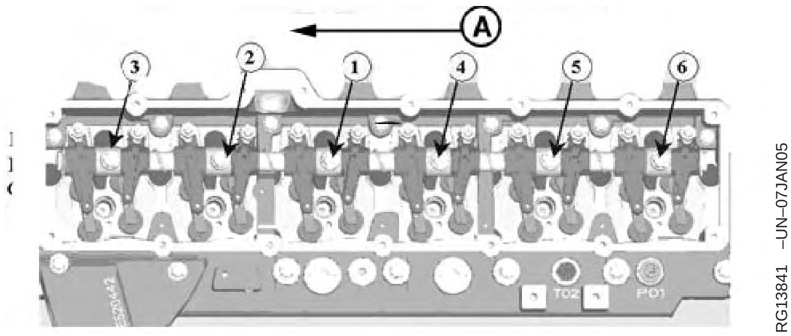

*Intake Manifold Torque Sequence*

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)

RE38635,00000A1 –19–30MAR05–2/2

## Install Rocker Arm Assembly




*Rocker Arm Shaft Assembly Torque Sequence*

**A—Front of Engine**

**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.**

1. Install push rods in holes from which removed.

2. Lubricate rocker arm pedestal cap screws in cylinder head with SAE 30 diesel engine oil.

3. Lubricate rocker arm pedestal cap screws under head with SAE 30 diesel engine oil.

4. Assemble rocker arm assembly to head by guiding 6 flange head cap screws located in rocker arm pedestals into threads in cylinder head.

5. Seat rocker arm balls in push rod seats before tightening of rocker arm pedestal cap screws.

6. Align rocker arms centered on valve bridges..

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

7. 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)

8. Loosen one cap screw at a time 90° minimum.

9. 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°)

10. Adjust engine valve clearance. See CHECK & ADJUST VALVE CLEARANCE earlier in this group.

RE38635,000003B –19–03APR06–1/1

## Inspect and Clean Ventilator Outlet Hose

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

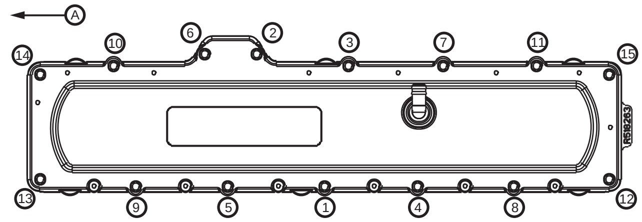
2. Clean ventilator hose if restricted.



RE38635,000003A –19–07JAN05–1/1

## Complete Final Assembly of Fuel Pump Side of Engine

RG13907 –UN–14JAN05




*Rocker Arm Cover Torque Sequence*

**A—Front 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) |

*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.

RE38635,00000A2 –19–25APR06–1/1

## Complete Final Assembly on Exhaust Manifold Side of Engine

### 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)

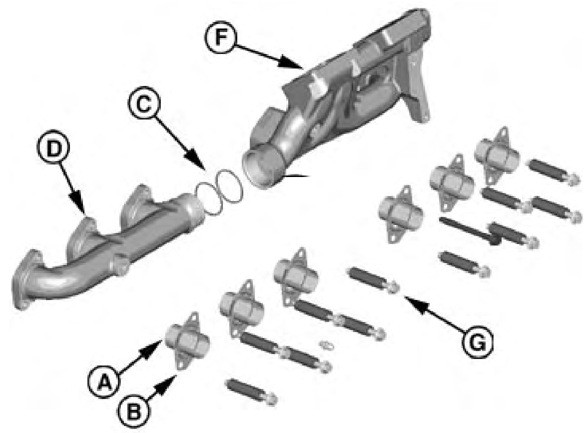
6. Install rear exhaust manifold (F) to front exhaust manifold (D).

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.*

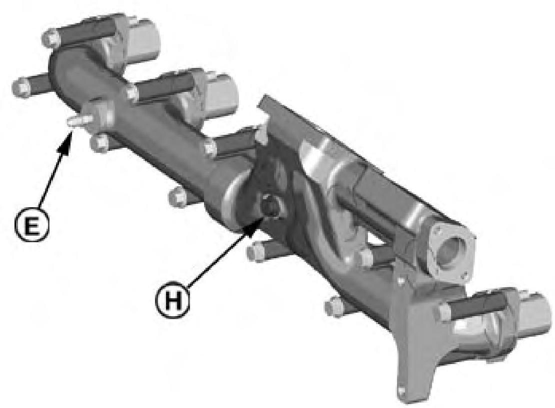
8. Apply PT569 NEVER-SEEZ® Compound, **only to cap screws being reused**. Install 6 cap screws (G) through spacers and into bottom holes of exhaust manifold and into cylinder head. Tighten finger tight.

9. Remove guide pins. Install 5 cap screws through spacers and into top holes finger tight in exhaust manifold and cylinder head.




RG13913 –UN–24JAN05

*Exhaust Manifold Assembly*




RG13914 –UN–24JAN05

*Exhaust Manifold Hardware*

**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**

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**Continued on next page**

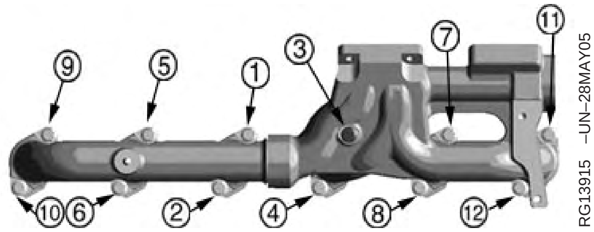
RE38635,00000A3 –19–30MAR05–1/7

**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.



*Exhaust Manifold Torque Sequence*

**Specification**

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

**Continued on next page** RE38635,00000A3 –19–30MAR05–2/7

## 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**

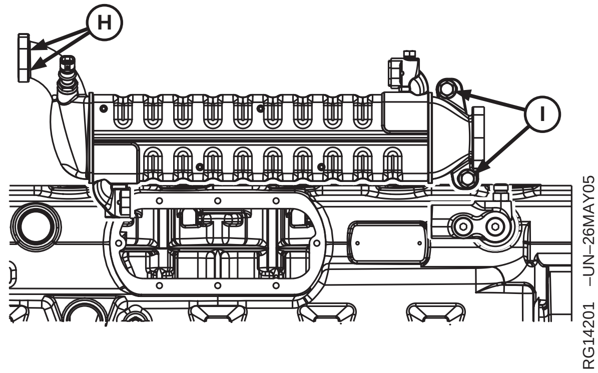
P Clamp Cap Screw—Torque .......... 30 N•m (22 lb-ft)

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

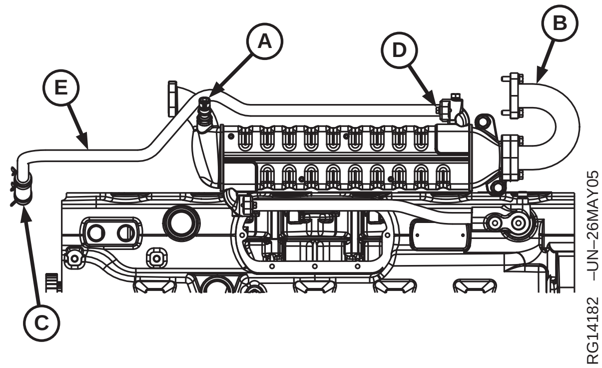
**Specification**

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

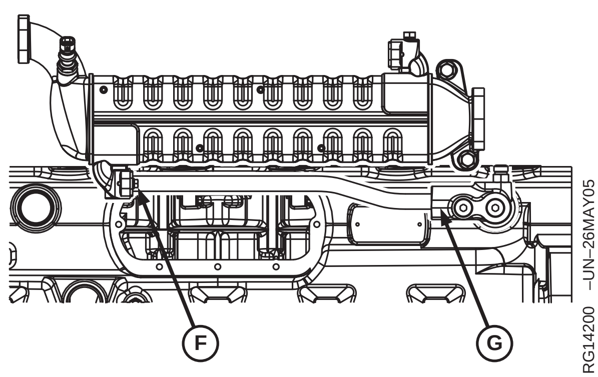
10. Install EGR coolant supply line (short end) into coolant manifold.




*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**

Continued on next page

02
021
44

11. Orient opposite end of coolant supply line into EGR cooler. Install cap screw and tighten to specification.

**Specification**

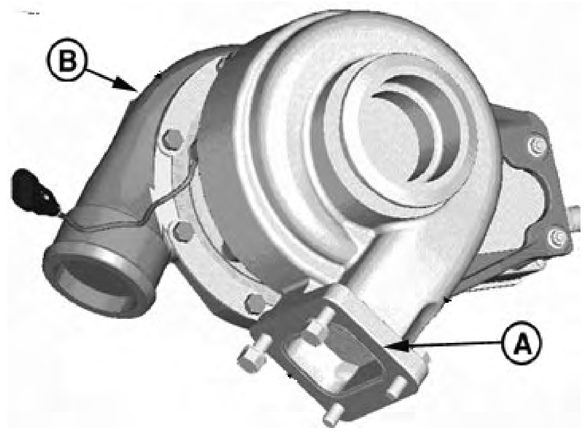
EGR Coolant Supply Line to Cooler & Coolant Manifold—Torque ................................................................................ 11 N•m (8 lb-ft)

**Continued on next page** RE38635,00000A3 –19–30MAR05–4/7

## 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.**




*6090 Turbocharger*

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.*

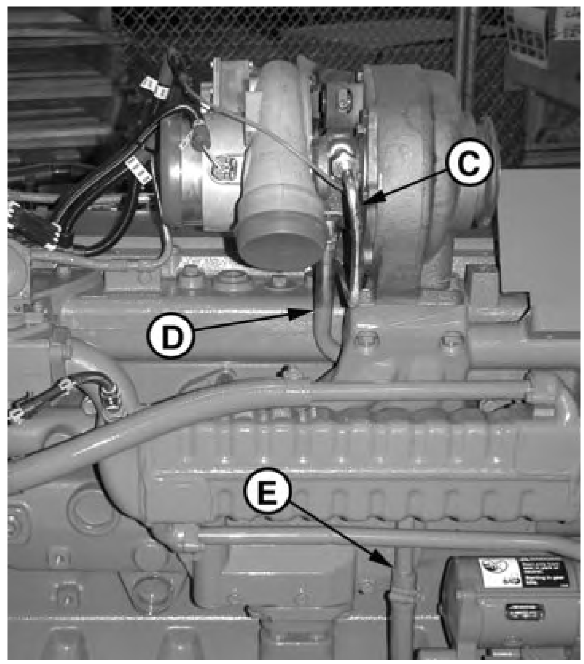
1. Install new gasket (A) over guide pins.

2. Position turbocharger on exhaust manifold over guide pins, with compressor inlet (B) facing front of engine.

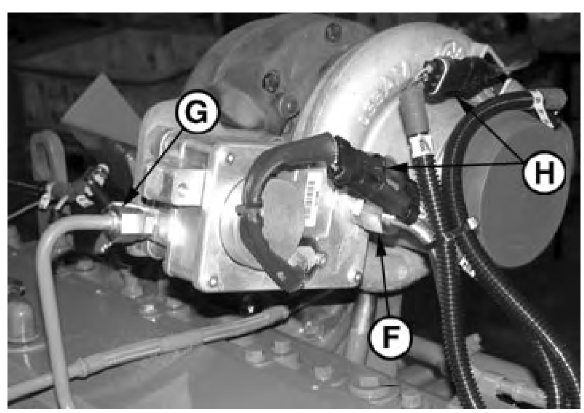
3. Apply PT569 NEVER-SEEZ® Compound to all turbocharger mounting cap screws. Install 2 cap screws through exhaust manifold into threaded holes of turbocharger finger tight.

4. Remove guide pins and install remaining 2 cap screws through turbocharger into exhaust manifold finger tight.

**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**




*Turbocharger Oil Line Installation*




*Turbocharger Actuator Coolant Lines*

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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.

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.)

**Continued on next page**

RE38635,00000A3 –19–30MAR05–6/7

**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.

RE38635,00000A3 –19–30MAR05–7/7



## Perform Engine Break-In

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.

**Continued on next page** RE38635,00000A5 –19–25APR06–1/2

**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)

Retorque 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.**

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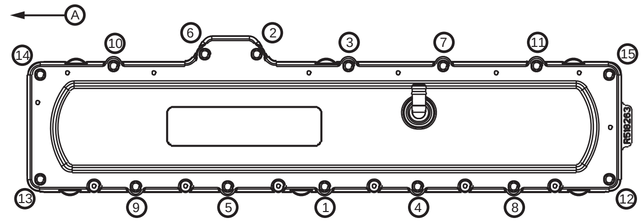



*Rocker Arm Cover Torque Sequence*

RE38635,00000A5 –19–25APR06–2/2

## 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.**

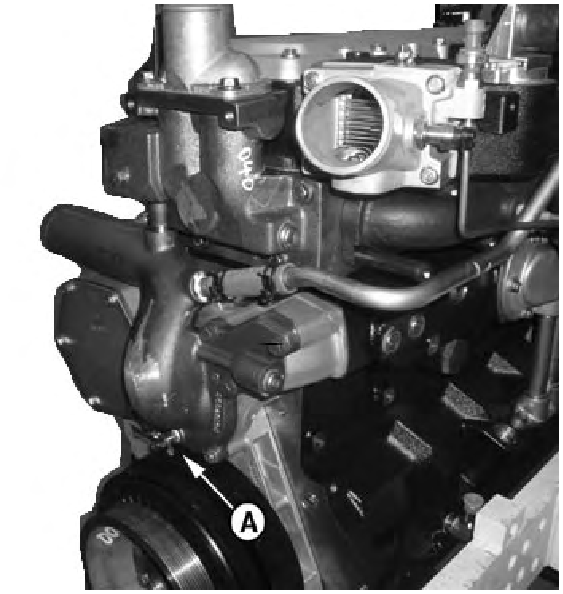
1. Drain all engine coolant and engine oil.

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

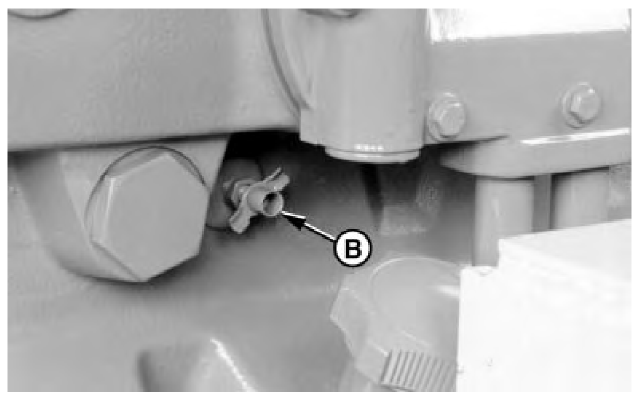
2. Remove cylinder head. See REMOVE CYLINDER HEAD in Group 020.

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**




*Coolant Pump Drain Valve*




*Cylinder Block Drain Valve*

**Continued on next page** RE38635,000003F –19–11JAN05–1/5

**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.**


*Bolt Down Cylinder Liners*

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.

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

**Continued on next page** RE38635,000003F –19–11JAN05–2/5

*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.*

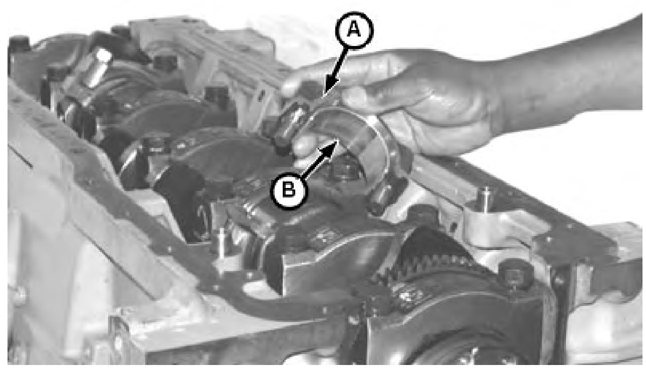
RE38635,000003F –19–11JAN05–3/5

**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).

**A—Rod Caps**
**B—Bearings**



*Removing Connecting Rod Caps*

**Continued on next page**

RE38635,000003F –19–11JAN05–4/5

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

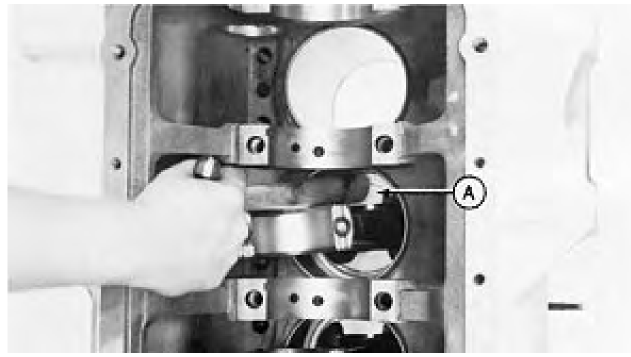
**IMPORTANT: Be careful not to let rod nick crankshaft bearing surface as piston and rod assembly is removed.**

**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.




RG3821 –UN–07DEC88

*Removing Pistons*

**A—Piston**

RE38635,000003F –19–11JAN05–5/5

## Measure Cylinder Liner Standout (Height Above Block)

**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.*

1. Bolt liners down using cap screws and flat washers. 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 ........ 68 N••m (50 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.*

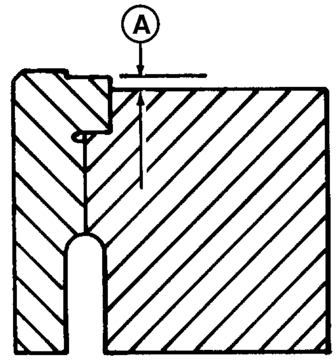
3. Measure each liner in four places, approximately at 1, 5, 7, and 11 O'clock positions as viewed from the rear of the engine (flywheel end). Record all measurements.

4. 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.

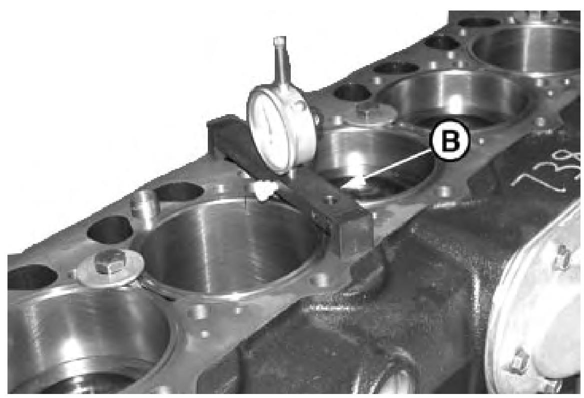
**Specification**

Cylinder Liners—Standout (Height Above Block) ........ 0.051—0.127 mm (0.002—0.005 in.)


*Bolt Down Cylinder Liners*




*Liner Height*




*Measure Cylinder Liner Height Above Block*

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

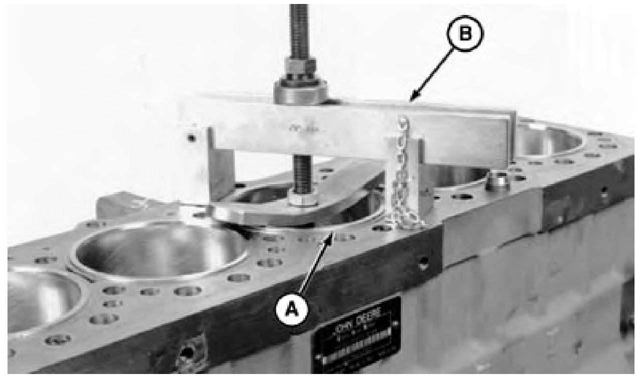
## Remove Cylinder Liners

1. Remove cap screws and washers securing liners to cylinder block.

2. Number cylinder liners and mark fronts to assure correct assembly.

**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).




*Removing Cylinder Liners*

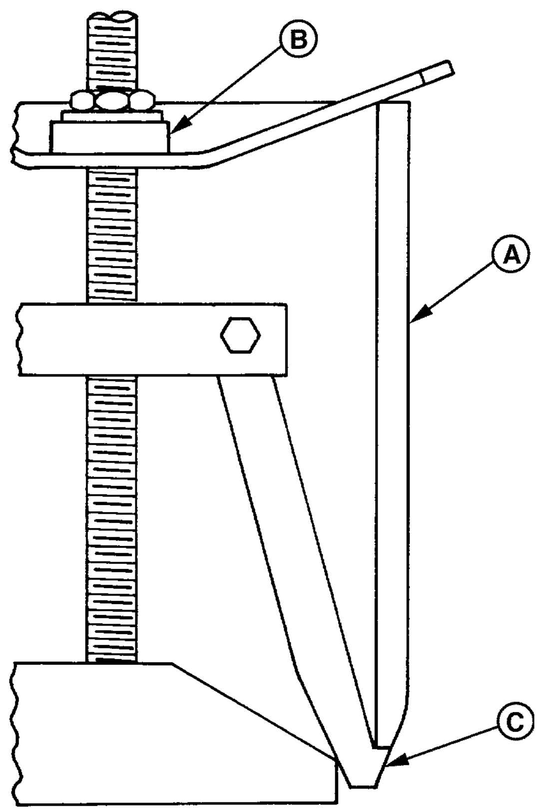
**A—Cylinder Liner**
**B—Cylinder Liner Puller**



RE38635,0000040 –19–11JAN05–1/3

**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*

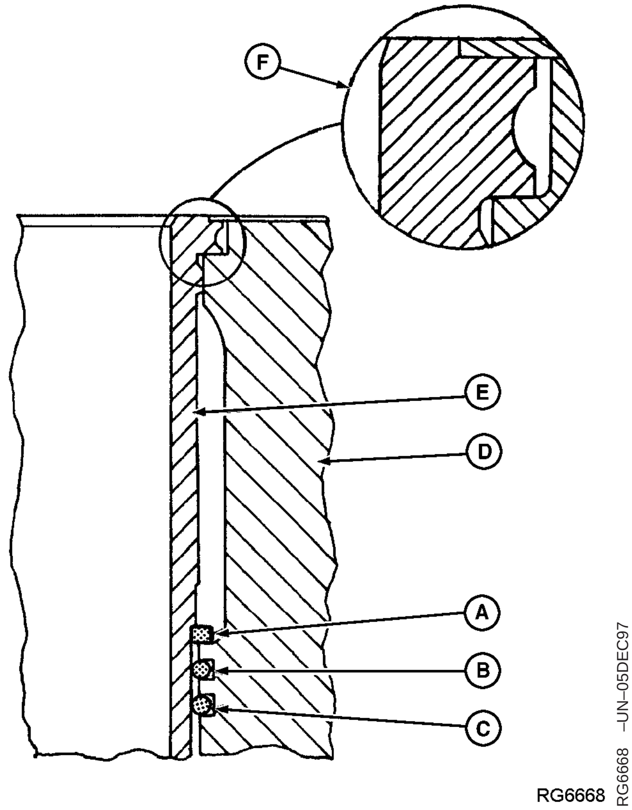
**Continued on next page**

RE38635,0000040 –19–11JAN05–2/3

4. Remove the cylinder liner square packing (A) from liner (E).

5. Remove red O-ring (B) and black O-ring (C) from cylinder block (D).

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




*Cylinder Liner and Seals*

RE38635,0000040 –19–11JAN05–3/3

## 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.*

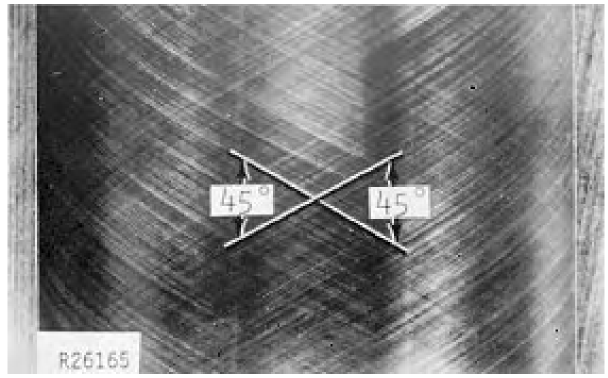

*Deglazing Cylinder Liners*

**Continued on next page**

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

## Clean Cylinder Liners

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 –19–23OCT97–1/1

## Disassemble Piston and Rod Assembly

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



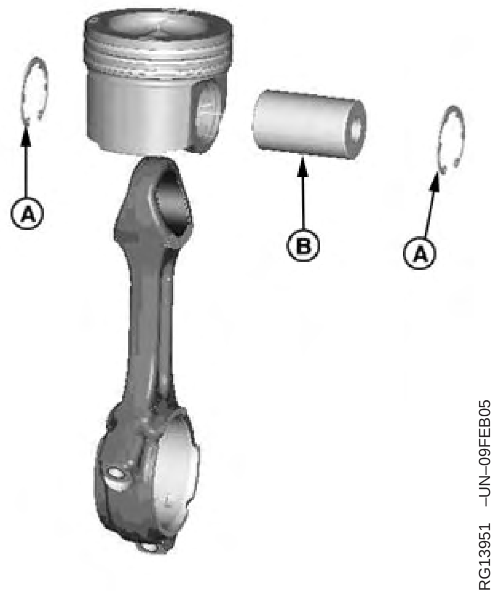
*NOTE: Discard snap rings, DO NOT reuse.*

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

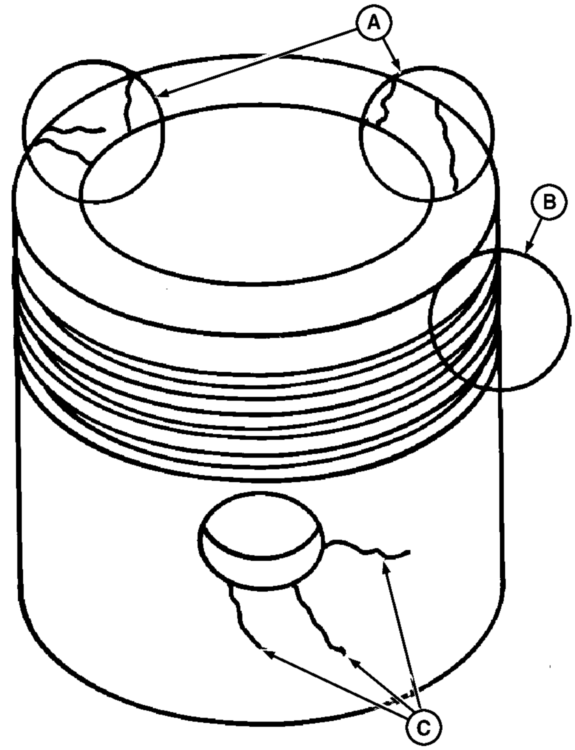
## Visually Inspect Pistons

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 –19–05MAR04–1/1

## 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.

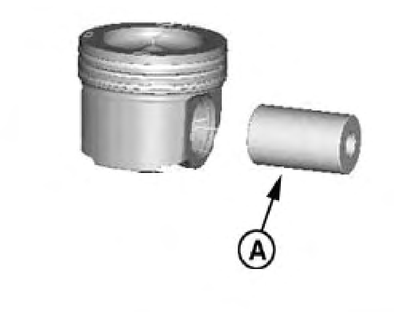
3. Check taper in piston pin bore by inserting pin from both sides. If pin enters freely, but binds in the center, the bore could be tapered (B).

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.

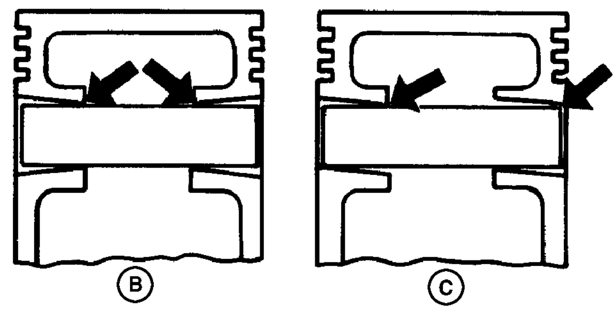
**Specification**

| | |
|---|---|
| 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.) |




RG13985 –UN–19FEB05

*Check Piston Pin to Piston*




RG4984 –UN–05DEC97

*Inspecting for Piston Pin Bore Wear*

**A—Piston Pin**
**B—Tapered Bore**
**C—Bore Out-of-Alingment**

RE38635,0000041 –19–11JAN05–1/1

## Visually Inspect Cylinder Liners

**IMPORTANT: If liner pitting has occurred, check condition of coolant.**

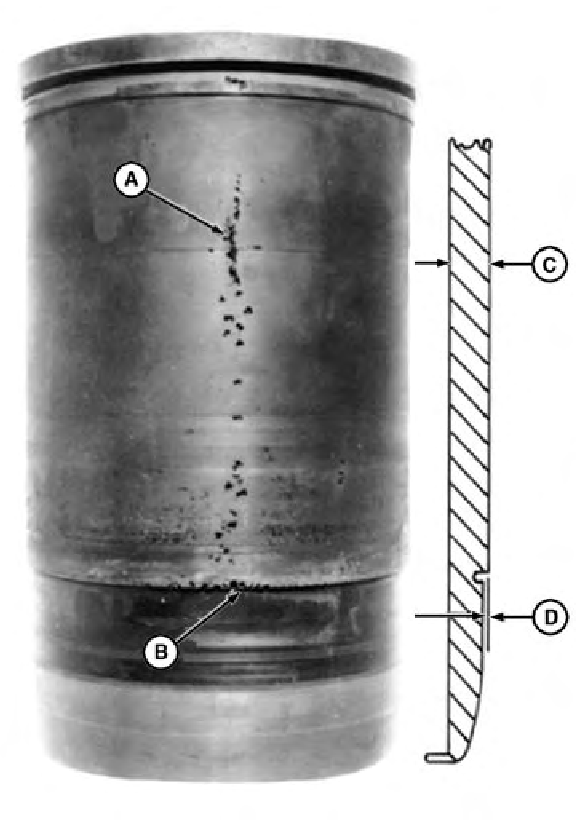
1. Inspect exterior length of liner for pitting (A). Check packing step for erosion (B). If pitting or erosion is observed, measure depth of pits with a fine wire or needle. Replace piston and liner if:

   - 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.*




RG4643 –UN–05DEC97

*Inspecting Cylinder Liners*

**A—Liner Pitting**
**B—Liner Erosion**
**C—Liner Thickness**
**D—Packing Step**

Continued on next page RE38635,0000042 –19–11JAN05–1/2

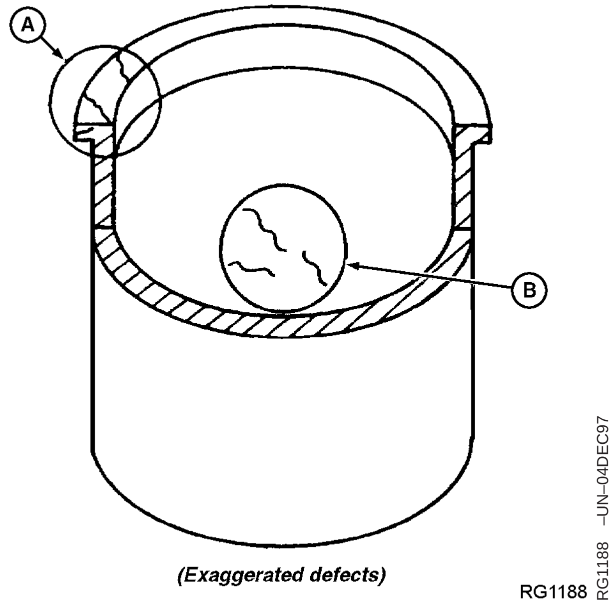
2. Visually examine liner I.D. Replace piston and liner if:

   - 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.


*Date Code on Cylinder Liner*

RE38635,0000043 –19–11JAN05–1/1

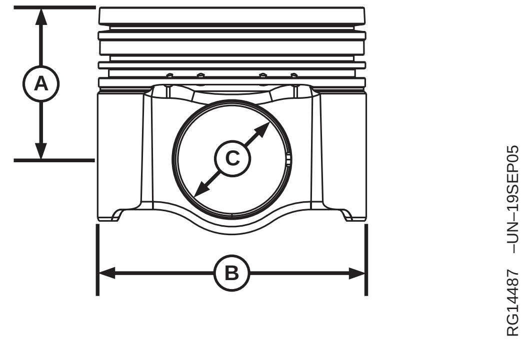
## Determine Piston-to-Liner Clearance

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).

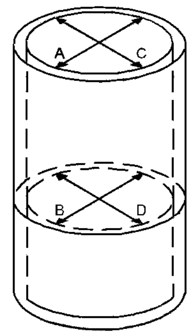
4. Measure bore in same position at bottom end of ring travel (B).

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.



*Measure Liner*

**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 |
| 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.

## 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.

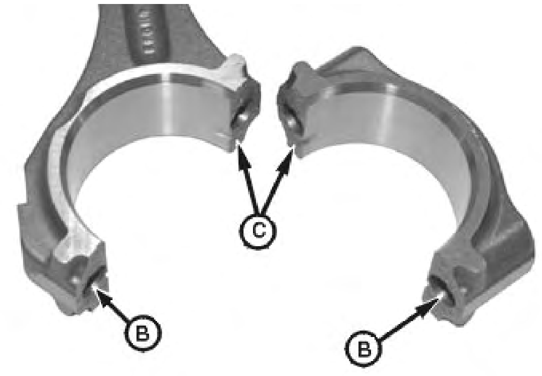
**IMPORTANT: Never use new connecting rod cap screws when checking rod bore I.D. Use new cap screws only for final assembly of connecting rods.**

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™ Rod and Cap*


*Clamping Rod in Vise*

**B—Cap Screw Holes**
**C—Precision Joint™ Mating Surfaces**

*Precision Joint is a trademark of Deere & Company*

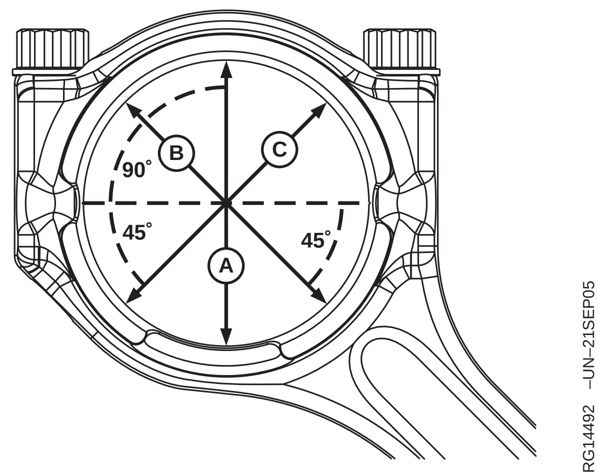
**Continued on next page** RE38635,0000078 –19–23SEP05–1/3

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.)




*Measuring Connecting Rod Pin Bore*

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**

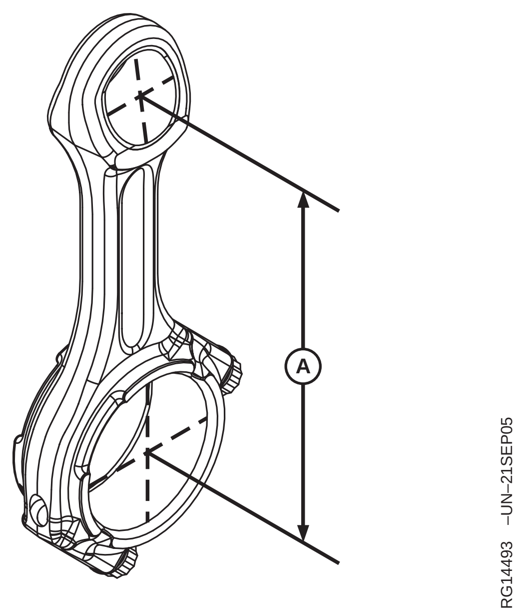
Connecting Rod Bore—Maximum Out-of-Round ........ 0.025 mm (0.0010 in.)

RE38635,0000078 –19–23SEP05–2/3

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 –19–23SEP05–3/3

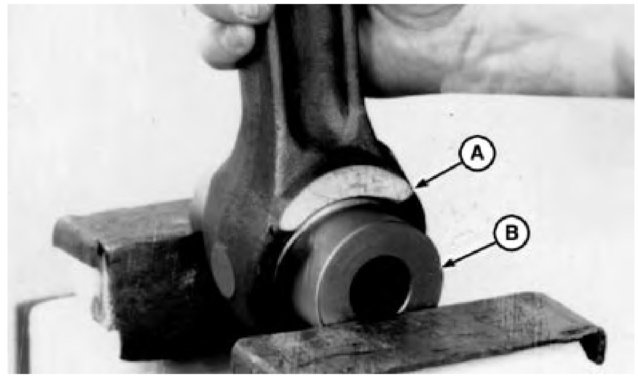
## Inspect Piston Pins and Bushings

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*

RE38635,0000048 –19–14JAN05–1/2

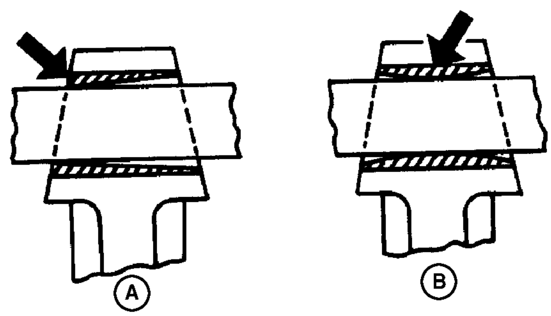
4. Insert pin from either side of rod bushing. If pin is free on one end, but tight on the other, the bore could be tapered (A). If pin enters freely from both sides, but is tight in the center, bore is bell-mouthed (B).

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

## Remove Piston Pin Bushing, Clean and Inspect Pin Bore

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.) |

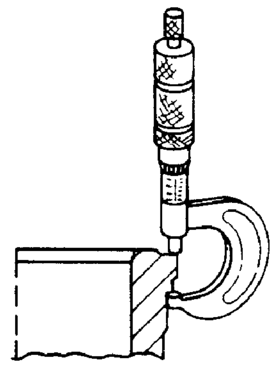
**IMPORTANT: If piston pin bushing bore diameter in rod is not within specification or bushing has spun in rod, discard rod and replace with a new one.**


*Removing Piston Pin Bushing from Rod*

**A—JDG339 Cup**
**B—JDG338 Adapter**
**C—JDE98-4 Driver**
**D—STD36104 Forcing Screw With Washer**

RE38635,0000049 –19–14JAN05–1/1

## Measure Liner Flange




*Measuring Liner Flange*

Measure cylinder liner flange thickness at several locations and compare with specification given below.

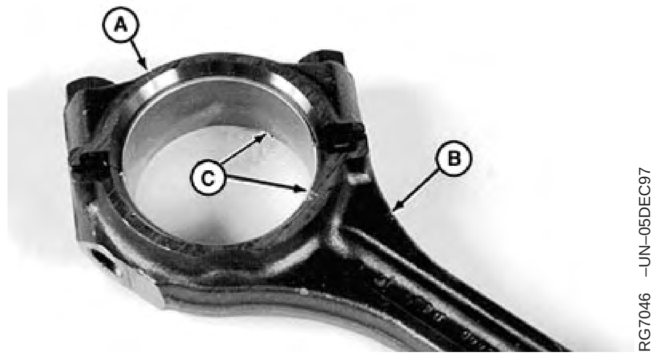
If liner flange is not within specification, either use liner shims as needed or replace piston and liner as a set if shims don’t bring liner standout within specification. See RECHECK CYLINDER LINER STANDOUT and see INSTALL LINER SHIMS—IF REQUIRED, later in this group.)

**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.) |

RG,RG34710,1126 –19–18MAY99–1/1

## Inspect and Measure Connecting Rod Bearings




*Connecting Rod Bearings*

**A—Rod Cap**
**B—Rod**
**C—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

See TORQUE-TURN CONNECTING ROD CAP SCREWS , described later in this group.

*PLASTIGAGE is a registered trademark of DANA Corp.*
*Precision Joint is a trademark of Deere & Company*

**Continued on next page** RE38635,000004A –19–14JAN05–1/2

4. Using an inside micrometer (A) measure I.D. of bearing.

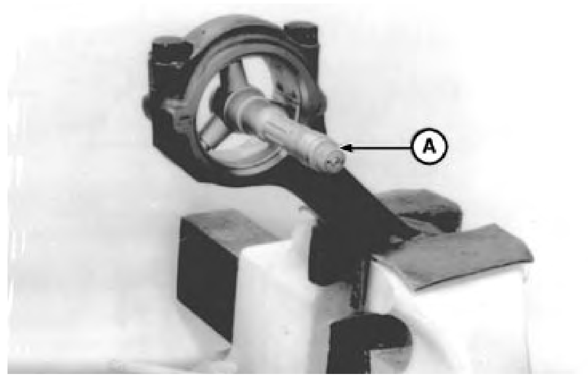
5. Subtract O.D. of crankshaft journals from I.D. of rod bearings to obtain oil clearance.

6. Compare measurements with the following specifications.

**Specification**

| | |
|---|---|
| Crankshaft Rod Journal—OD | 83.487—83.513 mm (3.2869—3.2879 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.




*Measuring Connecting Rod Bearings*

**A—Inside Micrometer**

RE38635,000004A –19–14JAN05–2/2

## Install Piston Pin Bushing in Connecting Rod

**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.

4. Replace rod pin as required.


*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**

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.

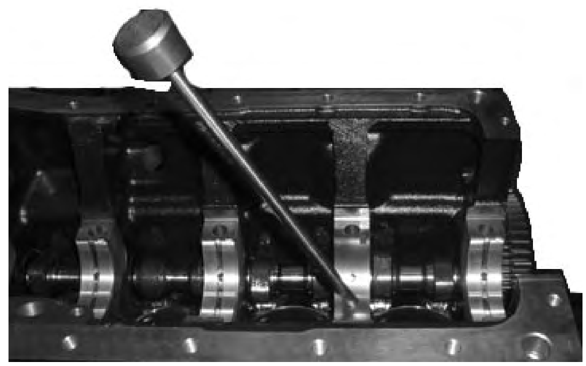
RG,RG34710,1132 –19–23OCT97–1/1

## Remove and Clean Piston Cooling Orifices

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.**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*Remove Piston Spray Orifice*

RE38635,0000069 –19–19FEB05–1/1

## 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.

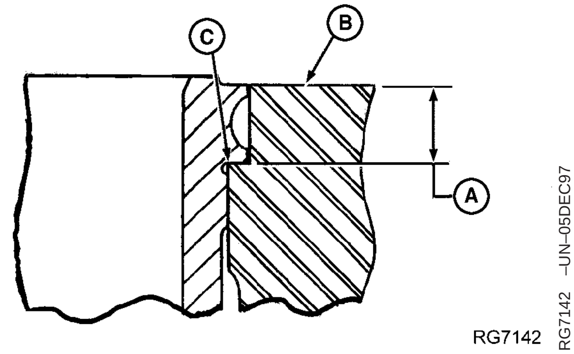
*NOTE: DO NOT file liner support flange excessively. Excess filing can damage liner support flange and allow an improper liner fit. Thoroughly clean all filings from cylinder block.*

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

## Install Piston Cooling Orifices

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.

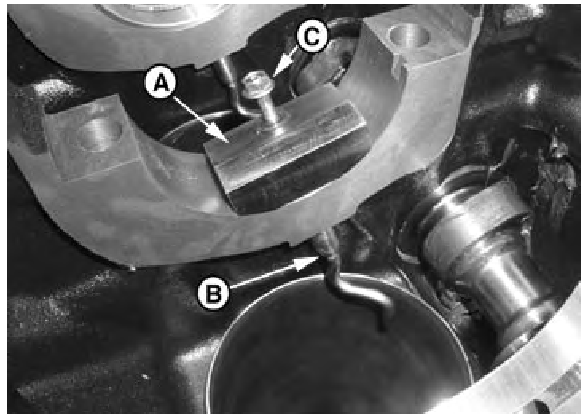
5. Assemble installation screw into cooling orifice with fingers. This will begin to seat cooling orifice in block.

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)

**A—JDG1948 Piston Spray Orifice Installation Tool**
**B—Piston Spray Orifice**
**C—JDG1948 Installation Tool Screw**
**D—Depth Verification Mark**



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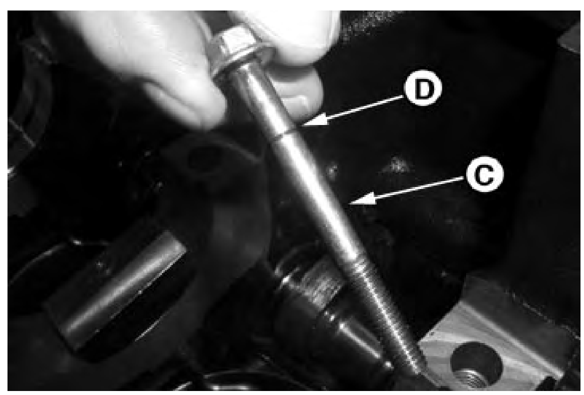
*Assemble Piston Spray Orifice*

RG14680 –UN–13JAN06

*Coat with Loctite 242*



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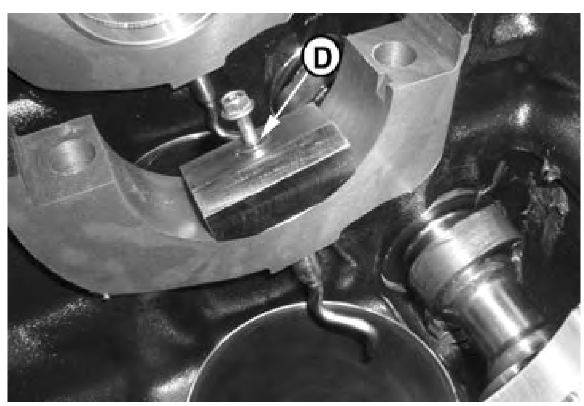
*Verify Piston Spray Orifice Depth*



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*Verification of Depth*

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Continued on next page RE38635,0000057 –19–13JAN06–1/2

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.

RE38635,0000057 –19–13JAN06–2/2



## Recheck Cylinder Liner Standout

*NOTE: If a new liner assembly is being installed in a new or used cylinder block, liner height must be checked.*

Be sure liner bore in cylinder block and top deck of block are clean.

Install liners without packing. Secure with cap screws and washers and measure liner standout. See MEASURE CYLINDER LINER STANDOUT (HEIGHT ABOVE BLOCK) earlier in this group.

Liner shims may be used to bring standout within specification. See INSTALL LINER SHIMS—IF REQUIRED later in this group.

RG,RG34710,1137 –19–23OCT97–1/1

## Install Packing on Cylinder Liner and O-Rings in Block

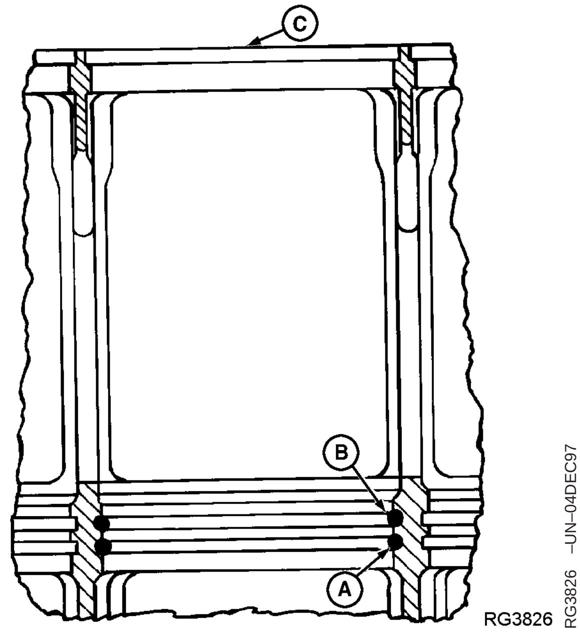
**IMPORTANT: DO NOT use oil on cylinder liner packing or O-rings. Oil can cause the red packing to swell, which squeezes liner and could possibly cause a scored piston.**

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 black viton O-ring (A) in the lower O-ring groove in the cylinder block (C).

4. Install the red silicone O-ring (B) in the upper O-ring groove in the cylinder block.




*Cylinder Liner Seals*

**A—O-Ring**
**B—O-Ring**
**C—Cylinder Block**

RG,RG34710,1139 –19–23OCT97–1/2

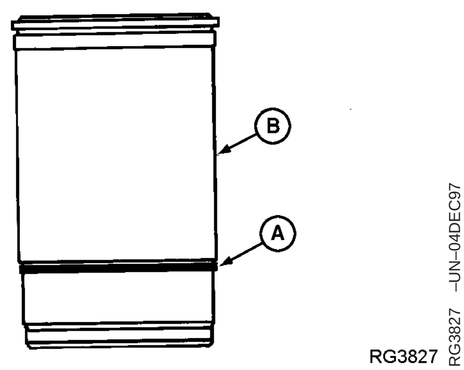
5. Turn cylinder liner (B) upside-down and install the square neoprene packing (A) over outside of liner.

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**




*Installing Cylinder Liner Packing*

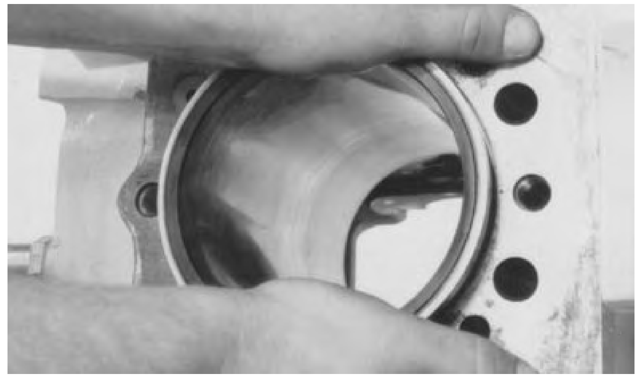
RG,RG34710,1139 –19–23OCT97–2/2

## 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.**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*Installing Cylinder Liners in Block*

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.

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.

**Continued on next page** 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.

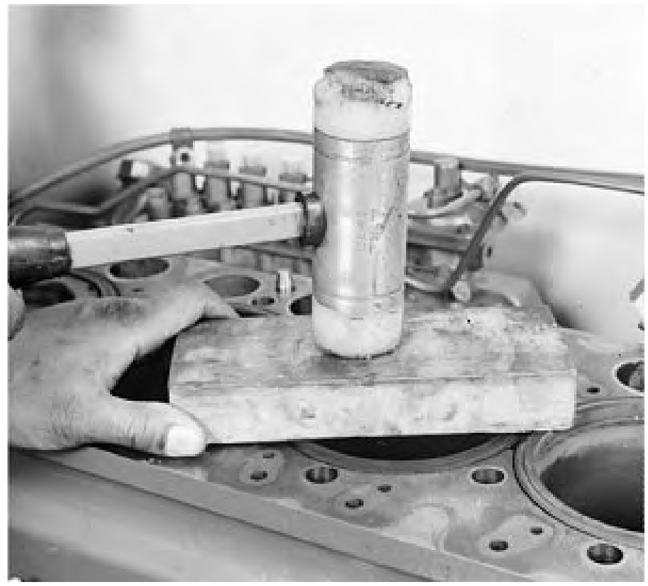
*NOTE: Cylinder liner will protrude over top of cylinder block more than normal due to uncompressed packings and O-rings.*

**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: Full keystone compression ring (one "Pip" mark) goes in top piston ring groove. Rectangular second ring (two "Pip" or "Top" marks) goes in second ring groove of piston."Pip" mark(s) on No. 1 and No. 2 compression rings must face top of piston.**

**KS piston rings are color coded. The No. 1 ring is orange, No. 2 is yellow and No. 3 is white. The expander ring is white. Be sure the white paint stripe on the expander ring is visible in the oil ring gap.**

1. Using JDE93 Ring Expander, install oil control ring with expander ring (A) 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 yellow paint stripe and double pip mark in the middle piston groove. The pip marks must face top of piston.

3. Install the number 1 compression ring (C) with orange paint stripe and single pip mark in the top piston groove. The pip mark must face top of piston.


*Install Piston Rings*

**A—Oil Control, or Expander,Ring**
**B—Middle (Second) Compression Ring**
**C—Top Piston Ring**

**Continued on next page** RE38635,0000046 –19–07FEB06–1/6

## 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.**

1. Install one snap ring (A) into piston pin bore groove

2. Lubricate piston pin (C), piston and rod bores with clean engine oil.

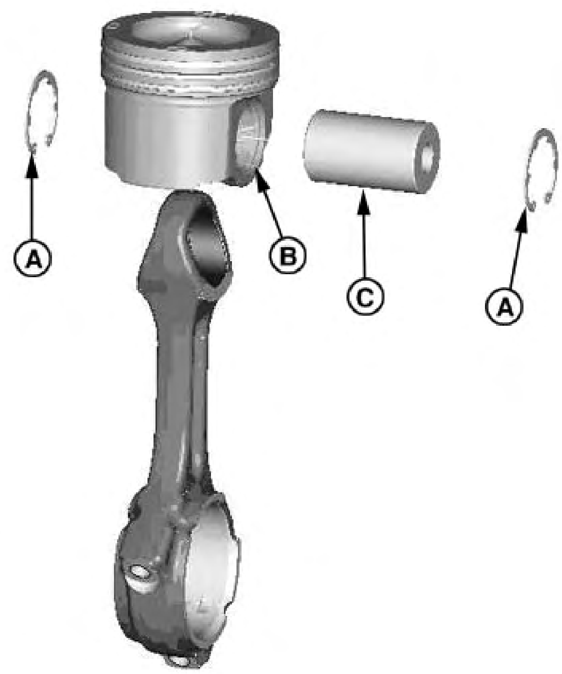
**IMPORTANT: Be certain "FRONT" of connecting rod aligns with arrow, or "FRONT" of piston.**

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.




RG13909 –UN–13JAN05

*Assemble Piston to Connecting Rod*

**A—Snap Ring**
**B—Piston**
**C—Piston Pin**

**Continued on next page** RE38635,0000046 –19–07FEB06–2/6

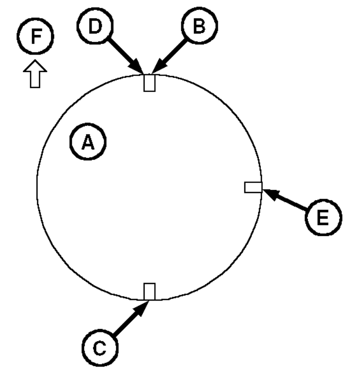
## Install Piston and Rod Assembly into Block

*NOTE: New rings are furnished with the correct end gap, therefore, fitting to the liner is not necessary.*

2. 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.*

3. Lubricate all parts in piston & rod assembly (piston, rings, liners and I.D. of JDG1963 Piston Ring Compressor) with clean engine oil.




RG10050 –UN–21MAY99

*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**

RE38635,0000046 –19–07FEB06–3/6

4. 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.

5. Lubricate crankshaft journal and liner bore with clean engine oil.

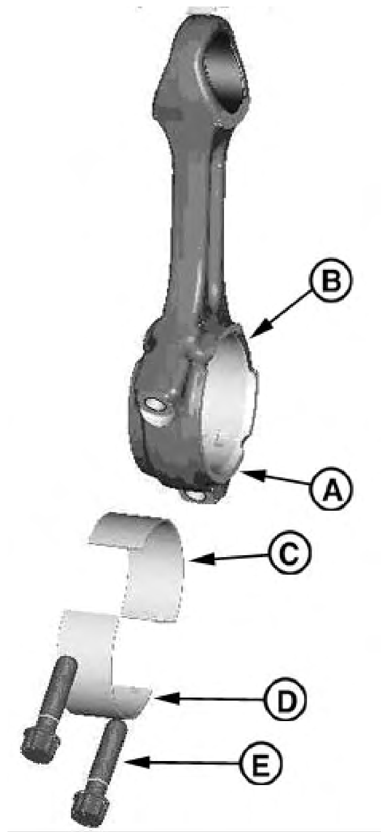
6. Carefully place ring compressor with piston and rod over liner.

**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 piston and rod face toward the front of the engine.*

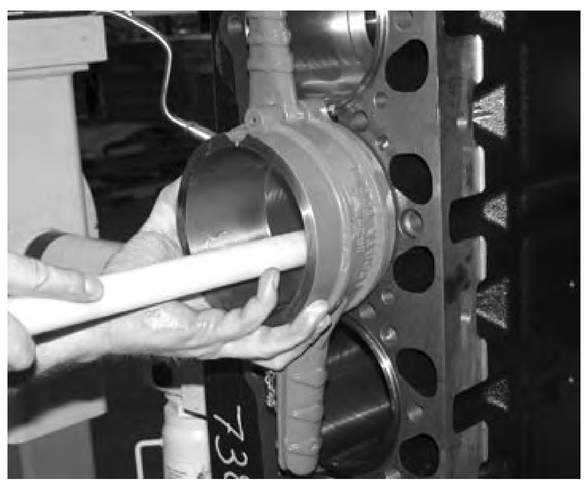
7. With piston centered in ring compressor and rings staggered correctly, push piston into liner, as shown, until top ring is inside the liner.

**A—Connecting Rod**
**B—Connecting Rod Cap**
**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*

**Continued on next page** RE38635,0000046 –19–07FEB06–4/6

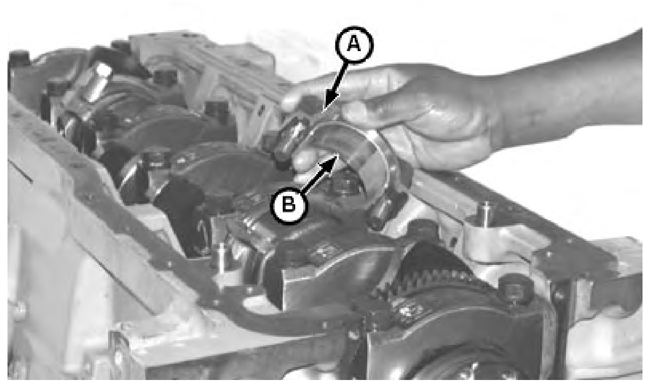
8. Apply clean engine oil to bearing inserts (B) and matching crankshaft rod journals.

**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.**

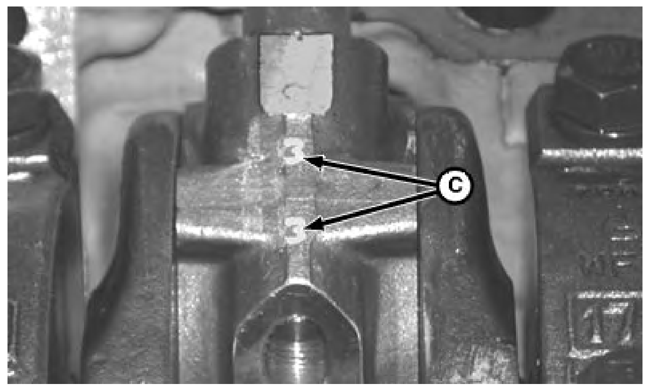
9. Install connecting rod caps (A).

**A—Connecting Rod Caps**
**B—Bearing Inserts**
**C—Stamped Numbers**




RG10209 –UN–18JUN99

*Installing Connecting Rod Caps with Bearing Inserts*




RG10215 –UN–23JUN99

*Stamped Numbers*

*Precision Joint is a trademark of Deere & Company*

**Continued on next page**

RE38635,0000046 –19–07FEB06–5/6

**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.**

10. Dip NEW cap screws and washers in clean engine oil. Make sure bore threads and all threads on cap screws are thoroughly oiled.

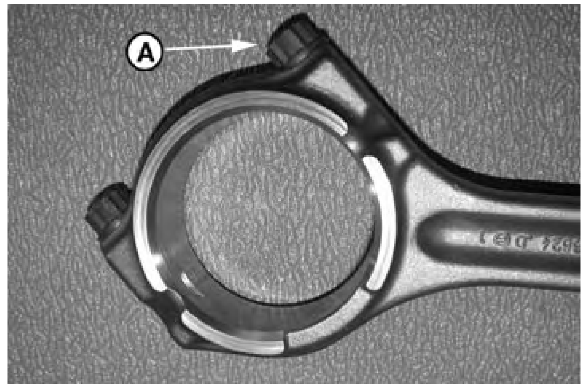
**IMPORTANT: DO NOT use pneumatic wrenches to install connecting rod cap screws. Doing so may damaged threads. Use speed-handle wrench instead.**

11. **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**

| 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 next in this group.




RG14186 –UN–28MAY05

*Connecting Rod*

**A—Tighten This Cap Screw First**

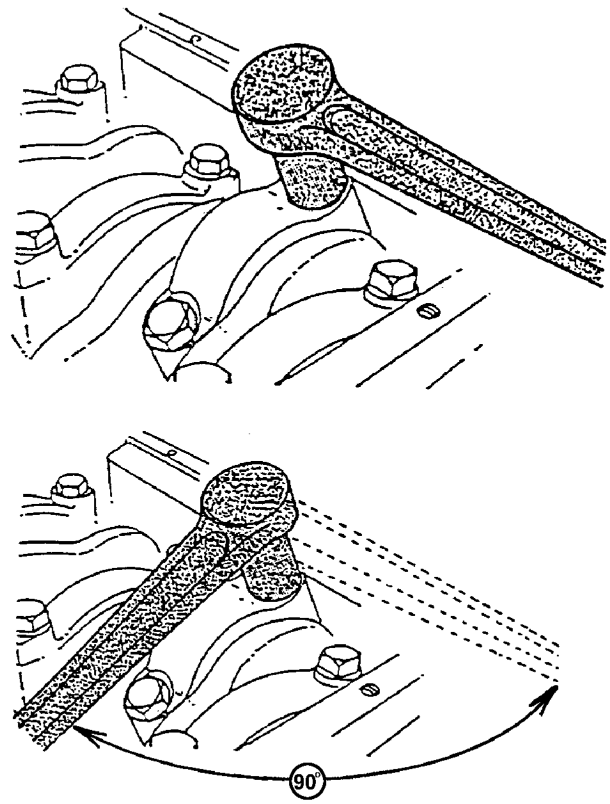
*Precision Joint is a trademark of Deere & Company*

RE38635,0000046 –19–07FEB06–6/6

## 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.



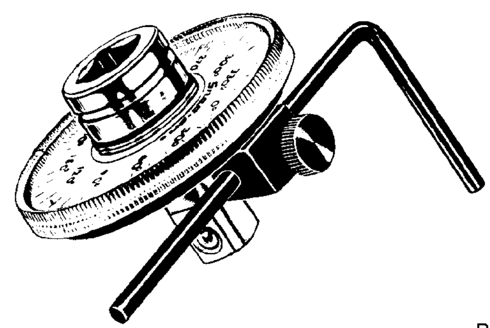

RG7047 RG7047 –UN–05DEC97

*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 RG5698 –UN–05DEC97

*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:**

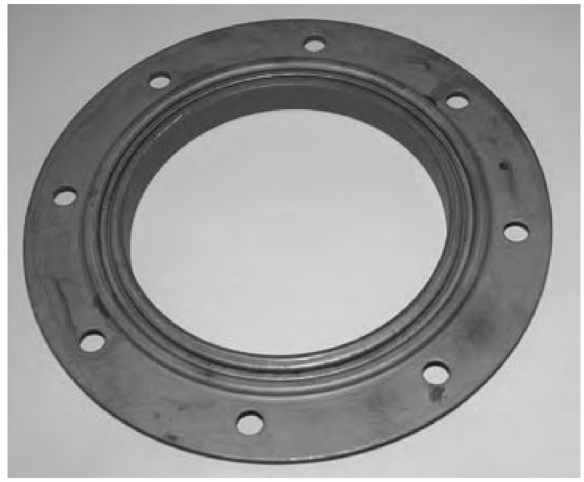
- Overspeeding.
- Excessive idling.
- Lugging.
- Excessive oil clearance.
- Improper installation.

RG,RG34710,1149 –19–23OCT97–1/1

## Crankshaft Rear Oil Seal and Wear Sleeve General Information

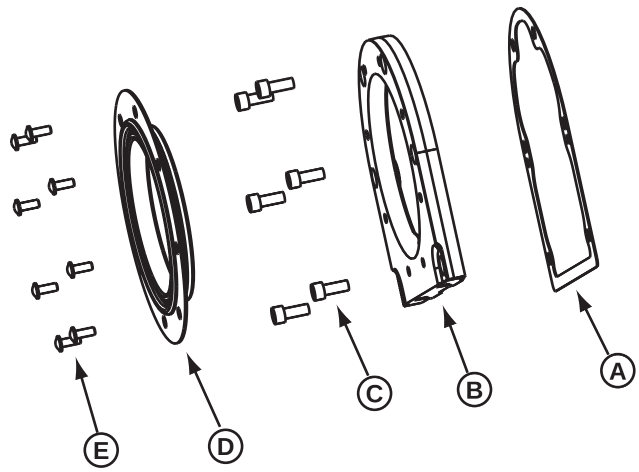
The 9.0 L rear seal and wear sleeve design is similar to the seal used on the 6125 engines. The removal tool used on the 6125 rear seal assembly will work for the 9.0 L. A new installation tool must be used due to dimensional differences.

**A—Rear Oil Seal Housing Gasket**
**B—Rear Oil Seal Housing**
**C—Socket Head Screws - Housing to Block**
**D—Crankshaft Rear Seal & Wear Sleeve**
**E—Button Head Screws - Oil Seal to Oil Seal Housing**



RG13980 –UN–19FEB05

*9.0 L Rear Seal and Wear Sleeve Assembly*




RG14002 –UN–24FEB05

*Rear Oil Seal and Rear Oil Seal Housing*

RE38635,0000079 –19–15MAR05–1/1

## Remove Crankshaft Rear Oil Seal and Wear Sleeve

**IMPORTANT: To remove rear crankshaft oil seal, the seal housing MUST BE removed also.**

1. Remove engine oil pan.

2. Remove flywheel if not previously removed.

3. Remove eight button head screws (A) securing rear seal to housing.

4. Separate seal from housing using a small flat screwdriver and heel-type pry bar as shown.

5. Remove all cap screws securing rear seal housing to cylinder block except top cap screw and two bottom cap screws (A) as shown.

*NOTE: position split in collet halves at 12:00 position (C).*

6. Install JDG1020 Rear Seal Remover (B) using knife-edge jaws. Install puller jaws between seal carrier and seal housing.

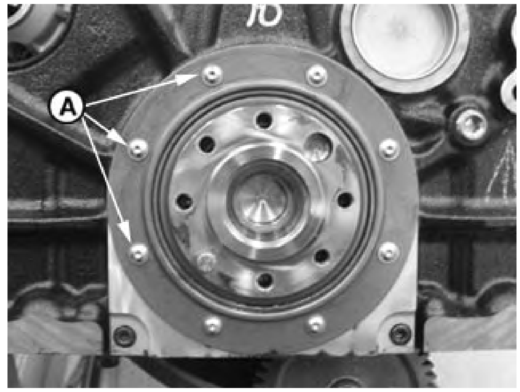
7. Secure assembly by tightening band clamp securely.

*NOTE: Always lubricate forcing screw with multi-purpose grease prior to using.*

8. Tighten forcing screw until rear seal is free from seal housing. Wear sleeve portion of seal assembly should remain on crankshaft flange.

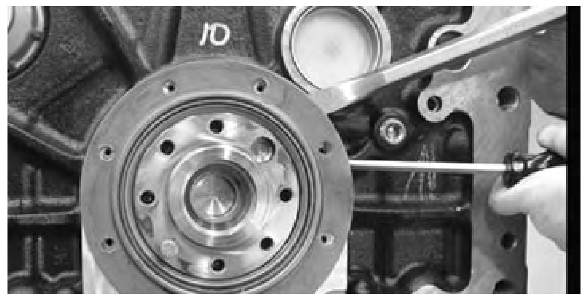
9. Remove three remaining cap screws securing seal housing to block and remove housing with gasket.

10. If necessary, push wear sleeve portion of seal assembly away from block to allow collet halves to be installed behind wear sleeve.



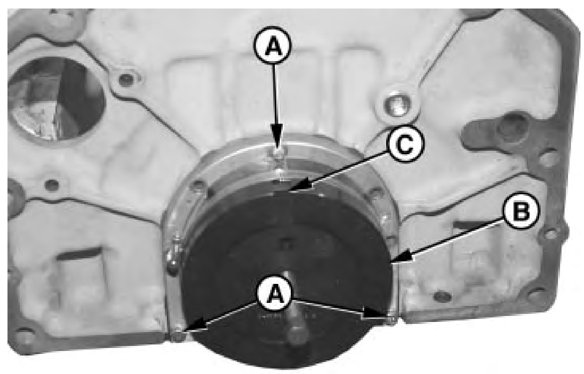

RG13981 –UN–21MAR05

*Removing Rear Oil Seal and Housing*



RG13982 –UN–21MAR05

*Separating Rear Seal from Housing*




RG8344 –UN–09DEC97

*Removing Rear Seal*

**A—Cap Screw**
**B—JDG1020 Rear Seal Remover**
**C—12:00 Position**

**Continued on next page** RE38635,000007A –19–15MAR05–1/2

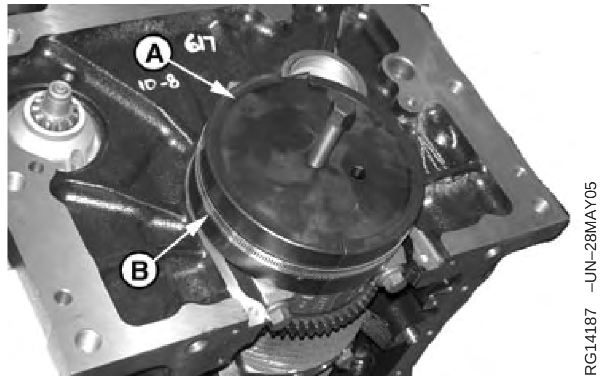
11. Install JDG1020 Removal Tool (A) behind wear sleeve using smaller knife edge jaws. Tighten band clamp (B) securely.

12. Lubricate threads and tighten forcing screw until wear sleeve is removed from crankshaft flange.

13. Inspect crankshaft flange for burrs and nicks.

14. Clean all oil and sealant from crankshaft flange using Brake Kleen or ignition cleaner. Polish burrs with fine emery cloth.

**A—JDG1020**
**B—Band Clamp**



*Removing Rear Wear Sleeve with JDG1020*

RE38635,000007A –19–15MAR05–2/2

## Crankshaft Rear Oil Seal and Wear Sleeve Handling Precautions

**Use the following precautions for handling seal and wear sleeve:**

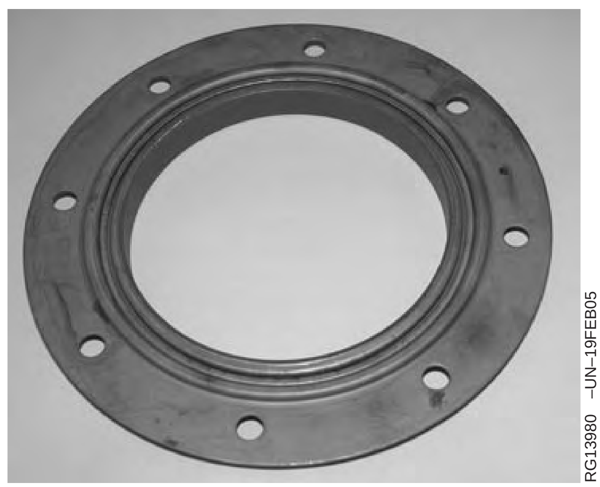
Seal and wear sleeve are assembled. DO NOT SEPARATE. If parts become separated, discard and replace with a new assembly. Attempts to reassemble will cause the wear sleeve to damage the seal allowing engine oil to leak past seal.

Always install seal and wear sleeve assembly immediately after removal from plastic bag to avoid possible dirt contamination.

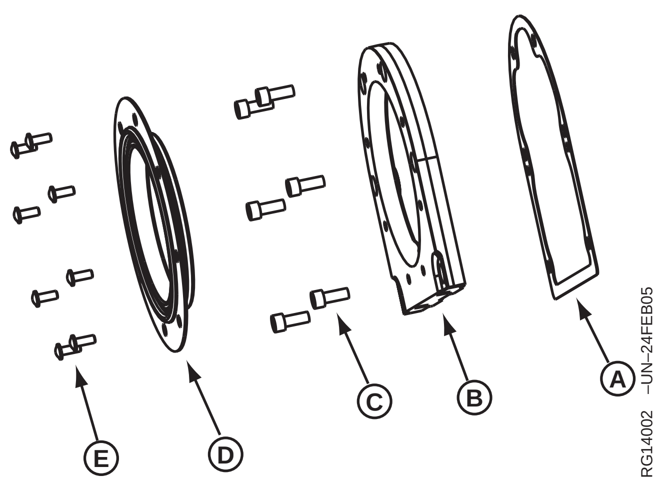
No lubricant of any kind is to contact seal when installing. Use of a lubricant may result in premature seal failure.

Install oil seal/wear sleeve assembly as shown in the illustration. Incorrect installation will result in an oil leak.

Oil seal/wear sleeve assembly MUST BE installed with the JDG1952, JDG1953, and JDG1954 Crankshaft Rear Oil Seal Installation Tool Set.



*Rear Oil Seal and Wear Sleeve Assembly*



*Rear Oil Seal and Housing*

RE38635,000007B –19–15MAR05–1/1

## Install Crankshaft Rear Oil Seal Housing

*NOTE: Clean all gasket material and sealant from oil pan gasket rail prior to installing rear seal housing for proper housing alignment*

**IMPORTANT: Ensure that OD of crankshaft flange and ID of rear seal housing is free of nicks and burrs. Restore damaged surfaces with emery cloth and clean surfaces thoroughly.**

1. Install JDG1954 Pan Rail Alignment Tool (F) onto rear pan rail (as shown) using two cap screws provided. Tighten cap screws securely.

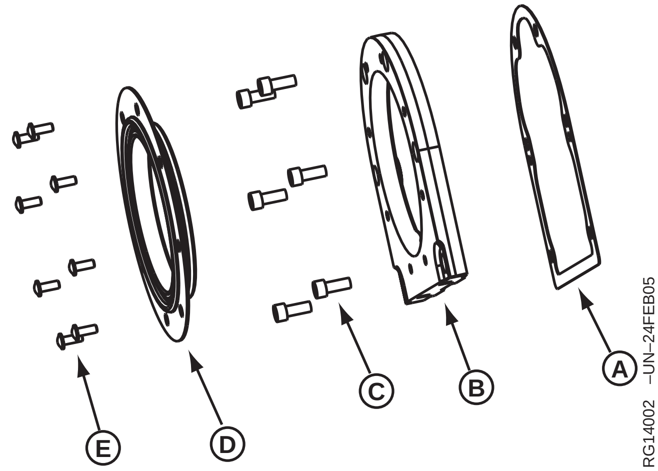
2. Using guide pins (G), install rear housing gasket (A) and rear seal housing (B) to rear flange of cylinder block. The bottom edge of gasket should extend through opening in alignment tool.

*NOTE: Centering tool will fit snugly over crankshaft flange. A hammer may be needed to carefully tap tool over flange to align seal housing.*

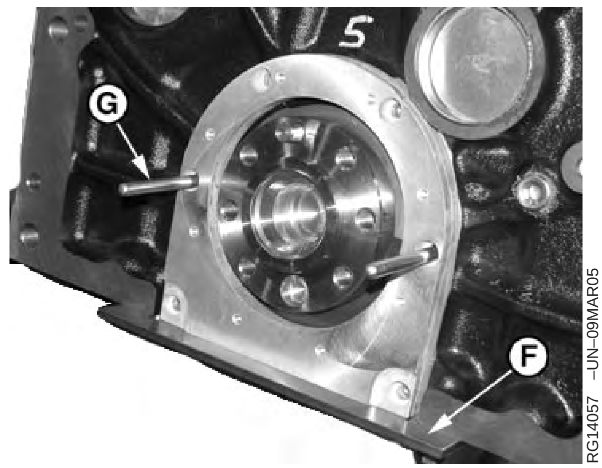
**IMPORTANT: It is important to keep the centering locators at the 9:00 and 3:00 position. These tabs center the oil seal housing in the left-right plane.**

3. Install JDG1953 Housing Centering Tool (H) onto crankshaft rear flange. Position tapered locators (I) at 3:00 and 9:00 positions as shown.

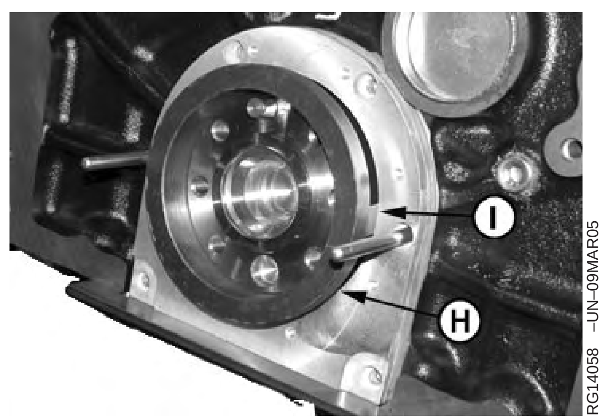
**A—Rear Seal Gasket**
**B—Rear Seal Housing**
**C—Socket Head Screws**
**D—Rear Oil Seal & Wear Sleeve Assembly**
**E—Button Head Screws**
**F—JDG1954 Alignment Tool**
**G—Guide Pins**
**H—JDG1953 Centering Tool**
**I—Centering Tool Locators**




*Rear Oil Seal & Housing Assembly*




*Rear Seal Housing Installed with JDG1954 Alignment Tool*




*Centering Real Seal Housing with JDG1953 Tool*

**Continued on next page** RE38635,000007C –19–13JAN06–1/2

02
040
5

*NOTE: The holes in the cylinder block for rear seal housing are blind holes. No sealant is required for these socket head screws.*

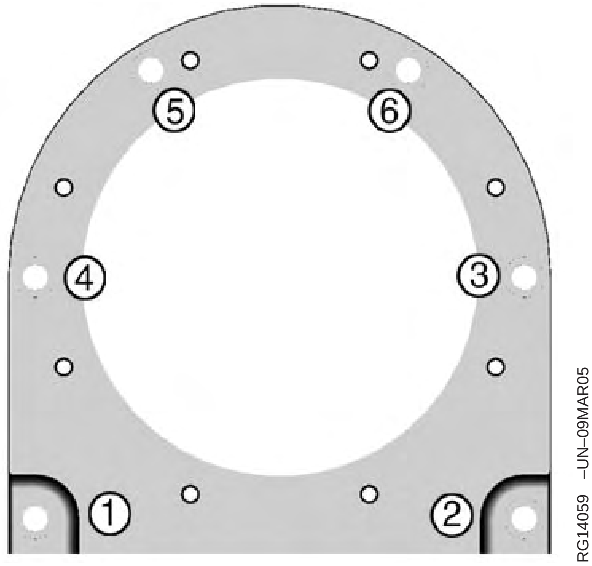
4. Install six socket head screws (C) through housing into rear block flange and tighten to specification in the sequence shown.

**Specification**

Rear Seal Housing to Cylinder Block—Torque ................................................ 27 N•m (20 lb-ft)

*NOTE: Leaving the rear seal housing centering tool in place on crankshaft flange will aid in installation of rear seal and wear sleeve assembly.*

5. Remove alignment tool from pan rail and trim gasket flush with bottom of seal housing and oil pan gasket surface.




*Rear Seal Housing Torque Sequence*

RE38635,000007C –19–13JAN06–2/2

## Install Crankshaft Rear Oil Seal & Wear Sleeve Assembly

1. Thoroughly clean ID of rear seal housing and OD of crankshaft flange. Dry with a clean shop towel.

2. With JDG1953 Rear Housing Centering Tool still in place (A), install JDG1952-1 Rear Seal Installation Tool (B), using the crankshaft dowel (C) for location. The rear seal housing centering tool will help align the installation tool to the crankshaft flange OD. Tighten two cap screws provided securely

3. Remove JDG1953 Rear Seal Housing Centering Tool.

*NOTE: Align mounting holes in seal casing with holes in rear seal housing as seal assembly is installed.*

4. Position rear seal and wear sleeve assembly (D) and JDG1952-2 Seal Installation Tool (E) onto rear crankshaft flange and forcing screw.

5. Lubricate forcing screw threads and both sides of friction washer. Install washer and nut; tighten nut (F), driving seal assembly onto crankshaft flange, until install tool bottoms.

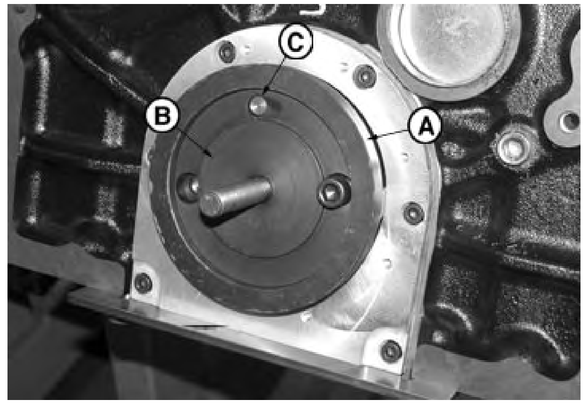
6. Remove seal installation tool set.

**IMPORTANT: It is best to install engine oil pan and torque hardware PRIOR to tightening the rear seal to rear seal housing. Installation of the oil pan first helps keep rear seal in alignment.**

7. Apply LOCTITE® Thread Sealant to button head screws. Install eight button head screws, securing seal to housing, and torque to specification in the sequence shown.

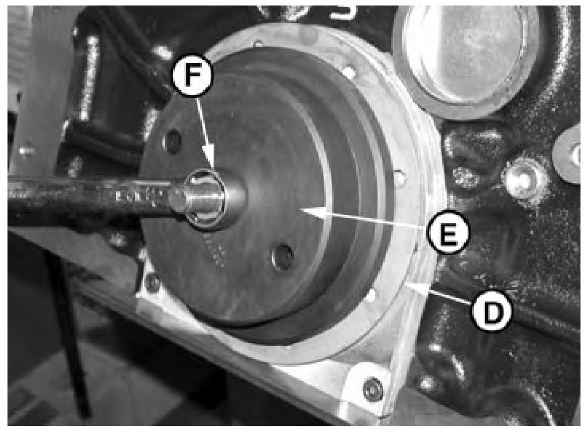
**Specification**

Rear Seal Assembly to Rear Seal Housing—Torque............................................................ 15 N•m (10 lb-ft)



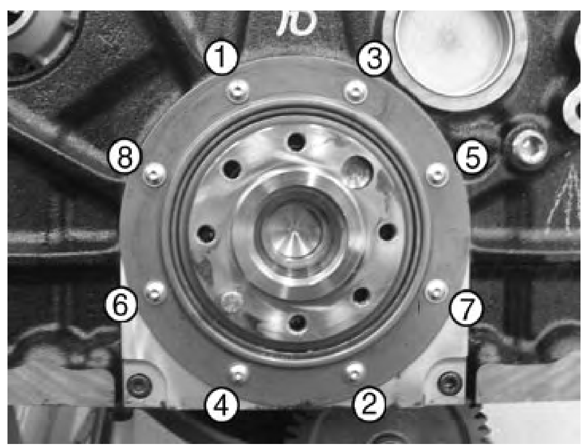

RG14060 –UN–09MAR05

*JDG1952-1 Rear Seal Installer*




RG14061 –UN–09MAR05

*Installing Rear Crankshaft Oil Seal & Wear Sleeve*




RG14062 –UN–09MAR05

*Rear Seal Torque Sequence*

*LOCTITE is a trademark of Loctite Corp.*

RE38635,000007D –19–17MAR05–1/1

## Inspect Vibration Damper

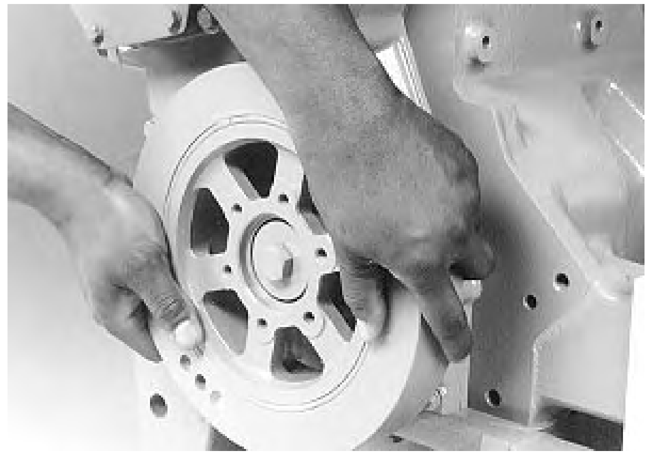
**IMPORTANT: The damper assembly is not repairable and should be replaced every 5 years or 4500 hours, whichever occurs first. Also, replace damper whenever crankshaft is replaced or major engine overhaul is performed. Dual dampers should always be replaced as a matched set.**

**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.**

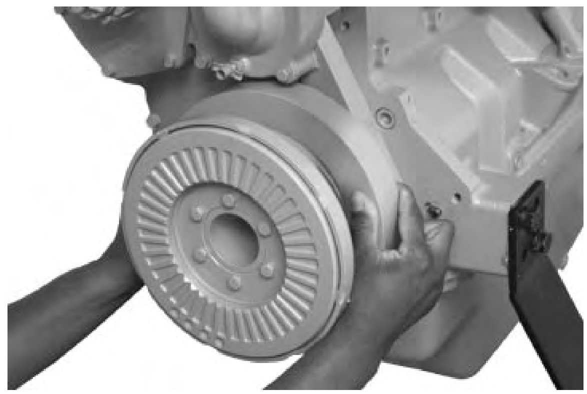
1. Relieve tension or remove V-belts (shown removed).

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.



RG7208 –UN–28JUL94

*Single Damper*



RG7369 –UN–05JAN98

*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.

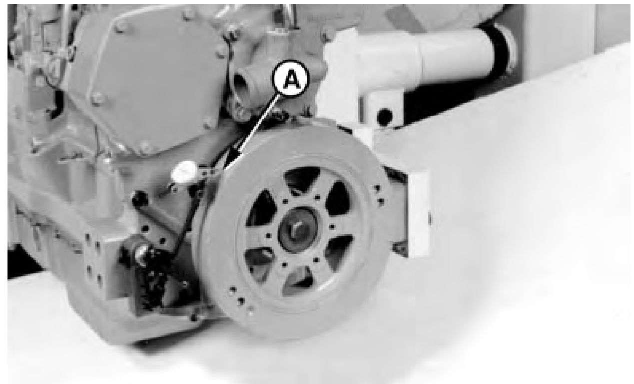
5. Note total dial indicator movement. Compare reading with specification below.

**Specification**

Vibration Damper—Maximum
Radial Runout............................................................ 1.02 mm (0.040 in.)

If runout exceeds specifications, replace vibration damper. See REMOVE CRANKSHAFT VIBRATION DAMPER 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

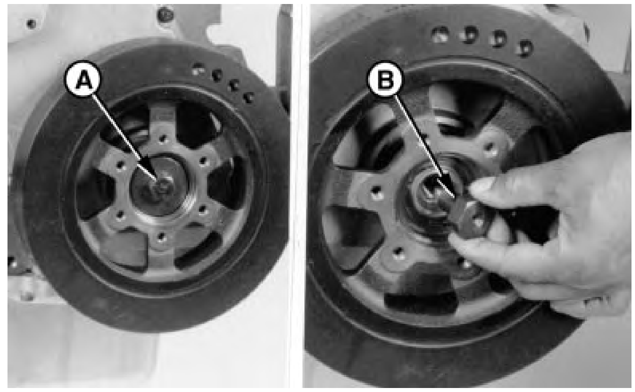
## Remove Crankshaft Vibration Damper

**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 JDG787 Thread Protector (B) in nose of crankshaft.




RG6751 –UN–26NOV97

*Preparing to Remove Crankshaft Vibration Damper*

**A—Cap Screw**
**B—Thread Protector**

RG,RG34710,1154 –19–23OCT97–1/2

**CAUTION: Plan a safe handling procedure to avoid personal injury or damage to damper.**

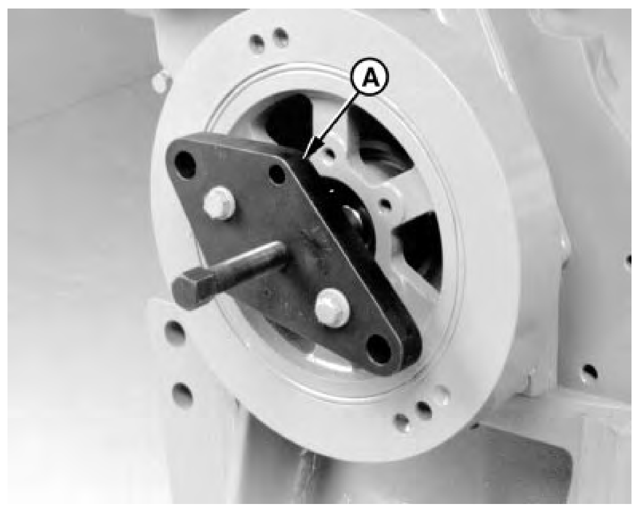
4. Remove damper from crankshaft using JDG721 Hub Puller (A).

*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.) |




RG7209 –UN–26NOV97

*Removing Crankshaft Vibration Damper*

**A—JDG721 Hub Puller**

RG,RG34710,1154 –19–23OCT97–2/2

## 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.*

**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.

RG6471 –UN–05DEC97

*Center Punching Front Oil Seal Casing*

RG,RG34710,1155 –19–23OCT97–1/5

3. Drill 3.175 mm (1/8 in.) hole in casing.

RG6472 –UN–05DEC97

*Drilling Hole in Front Oil Seal Casing*

RG,RG34710,1155 –19–23OCT97–2/5

4. Using JDG719 Seal Puller along with JDE38-2 Shank, JDE38-3 Hammer, and metal screw, remove seal.

5. Remove keyway from keyslot of crankshaft.

RG6473 –UN–05DEC97

*Removing Front Oil Seal*

Continued on next page

RG,RG34710,1155 –19–23OCT97–3/5

**To Remove Wear Sleeve Using JDG786:**

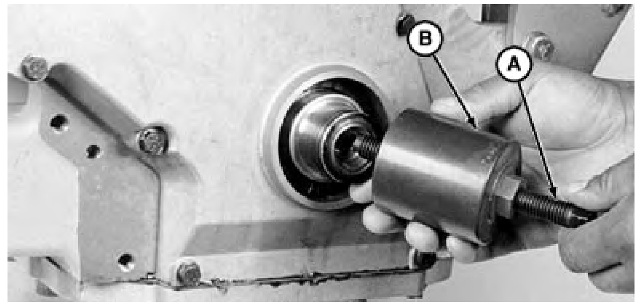
1. Start fully threaded centering screw (A) through hex head end of puller (B) from JDG786 Front Wear Sleeve Puller until head of screw is approximately 1/2 in. from hex on puller.

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.

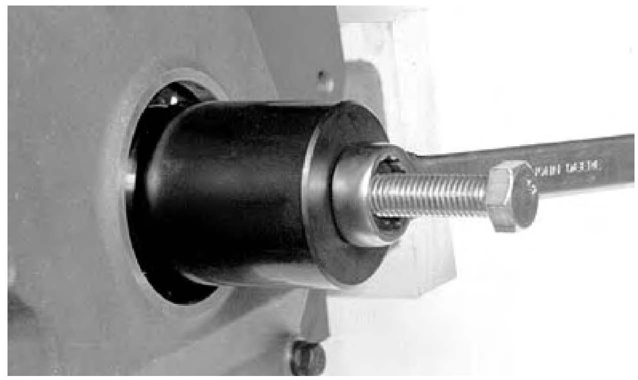
4. Remove centering screw from nose of crankshaft and puller.

**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*

RG,RG34710,1155 –19–23OCT97–4/5

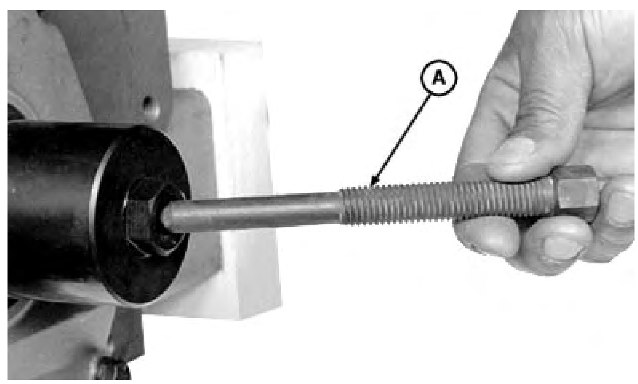
5. Install partially threaded forcing screw (A) into puller and tighten until bottoms in nose of crankshaft. There in no thread engagement in crankshaft; just with puller.

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

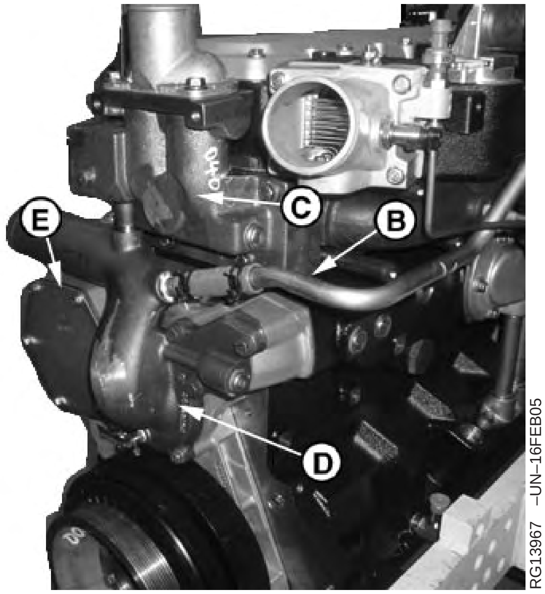
*Removing Front Wear Sleeve*

**A—Forcing Screw**

RG,RG34710,1155 –19–23OCT97–5/5

## 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.




*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.

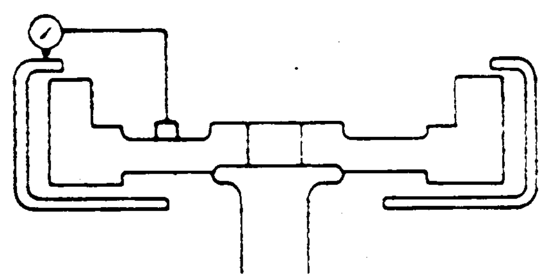
RG,RG34710,1158 –19–23OCT97–1/1

## 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.



R22212 –UN–14DEC88

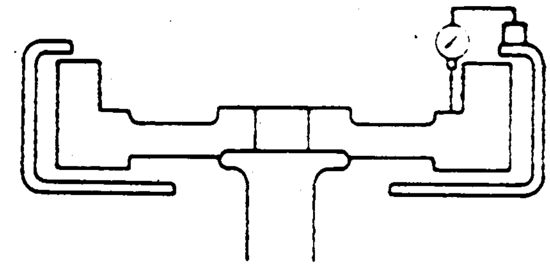
*Checking Flywheel Housing Face Runout*

**Specification**

Flywheel Housing Face—Runout............... 0.20 mm (0.008 in.) Maximum Variation

RG,RG34710,1159 –19–23OCT97–1/1

## Check Flywheel Face Flatness




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.**

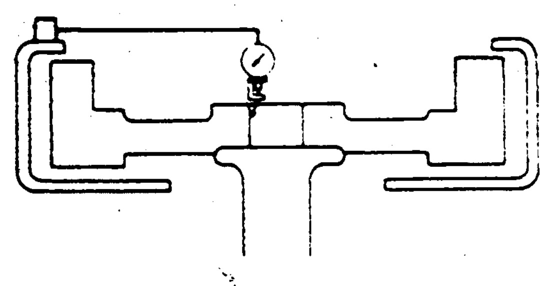
2. Rotate flywheel by turning crankshaft. Read total dial indicator movement. Resurface flywheel face or replace as required.

**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




*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.

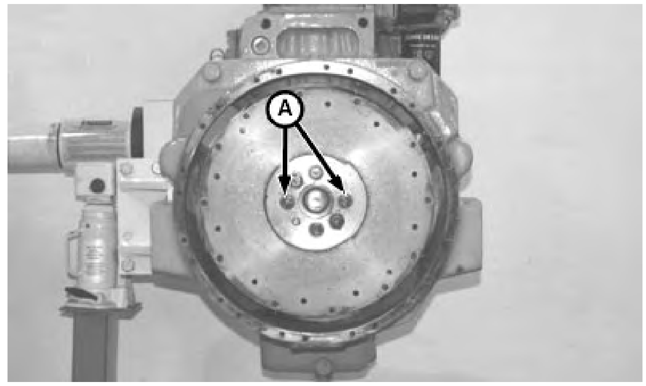
2. Remove remaining cap screws, remove drive hub (if equipped), and carefully pull flywheel from crankshaft.

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.*

**Specification**

Crankshaft Dowel Pin—Protrusion.......... 13.5—14.5 mm (0.53—0.57 in.) From Crankshaft Rear Flange




*Removing Flywheel*

**A—Cap Screws**

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.

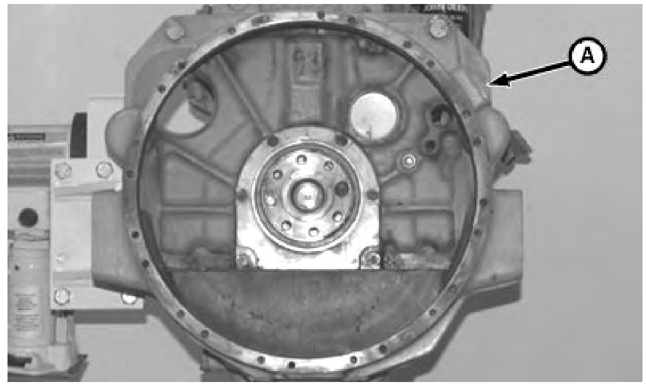
RG,RG34710,1163 –19–23OCT97–1/1

## 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.




RG10214 –UN–23JUN99

*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.

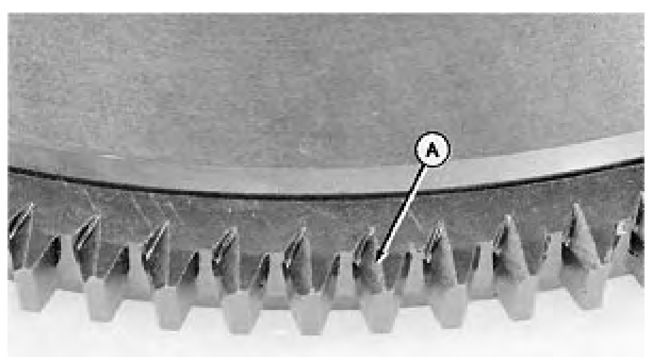
**IMPORTANT: If flame heat is used, be sure gear is heated uniformly around circumference. DO NOT OVERHEAT. Overheating may destroy original heat treatment of gear. SEE CAUTION.**

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.

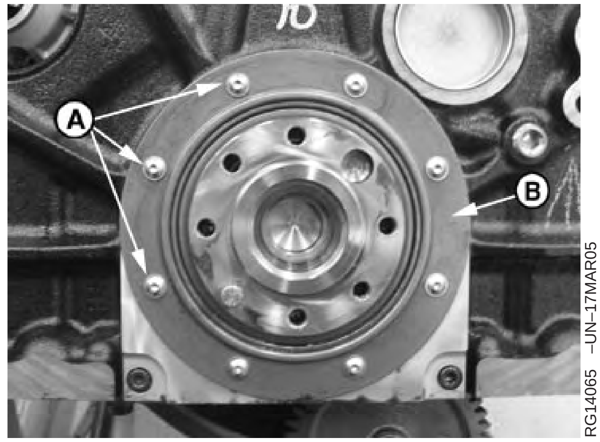
3. Remove eight button head screws (A) from rear seal assembly (B). Remove rear oil seal and wear sleeve assembly. See REMOVE CRANKSHAFT REAR OIL SEAL AND WEAR SLEEVE in this group.

**IMPORTANT: Whenever rear oil seal is replaced, also replace rear wear sleeve as a matched assembly.**

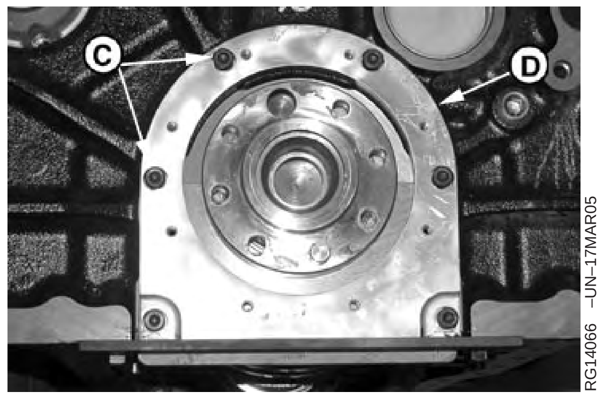
4. Remove six socket head screws (C) from rear seal housing (D). Remove housing from cylinder block flange.

**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.




*Remove Rear Crankshaft Seal & Wear Sleeve*




*Remove Rear Crankshaft Seal Housing*

**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**

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.*

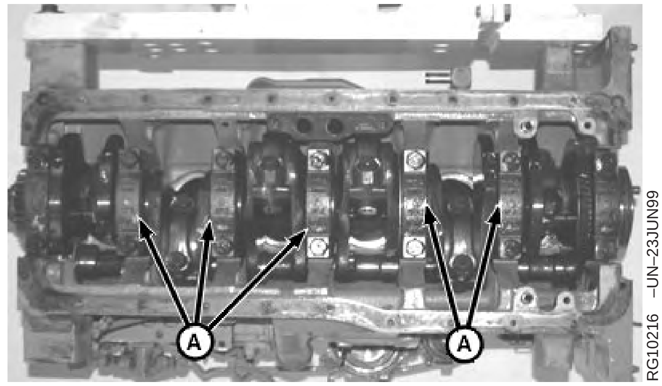
1. Remove main bearing cap screws.

2. Install JDG1069 Puller (B) so that tips (C) of blind hole puller legs are below bearing cap half.

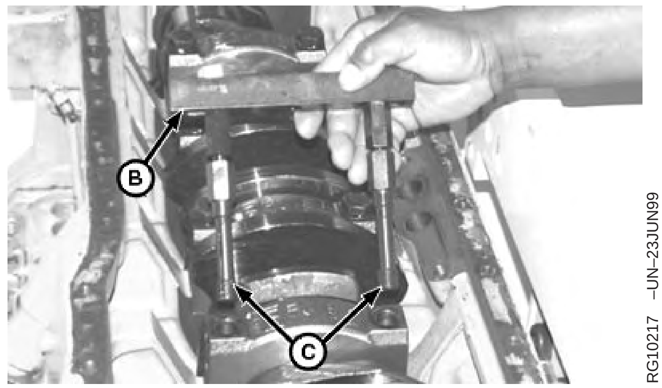
3. Tighten hex of actuator pin securely while holding collet portion of puller leg with second wrench.

4. Tighten both cap screws (D) on cross block finger tight.

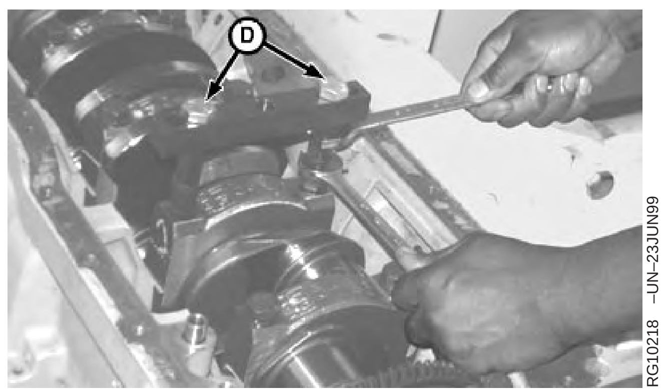
**A—Main Bearing Caps**
**B—Puller**
**C—Tips**
**D—Cap Screws**



*Checking Torques Before Removing Main Bearing Caps*



*Installing Main Bearing Cap Puller*



*Tightening Main Bearing Cap Puller*

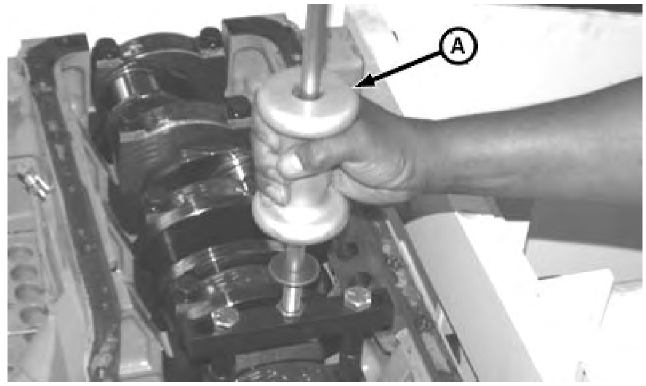
**Continued on next page** RG,RG34710,1168 –19–10JUN99–1/2

5. Attach D01300AA Slide Hammer (A) to cross block, tighten nut securely.

6. Remove main bearing cap by sliding up on hammer weight.

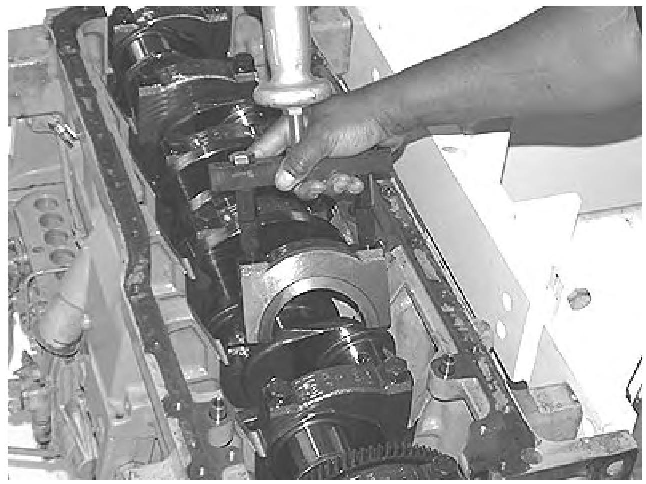
7. Use PLASTIGAGE® to measure journal-to-bearing oil clearance on each main bearing as they are removed. See CHECK MAIN BEARING OIL CLEARANCE later in this group.

**A—Slide Hammer**




RG10219 –UN–23JUN99

*Using Slide Hammer to Loosen Bearing Cap*



RG10220 –UN–18JUN99

*Removing Main Bearing Cap*

*PLASTIGAGE is a registered trademark of DANA Corp.*

RG,RG34710,1168 –19–10JUN99–2/2

## Check 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.

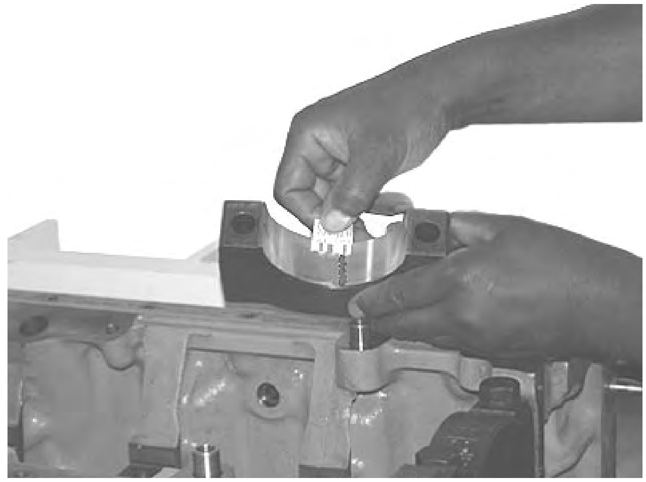
**Specification**

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.)


RG10237 –UN–24JUN99

*Checking Main Bearing Oil Clearance*

*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.*

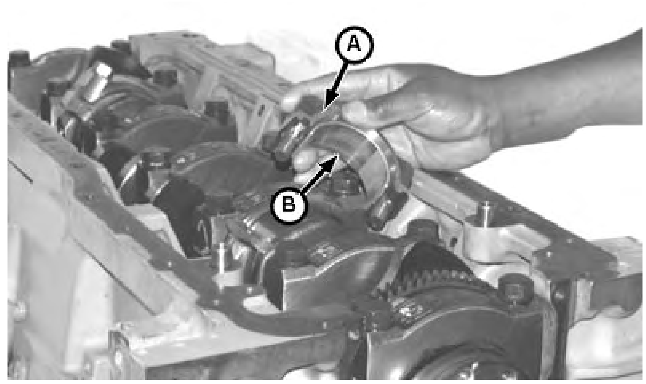
3. Install a cap screw in each end of crankshaft and attach a lifting strap to crankshaft as shown. Using proper lifting equipment, carefully raise crankshaft out of cylinder block.

4. Clean crankshaft, especially oil passages, using solvent and compressed sir.

5. Put crankshaft on clean V-blocks.

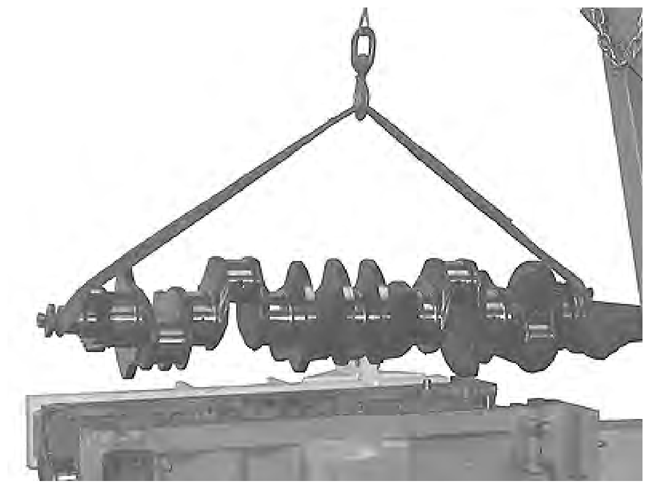
6. Remove rear wear sleeve from crankshaft flange, if not previously done, using one of the following methods:

   - 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).
   - Score (but do not cut) the wear sleeve in several places around O.D. with a blunt chisel.




RG10209 –UN–18JUN99

*Removing Connecting Rod Caps*



RG10222 –UN–18JUN99

*Removing Crankshaft*

**A—Connecting Rod Caps**
**B—Bearing**

RE38635,000007F –19–17MAR05–1/1

## Inspect Crankshaft

*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.

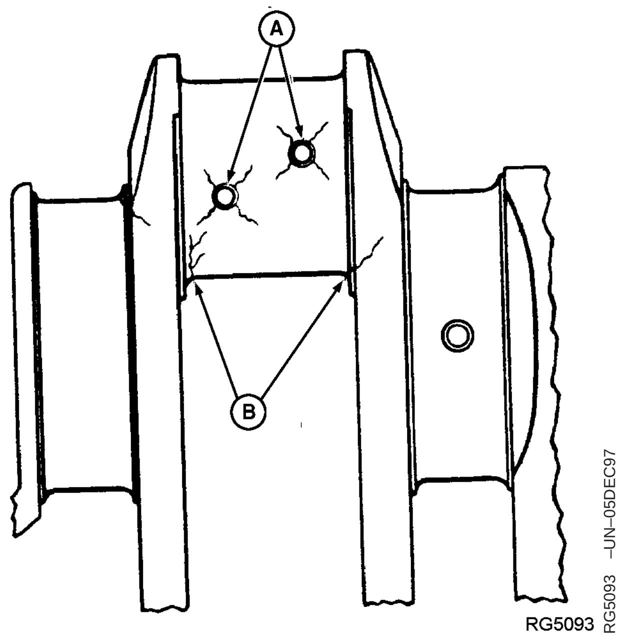
3. Inspect (front) crankshaft gear and (rear) oil pump drive gear for cracks, chipped teeth, or excessive wear. Replace gear(s) as required. See REPLACE CRANKSHAFT GEAR and REPLACE (CRANKSHAFT) OIL PUMP DRIVE GEAR, later in this group.

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**

**Continued on next page**

RG,RG34710,1171 –19–23OCT97–1/2

**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 –19–23OCT97–2/2

## 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)

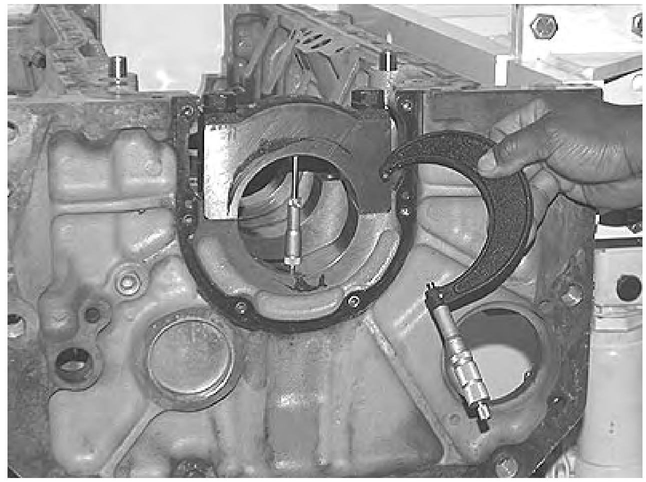
3. After initial torque, turn main bearing cap screws an additional 120 degrees.

4. Measure I.D. of all assembled bearings in four locations 90° apart with an inside micrometer. Compare measurements with the following specifications.

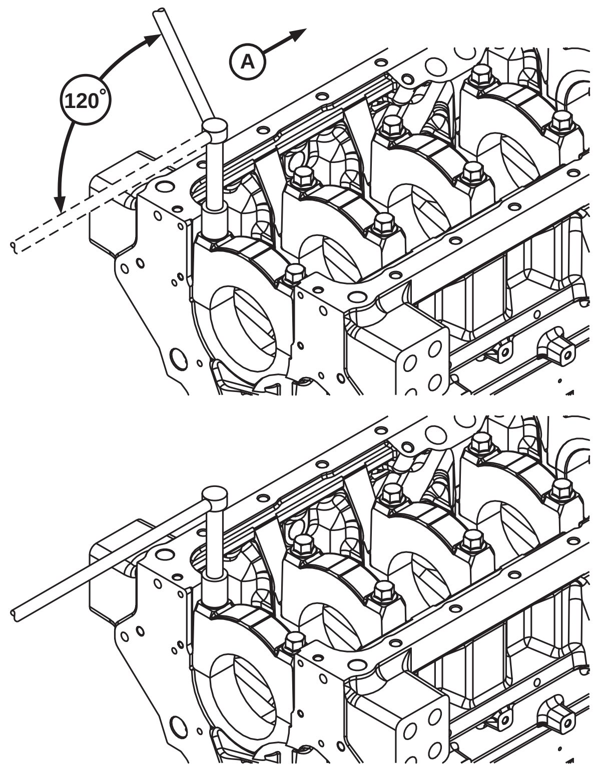
**Specification**

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**

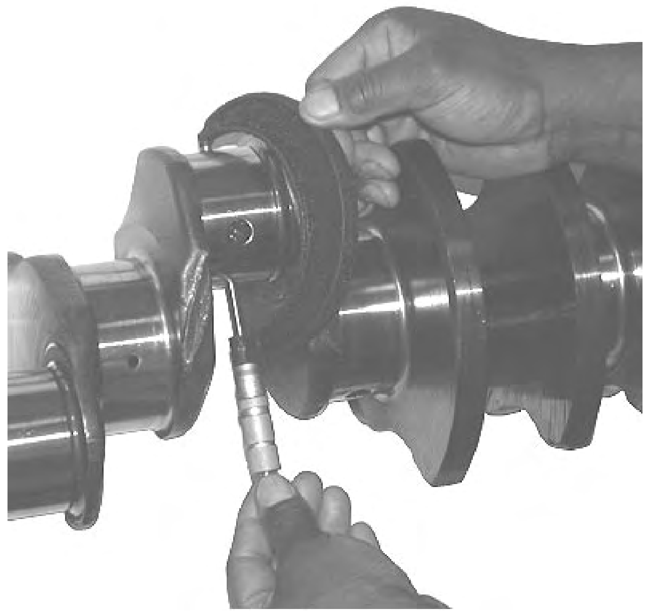
Crankshaft Main Journal—OD .................................. 95.196—95.222 mm (3.7479—3.7490 in.)

*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**

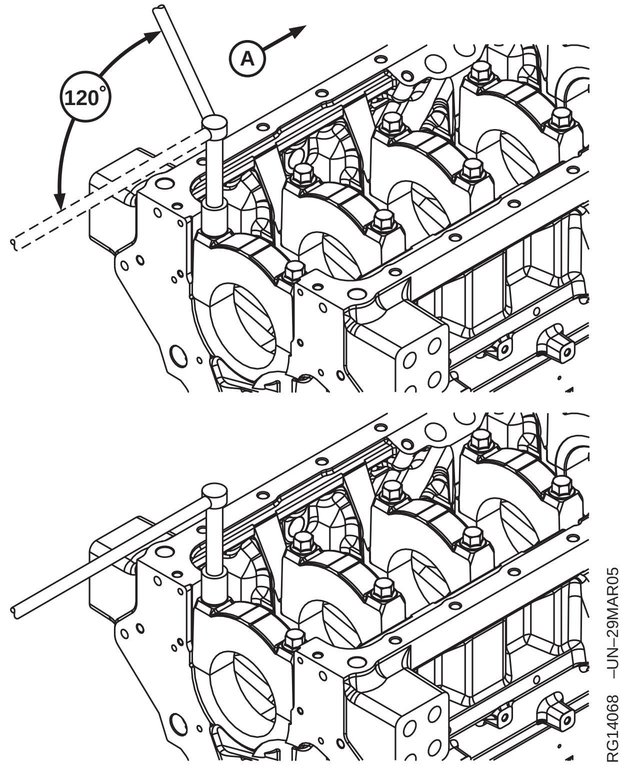
| | |
|---|---|
| Main Bearing Assembled ID—ID | 95.270—95.320 mm (3.7508—3.7528 in.) |

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.**

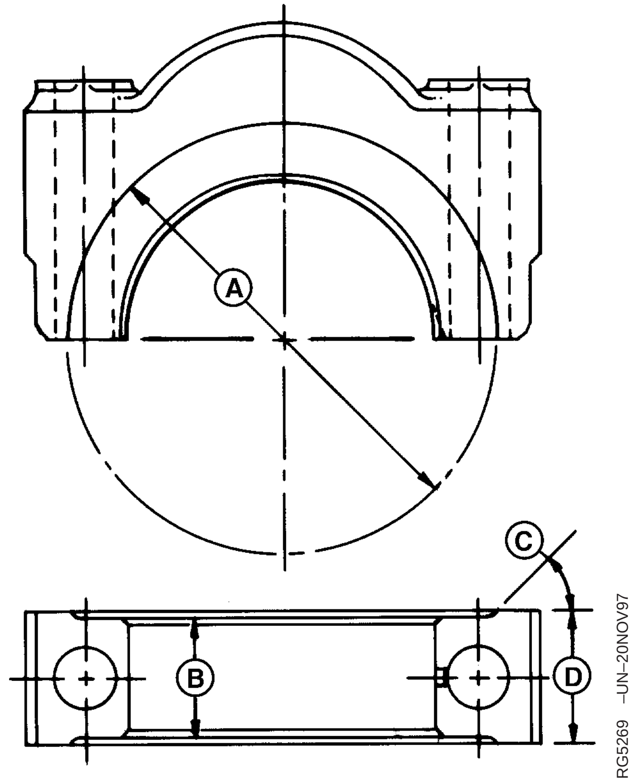
**Specification**

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.**

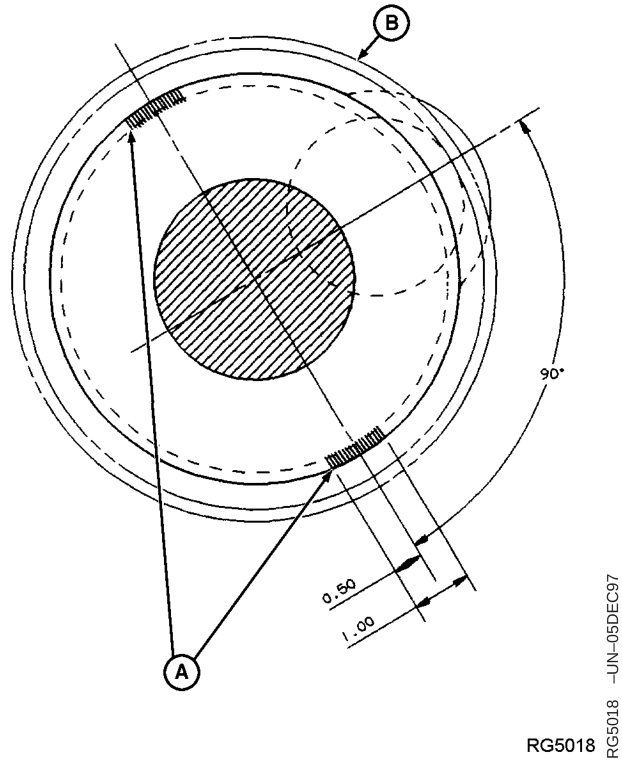
**IMPORTANT: DO NOT OVERHEAT GEAR. SEE CAUTION. Overheating may also destroy original heat treatment of gear.**

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. Grind away excess weld to eliminate the possibility of interference with cylinder block.




*Removing Crankshaft Oil Pump Drive Gear*

**A—Weld Beads**
**B—Gear**

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 D01251AA[1] 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.

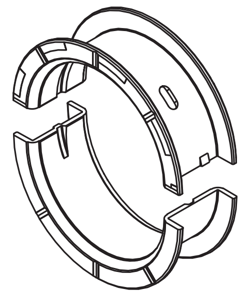
11. Once gear cools, reseat gear using JDH7 Driver.

*[1]Part of D01047AA 17-1/2 and 30-Ton Puller Set.*

RG,RG34710,1178 –19–23OCT97–1/1

## 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*

02
040
31

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.**

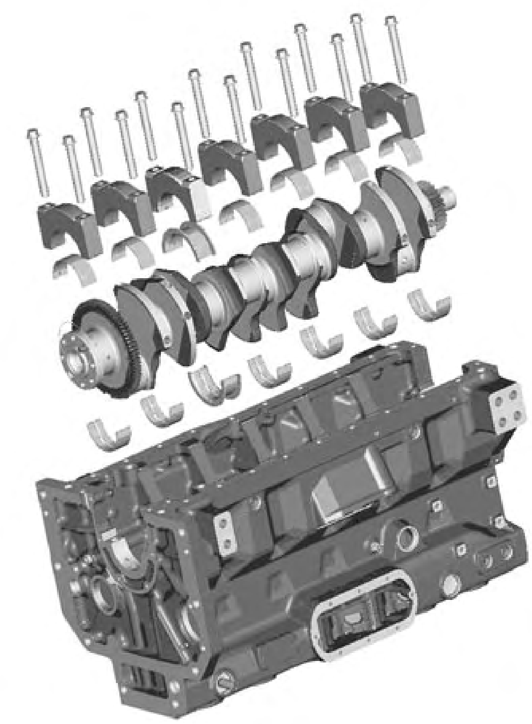
During assembly, apply a liberal coating of clean engine oil to:

- All main bearing webs in block
- Both sides 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

RE38635,0000082 –19–18MAR05–1/4

**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.

5. Dip entire main bearing cap screws in clean engine oil and position them in main bearing caps. Apply a liberal amount of oil to bearing inserts in caps.

6. Install each bearing cap (B), bearings (C), and cap screws with washer (A) 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 rebored, 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.**

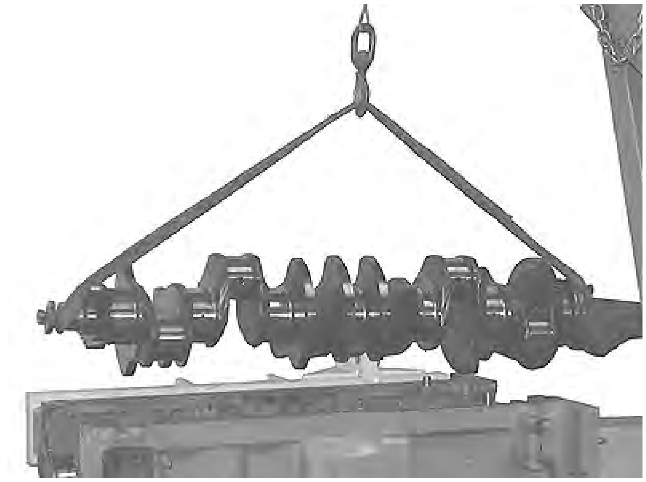
7. Before tightening cap screws on main bearing caps, align upper and lower thrust flanges on main thrust bearings. Using a soft-face hammer, tap crankshaft to the rear and then to the front to line up thrust bearing flanges.

8. Tighten No.'s 1, 2, 3, 4, 6, and 7 main bearing cap screws to initial torque specifications.

**Specification**

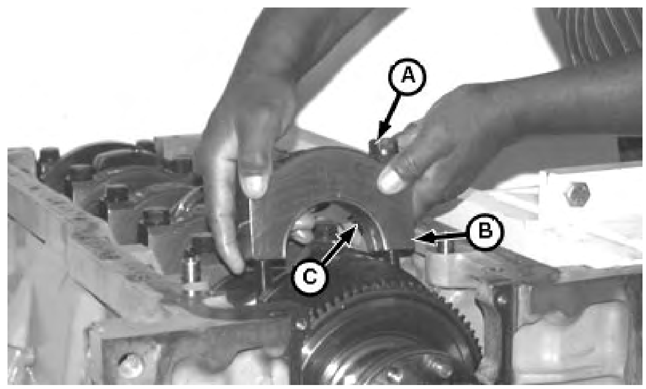
Crankshaft Main Bearing Cap Screws—Initial Torque ................................................ 122 N••m (90 lb-ft)

Hand-tighten No. 5 main thrust bearing cap screws.



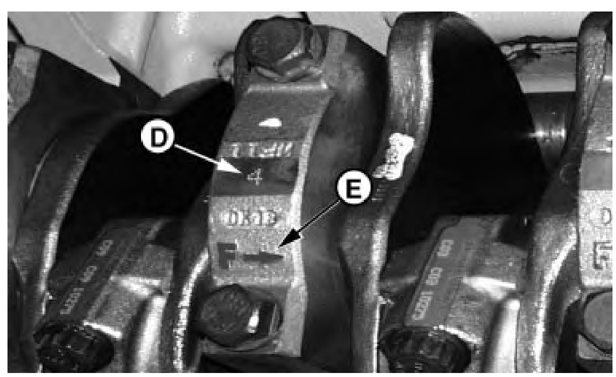
RG10222 –UN–18JUN99

*Installing Crankshaft*




RG10226 –UN–18JUN99

*Installing Main Bearing Caps*




RG11640 –UN–22DEC00

*Stamped Main Bearing Cap*

**A—Cap Screw with Washer**
**B—Bearing Cap**
**C—Bearing**
**D—Stamped Cylinder Number**
**E—Stamped Arrow**

Continued on next page

RE38635,0000082 –19–18MAR05–2/4

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.*

10. Tighten No. 5 main thrust bearing cap screws to specification above.



RE38635,0000082 –19–18MAR05–3/4

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.

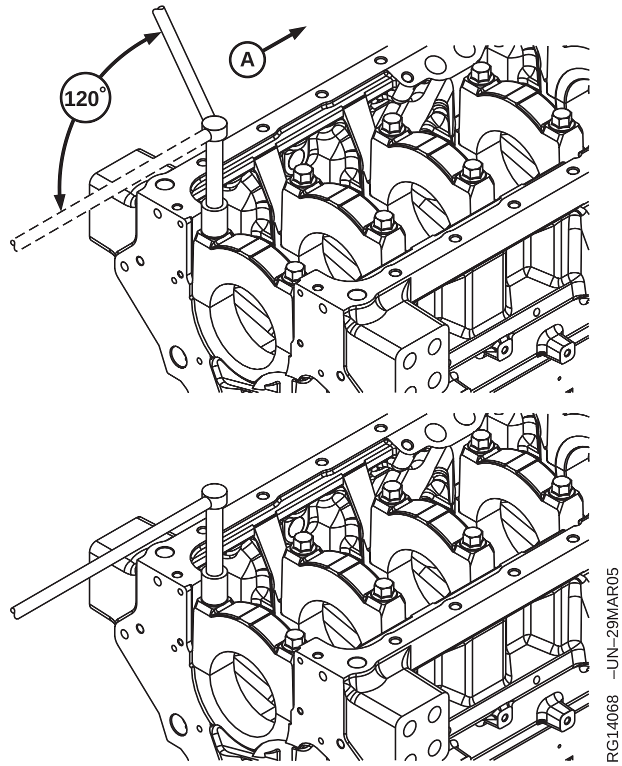
**Specification**

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**

RE38635,0000082 –19–18MAR05–4/4

## 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).

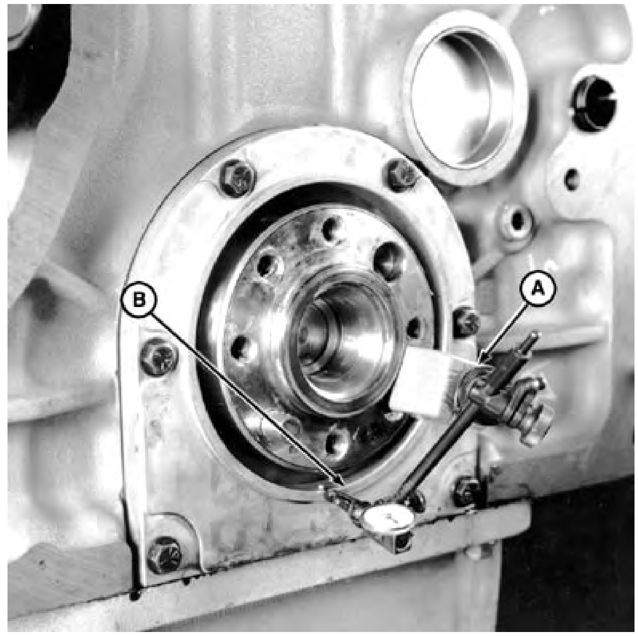
2. Zero dial indicator and rotate crankshaft one full revolution, observe full indicator movement. The maximum oil seal housing bore runout is as follows:

**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.



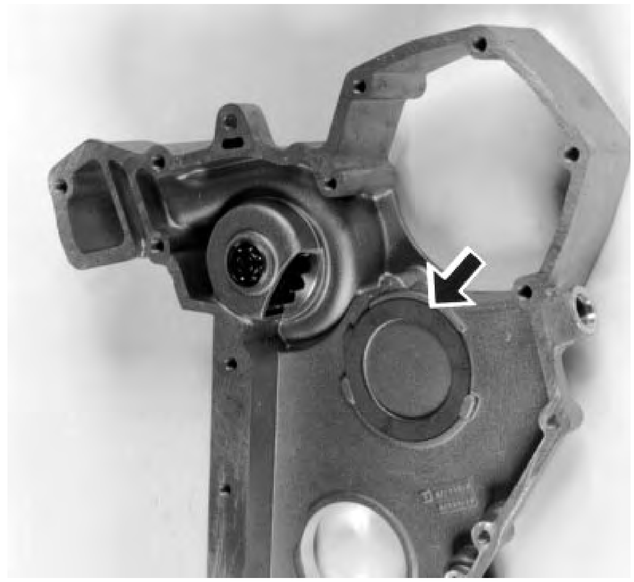

RG5751 –UN–05DEC97

*Checking Rear Oil Housing Runout*

**A—Magnetic Base Dial Indicator**
**B—Oil Seal Housing Bore**

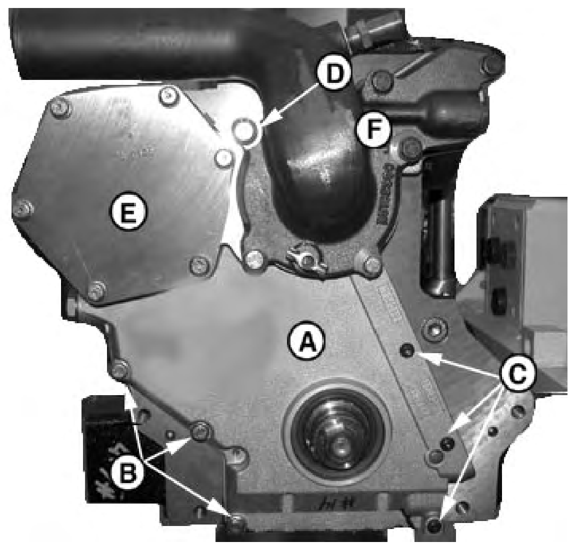
RG,RG34710,1183 –19–23OCT97–1/1

## Install Thrust Washer and Timing Gear Cover



RG7060 –UN–26NOV97

Thrust Washer in Timing Gear Cover




RG14748 –UN–03FEB06

Install Timing Gear over

**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**

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).

**Continued on next page** RE38635,0000066 –19–18FEB05–1/2

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 N••m (35 lb-ft)
M8 Cap Screw—Torque ............ 32 N••m (24 lb-ft)

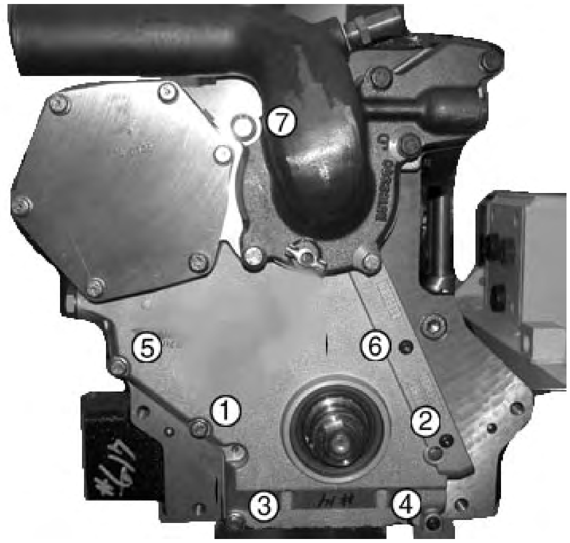
8. Check camshaft endplay. See CHECK CAMSHAFT END PLAY AND MEASURE GEAR BACKLASH earlier in this group.)

9. Install injection pump drive gear cover (E) using a new gasket and tighten cap screws to specifications.

**Specification**

Injection Pump Drive Gear Cover—Torque ............ 31 N••m (23 lb-ft)

10. Trim timing gear cover gasket flush with oil pan gasket rail.




*Timing Gear Cover Torque Sequence*

RE38635,0000066 –19–18FEB05–2/2

## Install Front Wear Sleeve

*NOTE: Front wear sleeve can be installed with timing gear cover removed or installed.*

1. Coat I.D. of new wear sleeve with LOCTITE® 680 Retaining Compound or equivalent. Position wear sleeve on crankshaft flange.
2. Use the JDG467 Driver (from JDE3 Installer Set), along with large washer and cap screw that secures damper to crankshaft.

   Tighten cap screw until driver bottoms.
3. Remove installation tools. Clean any sealant from O.D. of wear sleeve and I.D. of seal bore.

RG6476 –UN–05DEC97

*Tool for Installing Front Wear Sleeve*

RG6477 –UN–05DEC97

*Installing Front Wear Sleeve*

*LOCTITE is a registered trademark of Loctite Corp.*

RE38635,0000084 –19–18MAR05–1/1

## Install Crankshaft Front Oil Seal

**IMPORTANT: Whenever front oil seal is replaced, the wear sleeve MUST also be replaced.**

1. Place JDG720-2 Seal Protector (A) on nose of crankshaft.

   Lubricate I.D. of front oil seal lips with clean engine oil. Slide seal with spring side of seal facing engine onto seal protector. Be careful not to roll oil seal lips.

**IMPORTANT: Use JDG10023 forcing screw on 9 L engine. Crankshaft nose threads are metric, as opposed to English threads on 6081.**

2. Place JDG720-5 Seal Installer onto seal protector against seal. Do not use spacer ring provided with tool set.

3. With nut and washer installed onto JDG720-1 Forcing Screw, thread forcing screw into nose of crankshaft until it bottoms.

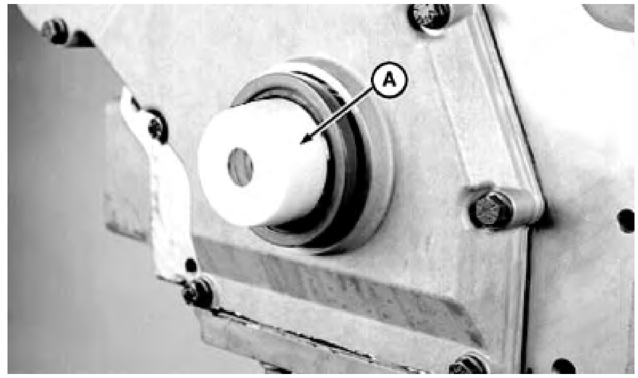
4. Tighten nut against crossplate of installer until installer bottoms onto front face of timing gear cover.

5. Remove installation tools. Verify seal is installed square in bore and that seal lips are not rolled on wear sleeve.

   Oil seal should be installed to following specification.

**Specification**

Front Oil Seal Installed Below
Front Lip of Seal Bore—Recess .................................... 8.9 mm (0.35 in.)




*Protector for Installing Front Oil Seal*


*Installing Front Oil Seal*

**A—JDG720-2 Seal Protector**

RE38635,0000085 –19–18MAR05–1/1

## 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.

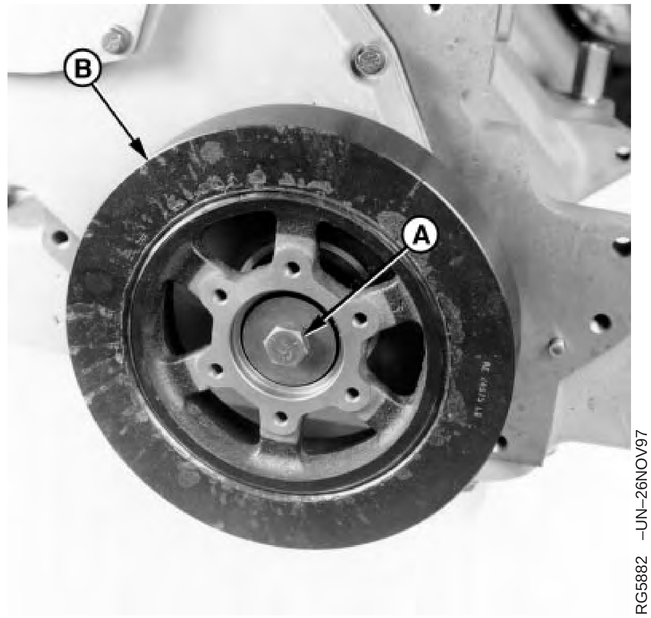
3. Remove cap screw and install original cap screw with same hardened washer.

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: Engines not requiring a gasket are usually dry clutch applications and are metal to metal connection.*

1. On engines requiring a gasket between block and flywheel housing, inspect cylinder block and flywheel housing gasket surfaces to see that they are clean. Scrape off all old gasket material.

2. Place a bead of LOCTITE®515 across the “T Joint” where the rear of the block and oil pan joint is located.

3. Position flywheel housing gasket over the two dowel pins, with the rubber bead side of the gasket toward the block.

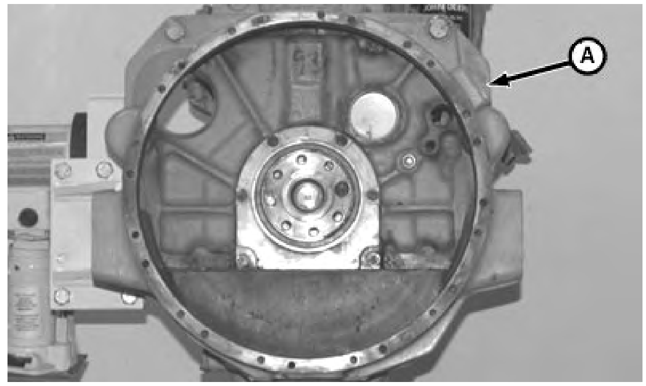
4. Apply Loctite 515 once again on the “T Joint” area on the block. The gasket will thus have sealant on both sides in the T Joint areas.

5. Install flywheel housing on cylinder block.

*NOTE: Use new cap screws when installing flywheel housing.*

6. Dip threads of cap screw in engine oil before installing. Install and tighten cap screws to specifications.

| 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) |




RG10214 –UN–23JUN99

*Installing SAE 3 Flywheel Housing*

**A—Flywheel Housing**

*LOCTITE is a trademark of Loctite Corp.*

Continued on next page

RE38635,0000088 –19–18MAR05–1/2

**Specification**

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)

RE38635,0000088 –19–18MAR05–2/2

## 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.

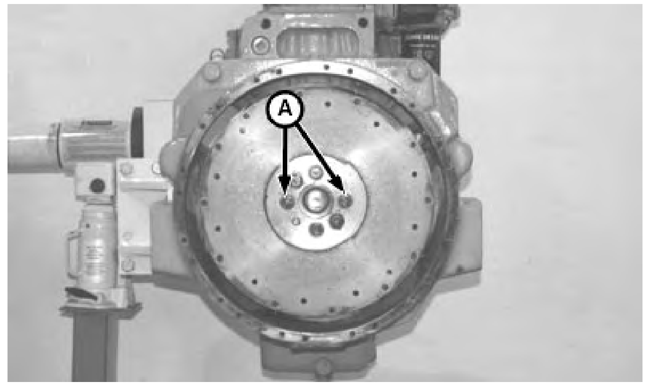
2. Position flywheel over dowel pin and install drive hub (if equipped). Start four cap screws. Remove guide studs and install remaining cap screws.

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)
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)




RG10213 –UN–23JUN99

*Installing Flywheel*

**A—Locations for Guide Studs**

*LOCTITE is a registered trademark of Loctite Corp.*

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. Scrape off all old gasket material. Install a new gasket without sealant between block and flywheel housing.

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) |

RE38635,0000087 –19–18MAR05–1/1



## 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 –19–23OCT97–1/1

## 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.

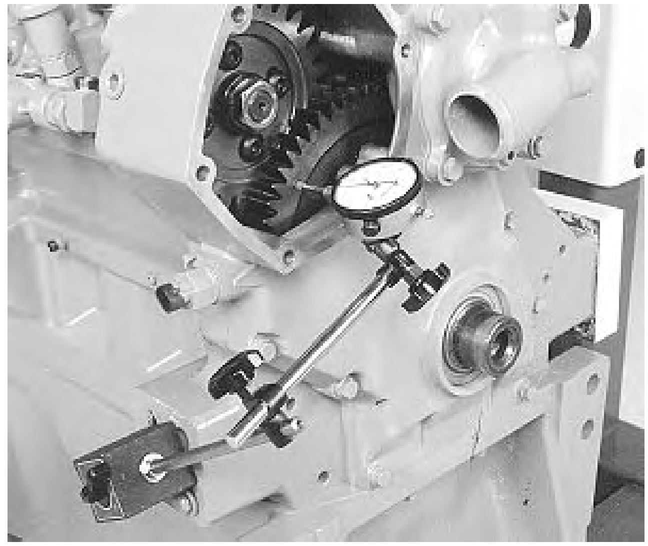
4. Position indicator plunger tip against camshaft gear tooth with a preload.

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.

**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.


RG7211 –UN–28JUL94

*Measuring Camshaft End Play*



RG,RG34710,1199 –19–16FEB05–1/1

## Remove Vibration Damper and Timing Gear Cover

For timing cover removal procedure with engine installed in vehicle (8030 Tractors), refer to REMOVE AND INSTALL TIMING GEAR COVER—ENGINE INSTALLED IN VEHICLE, in Group 040.

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).

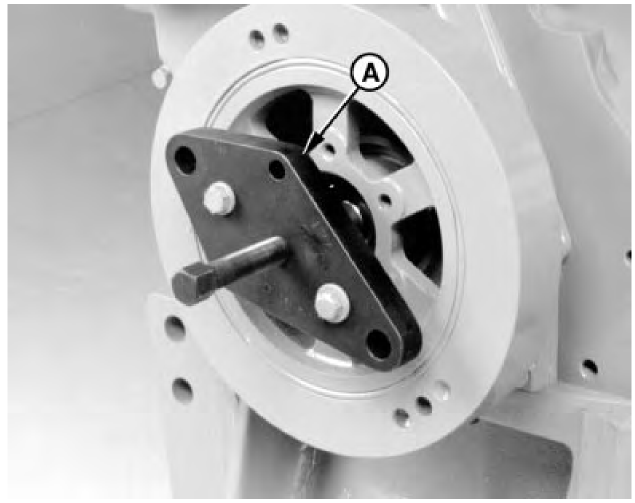
7. Check camshaft end play. See CHECK CAMSHAFT END PLAY AND MEASURE GEAR BACKLASH earlier in this group.

**IMPORTANT: Whenever timing gear cover is removed, ALWAYS install a new front oil seal and wear sleeve.**

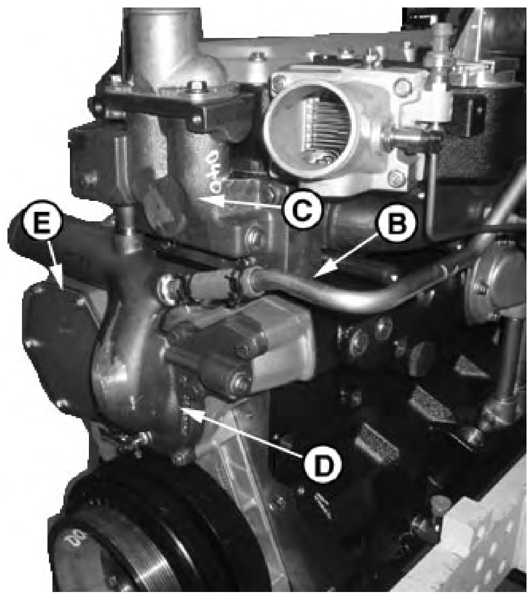
8. Remove thermostat cover & thermostat housing (C).

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).




*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**

Continued on next page

RE38635,0000060 –19–14FEB05–1/2

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.

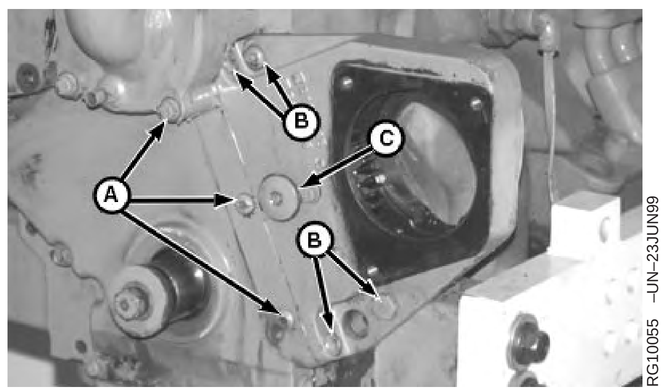


RE38635,0000060 –19–14FEB05–2/2

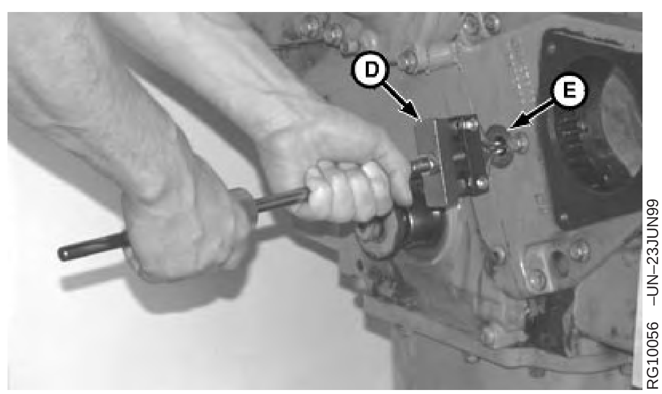
## Remove, Inspect, and Install Crankshaft Gear-Driven Auxiliary Drive—If Equipped

*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.*




*Button Head Cap Screw*




*Auxiliary Drive Idler 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**

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.

Continued on next page

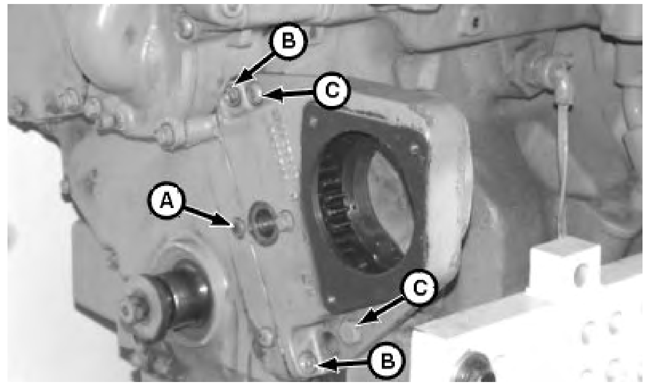
RE38635,0000061 –19–21FEB05–1/7

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**




*Remove Auxiliary Drive Assembly*

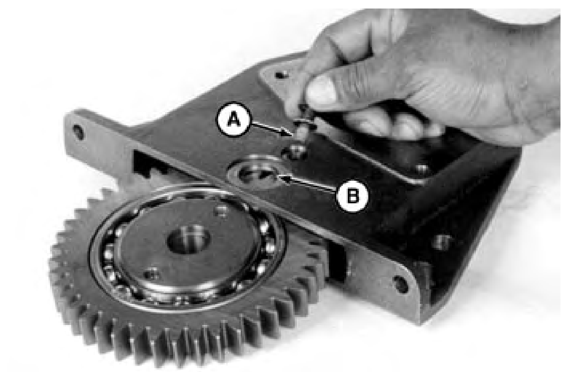
RE38635,0000061 –19–21FEB05–2/7

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*

**Continued on next page** RE38635,0000061 –19–21FEB05–3/7

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 –19–21FEB05–4/7

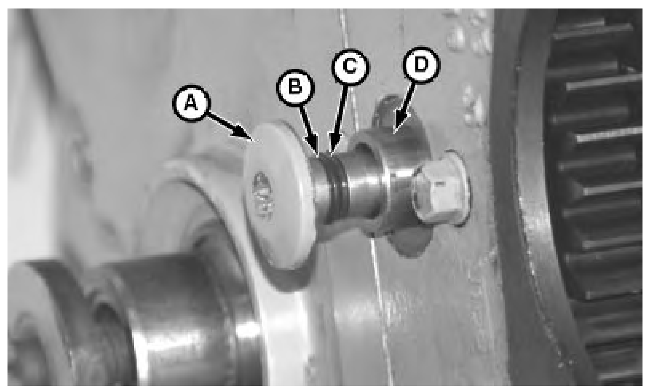
*NOTE: Face seal may be reused if it is not cut, nicked, or damaged.*

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 –19–21FEB05–5/7

*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:

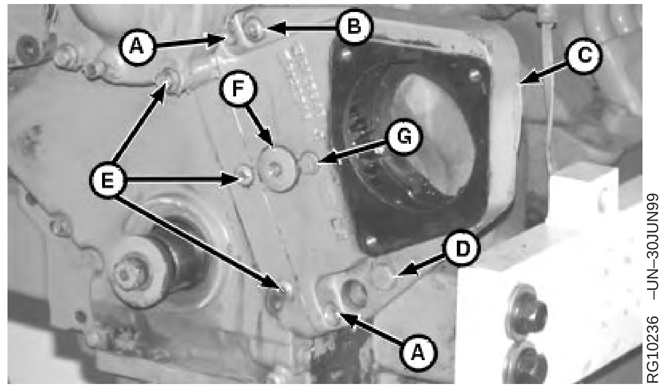
**Specification**

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 N••m (110 lb-ft)




*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**

**Continued on next page** RE38635,0000061 –19–21FEB05–6/7

- 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)

- 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 –19–21FEB05–7/7

## 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.*


*Timing Marks—Camshaft and Crankshaft Gears*

**A—Timing Marks**

1. Drain engine oil and coolant, if not previously done. Remove timing gear cover as detailed earlier in this group. See REMOVE VIBRATION DAMPER AND TIMING GEAR COVER 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 REMOVE CYLINDER HEAD in Group 020.

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).

**Continued on next page** RG,RG34710,1202 –19–23OCT97–1/3

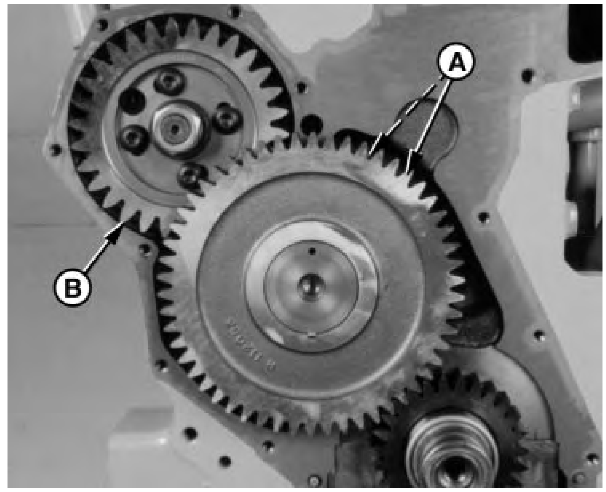
5. Examine both camshaft gears (A) and injection pump drive gear (B) for worn or damaged gear teeth. Gears should have a minimum backlash as follows:

**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**



*Camshaft Gears*

RG,RG34710,1202 –19–23OCT97–2/3

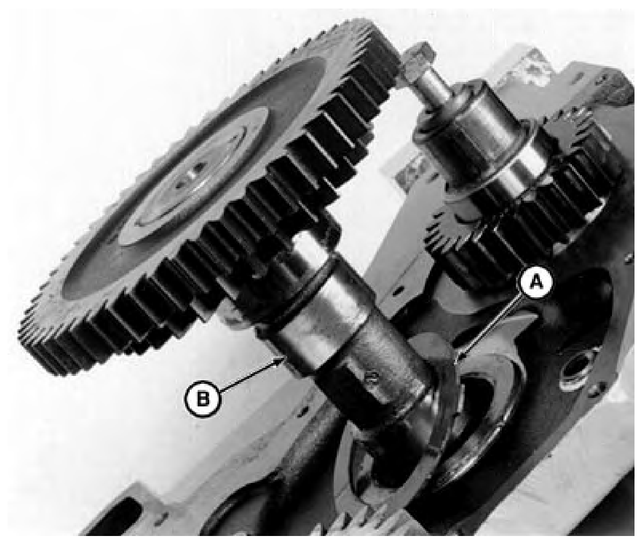
6. Carefully remove camshaft (B) from cylinder block so that camshaft lobes do not drag in bores.

*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**



*Removing Camshaft*

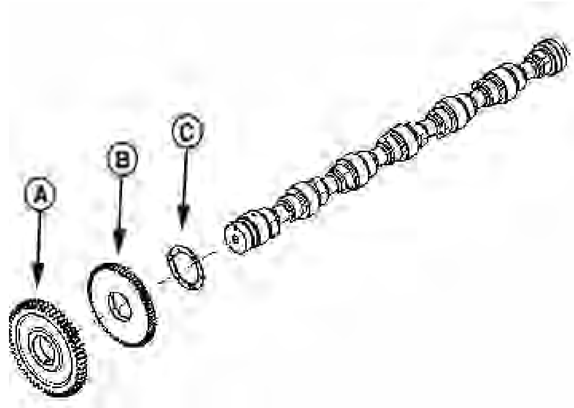
RG,RG34710,1202 –19–23OCT97–3/3

## 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.


*Inspect Roller Follower*

RE38635,0000063 –19–16FEB05–1/1

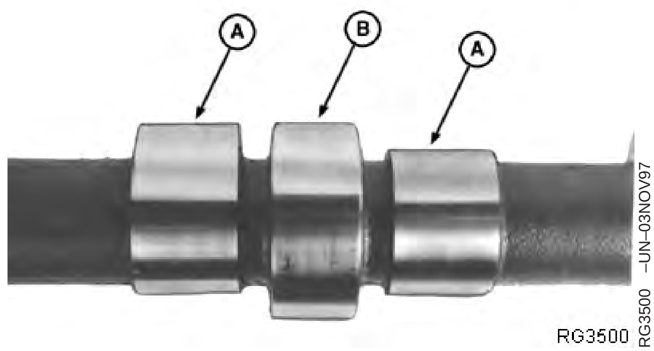


## Visually Inspect Camshaft

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.*




*Inspecting Camshaft*

**A—Camshaft Lobes**
**B—Journals**

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

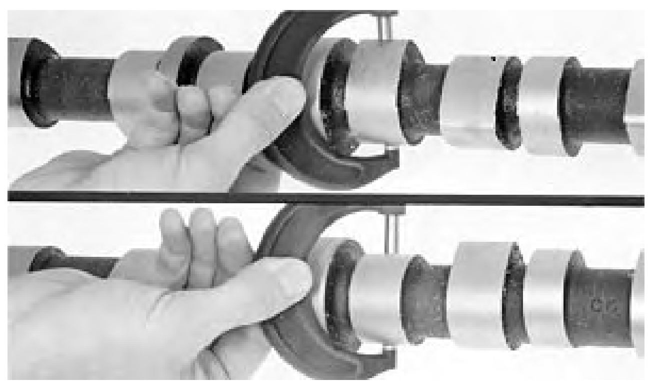
## Measure Camshaft Lobe Lift

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.) |



T81262 –UN–01NOV88

*Measuring Camshaft Lobes*

RG,RG34710,1208 –19–23OCT97–1/1

## Install Camshaft Gears

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 TY6333 or TY6347 High Temperature Grease and assemble to inside (with ribs) thrust surface of pump gear, as shown.

4. Set fuel pump drive gear (D) on camshaft (C) nose with thrust washer surface and cast ribs to the inside - toward the camshaft (E). Align Woodruff key and keyway.

5. Install gear onto nose of camshaft. Push inner (fuel pump) gear on until tight against the camshaft bearing journal.

6. Set outer (drive) gear (F) on camshaft with timing mark away from the camshaft (G). Align Woodruff key and keyway of drive gear.

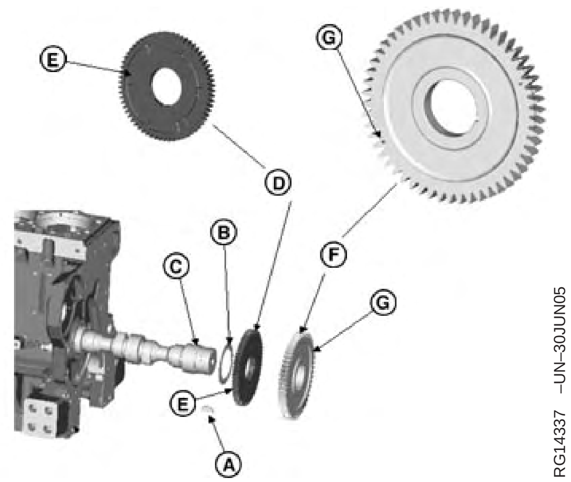
7. Push drive gear onto camshaft nose until tight against inner (pump) gear.

8. Support each end of the camshaft on centers. Use a dial indicator with plunger resting on the thrust surface of the camshaft gears.

9. Check the runout of the inner and outer gear thrust surfaces.

**Specification**

Camshaft Gear Thrust Surfaces—
Runout ........................................................ 0.10 mm (0.004 in.) maximum




*Camshaft Gear Assembly*

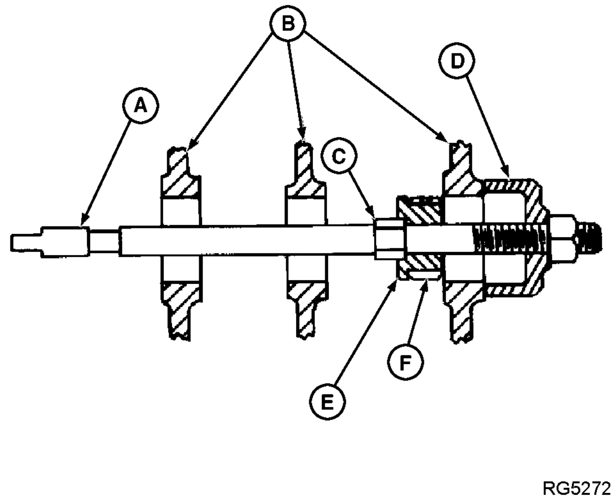
**A—Woodruff Key**
**B—Thrust Washer**
**C—Camshaft Nose**
**D—Fuel Pump rive Gear**
**E—Fuel Pump Gear Orientation**
**F—Camshaft Drive Gear**
**G—Camshaft Gear Timing Marks**

*LOCTITE is a trademark of Loctite Corp.*

RG,RG34710,1209 –19–23OCT97–1/1

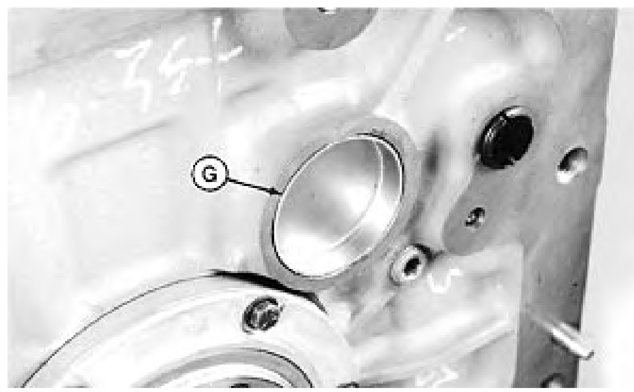
## Service Camshaft Bushings Using JDG602 Adapter Set

*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.*




RG5272 –UN–07NOV97

*Removing Camshaft Bushings*




RG5949 –UN–30AUG91

*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**

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.

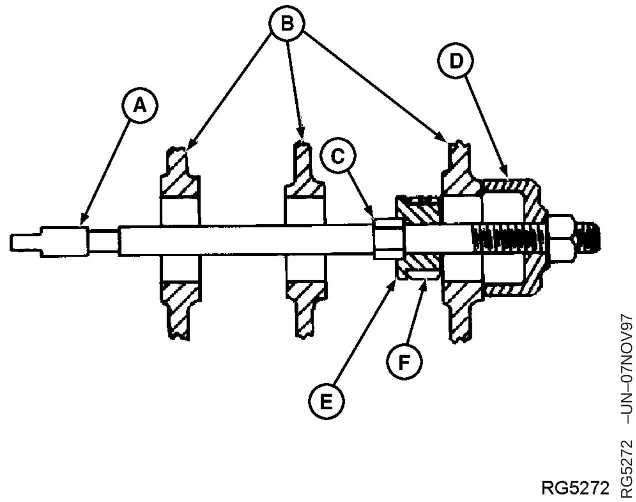
Continued on next page RE38635,0000065 –19–16FEB05–1/2

**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.




*Installing Camshaft Bushings*

**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**

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.) |

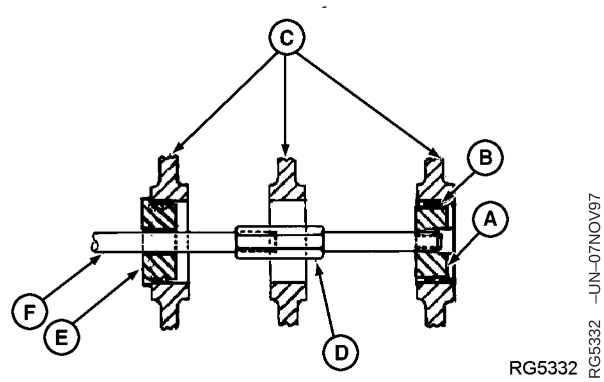
*NOTE: The front camshaft bushings can be reached from the front to the engine. The flywheel and rear camshaft bore plug (G) must be removed to reach the rear camshaft bushings.*

*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.*

3. Inspect and measure each camshaft bushing bore in block as bushings are removed.




*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**

Continued on next page

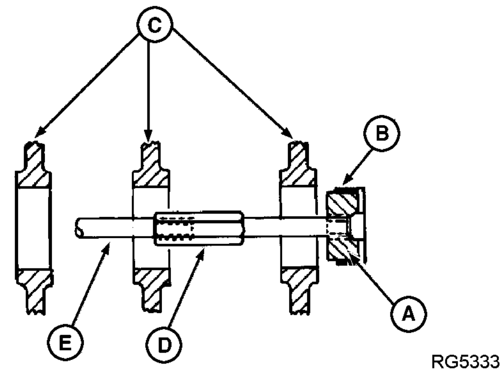
**IMPORTANT: Oil holes in bushings and cylinder block must be aligned after installation. The elongated hole in bushing must be toward the top. After installation, use a small mirror with extension to be sure oil holes are properly aligned.**

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.




RG5333 –UN–07NOV97

*Installing Camshaft Bushings*

**A—Bushing Driver (JDG607)**
**B—Camshaft Bushing**
**C—Cylinder Block Web**
**D—Slide Hammer Adapter (JDG408)**
**E—Slide Hammer (D01299AA)**

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DPSG,OUOE003,30 –19–18DEC98–2/2

## Install Camshaft

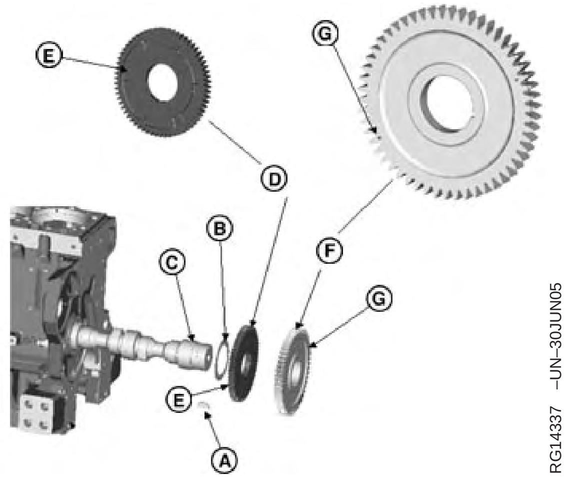
**IMPORTANT: Set engine at TDC of No. 1 piston's compression stroke before installing camshaft so timing marks on camshaft and crankshaft gears will be aligned. Align the "V" marks on camshaft and crankshaft gears. Align the "2" marks on the camshaft and fuel pump gears.**

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.




*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**

**Continued on next page** 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.

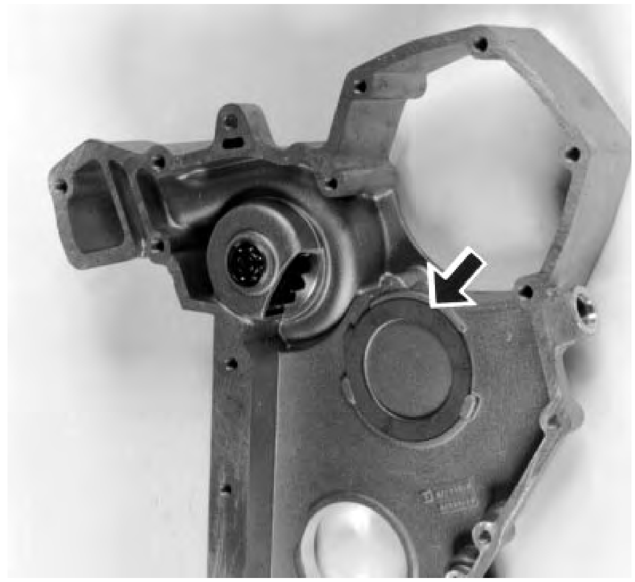
2. Install a new gasket over dowel pins at bottom of cylinder block face. Use additional guide pins if necessary.

3. If equipped with auxiliary drive, install a new gasket with the auxiliary drive housing with gear onto the timing gear cover. See 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.**

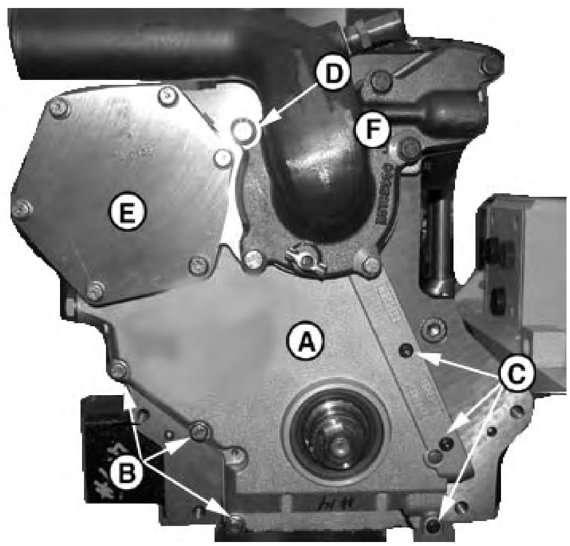
**If equipped with auxiliary drive, tighten auxiliary drive housing to timing gear cover and to cylinder block prior to tightening the timing gear cover to cylinder block. See REMOVE, INSPECT AND INSTALL CRANKSHAFT GEAR-DRIVEN AUXILIARY DRIVE earlier in this group.**

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).



RG7060 –UN–26NOV97

*Thrust Washer in Timing Gear Cover*




RG14748 –UN–03FEB06

*Install Timing Gear Cover*

**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**

**Continued on next page** RE38635,0000066 –19–18FEB05–1/2

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 N••m (35 lb-ft)
M8 Cap Screw—Torque ........ 32 N••m (24 lb-ft)

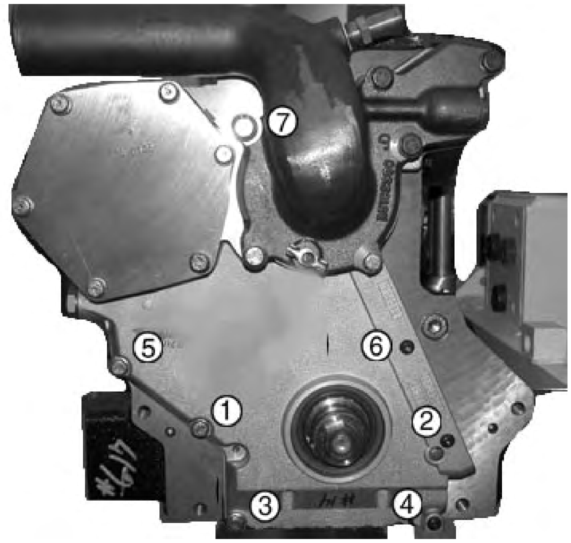
8. Check camshaft endplay. See CHECK CAMSHAFT END PLAY AND MEASURE GEAR BACKLASH earlier in this group.)

9. Install injection pump drive gear cover (E) using a new gasket and tighten cap screws to specifications.

**Specification**

Injection Pump Drive Gear Cover—Torque ........ 31 N••m (23 lb-ft)

10. Trim timing gear cover gasket flush with oil pan gasket rail.




RG14749 –UN–03FEB06

*Timing Gear Cover Torque Sequence*

RE38635,0000066 –19–18FEB05–2/2

## 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 –19–23OCT97–1/1

## 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).

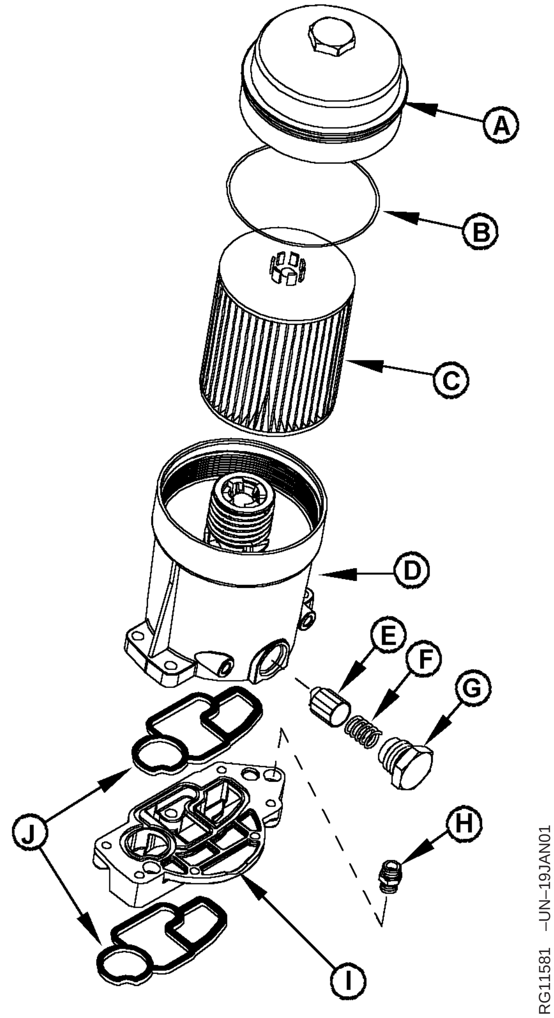
**Low Oil Pressure at Slow Idle:**

- 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

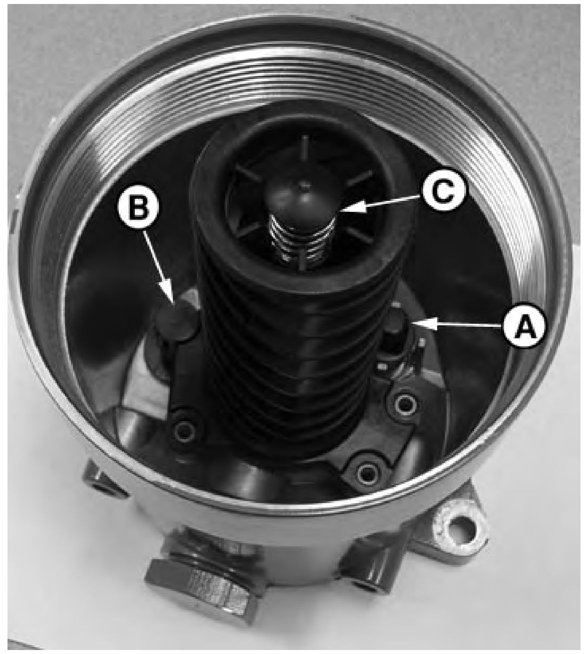
The top load oil filter assembly derives its name from the way the filter element "top loads" into the filter canister. The design is such that the filter element can be changed without the typical oil spill resulting from removal of the filter canister from the filter base. With the top load design, 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.

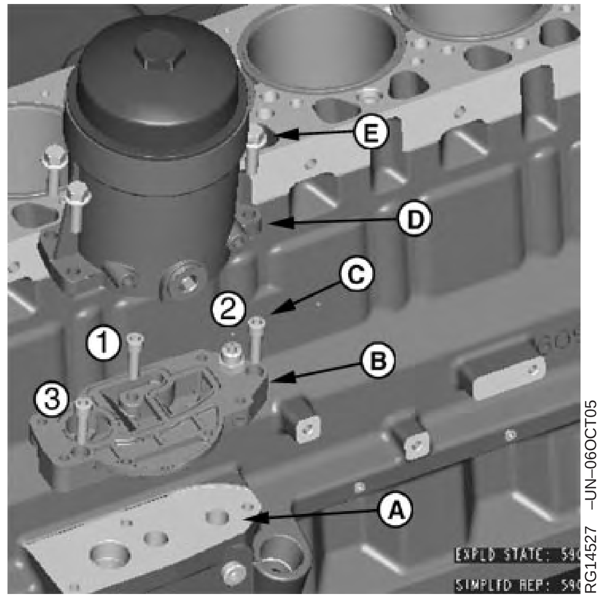
**Specification**

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)




*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


RG11629A –UN–20DEC00

*Top-Load Oil Filter Cap*

RG11628 –UN–01FEB01

*Strike on Surface to Remove 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.

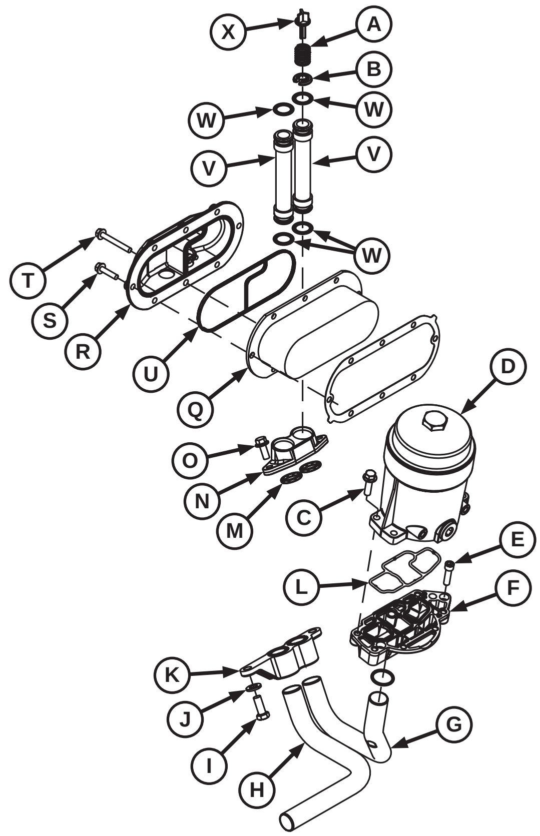
**Specification**

Top-Load Oil Filter Cap—Torque.................... 40—50 N•m (30—37 lb-ft)

**A—Cap**

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:**

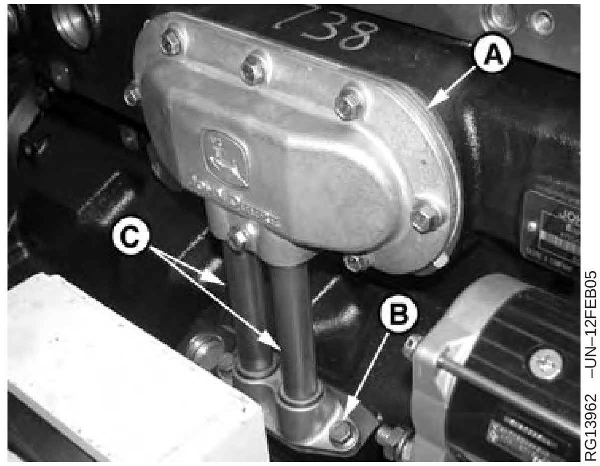
1. Remove eight cap screws securing oil cooler cover (A).
2. Remove two cap screws securing oil cooler tube adapter (B). Remove cover, tubes (C), and adapter as an assembly.
3. Remove oil cooler (D) from block bore. Clean all gasket material from mating surfaces.

**Inspect Oil Cooler Assembly:**

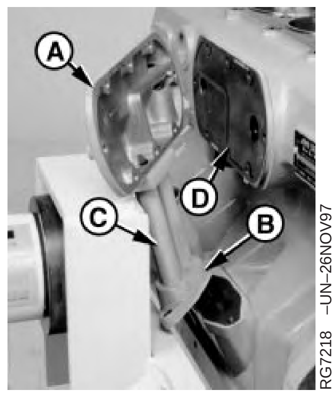
1. Inspect oil cooler for physical damage, plugging, or leakage which may allow mixing of oil and coolant.
2. Back flush oil cooler to clean all debris from core.
3. Pressure test oil cooler in liquid and compressed air if mixing of oil and coolant is suspected.

   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.

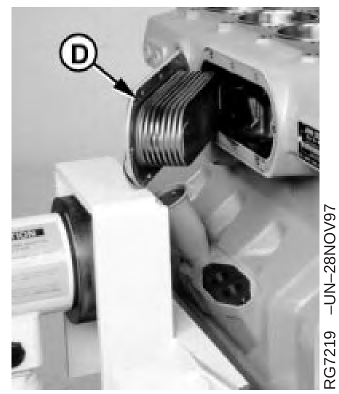
   Replace parts as needed. DO NOT attempt to repair oil cooler.




*Oil Cooler*




*Removing Oil Cooler*




*Oil Cooler Removed*

**A—Oil Cooler Cover/Bypass Valve Housing**
**B—Oil Cooler Tube Adapter**
**C—Oil Cooler Tubes**
**D—Oil Cooler**

**Continued on next page** RE38635,000005A –19–12FEB05–1/2

02
060
8

**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:

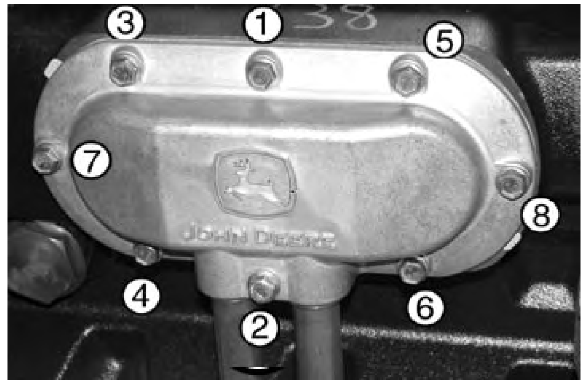
**Specification**

Oil Cooler Cover-to-Cylinder
Block Cap Screws—Initial Torque............ 20 N•m (15 lb-ft)

Then retighten in same sequence to final torque specification.

**Specification**

Oil Cooler Cover-to-Cylinder
Block—Final Torque............ 37 N•m (27 lb-ft)




RG13955 –UN–12FEB05

*Oil Cooler Cover Torque Sequence*

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

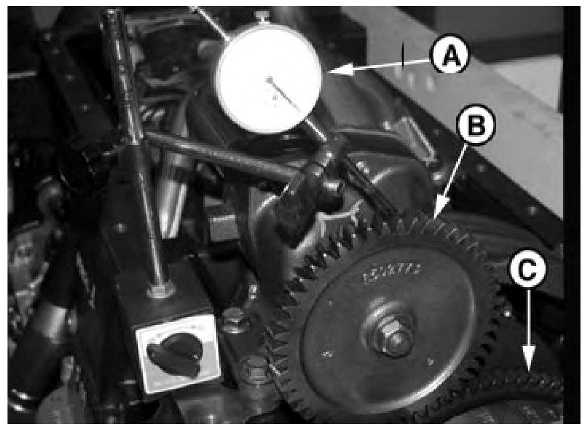
**IMPORTANT: Backlash must be at least 0.10 mm (0.004 in.) for spur gear. If backlash is less than specification, replace the oil pump drive gear.**

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–12FEB05

*Oil Pump Drive Gear Backlash*

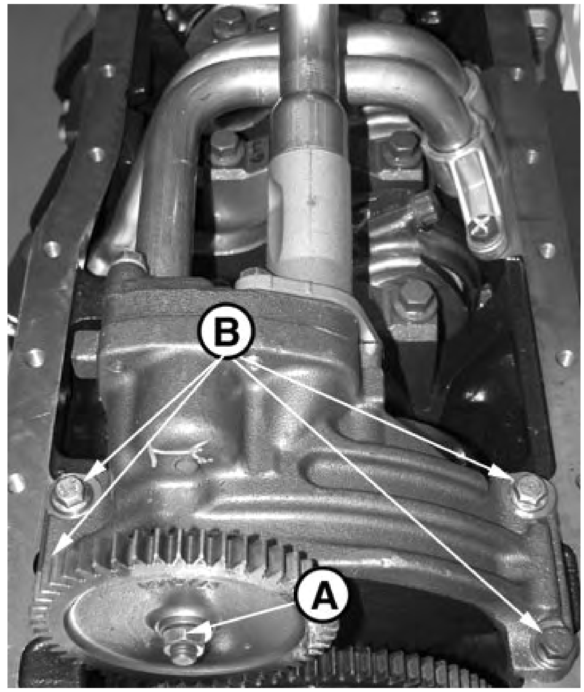
**A—Dial Indicator**
**B—Oil Pump Drive Gear**
**C—Crankshaft Gear**

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**



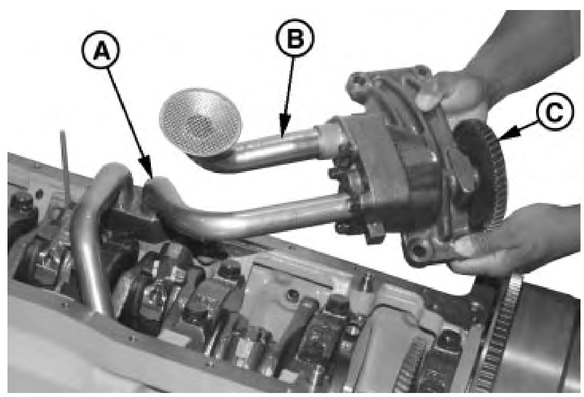

RG13961 –UN–12FEB05

*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


RG5917 –UN–05DEC97

*Checking Pump 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.

RG,RG34710,1227 –19–23OCT97–1/1

## Check Pumping Gear Backlash


RG5918 –UN–05DEC97

*Checking Backlash of Pumping Gear*

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.).

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.


*Inspecting Pump Drive Gear*

RG,RG34710,1229 –19–23OCT97–1/1

## Install Engine Oil Pump

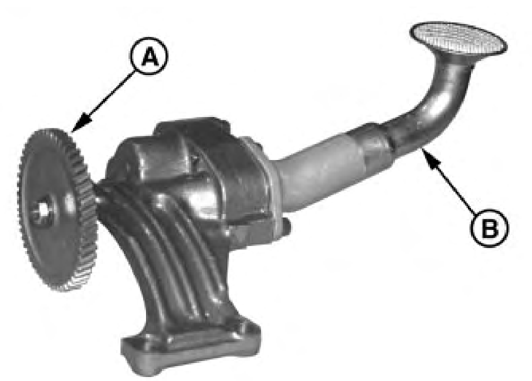
1. Install gear (A) onto pump and tighten snug using nut and washer. Final torque will be accomplished after installing pump.

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*

**Continued on next page** RE38635,000005E –19–12FEB05–1/2

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**

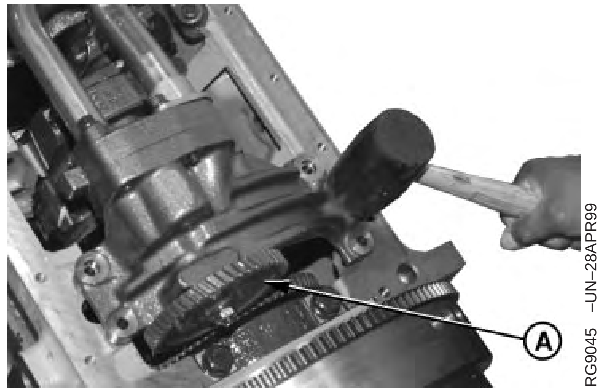
Oil Pump Housing-To-Cylinder Block—Torque ................................................................ 73 N••m (54 lb-ft)

7. Tighten oil pump drive gear retaining nut to specifications.

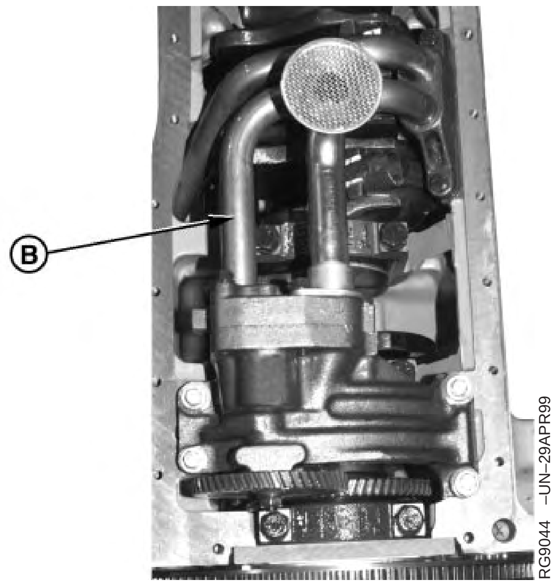
**Specification**

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*

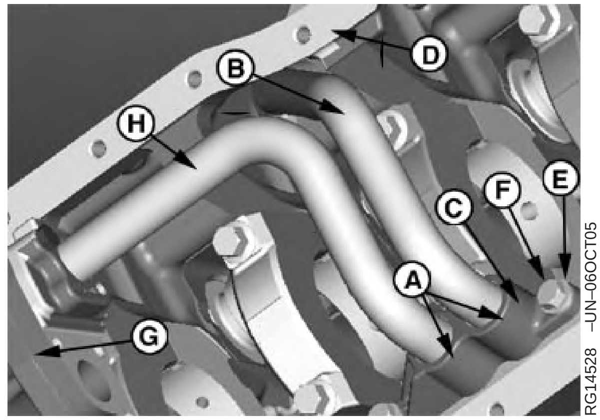
RE38635,000005E –19–12FEB05–2/2

## 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.

**Specification**

Oil Pump Adapter to Cylinder Block—Torque ................ 54 N•m (40 lb-ft)




*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**

RE38635,0000083 –19–06OCT05–1/1

## 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.

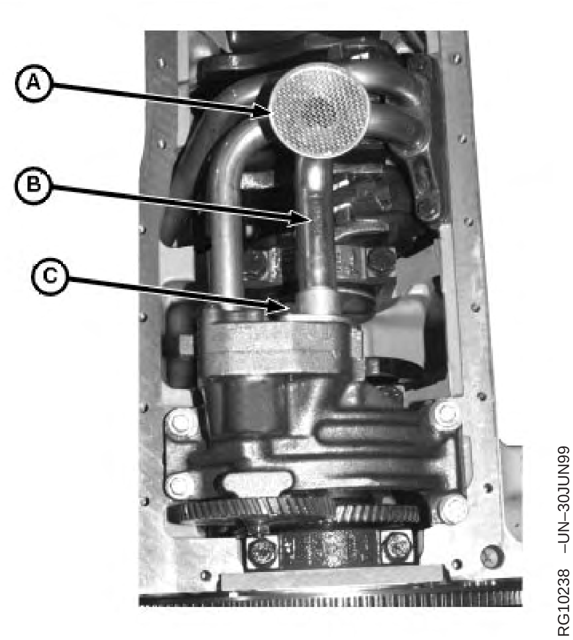
3. Clean and flush tube and pickup screen (A).

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.




*Oil Pickup Tube*

**A—Screen**
**B—Oil Pickup Tube**
**C—Cap Screws (3 used)**

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 PERMATEX® Aviation (Form-A-Gasket No. 3, TY6299) at timing gear cover-to-cylinder block mating surfaces.

2. Apply a thin layer of PERMATEX® Aviation (Form-A-Gasket No. 3, TY6299) 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)

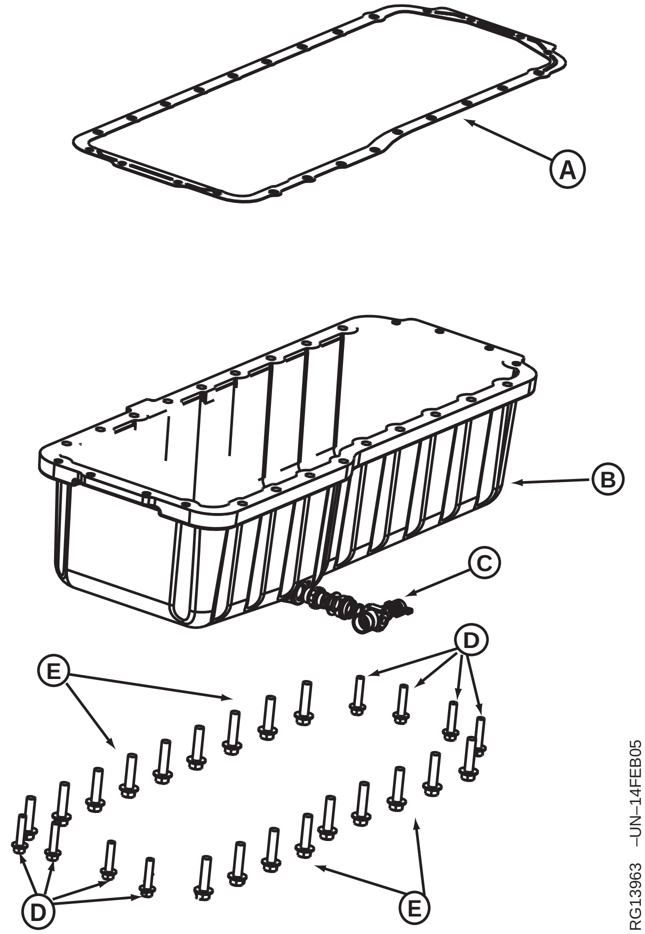
   b. Next tighten M10 cap screws (D) to specifications.

**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.




*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)**

*PERMATEX is a registered trademark of Loctite Corporation.*

**Continued on next page**

DPSG,OUO1004,824 –19–21APR99–1/2

**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).

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 –19–21APR99–2/2

## 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.

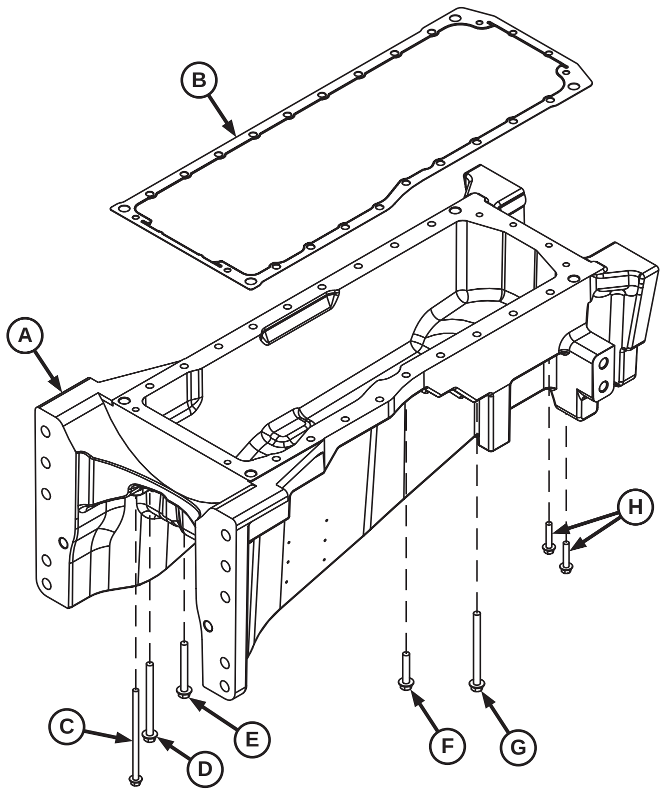
7. Apply clean engine oil to new O-ring for bottom drain plug and install drain plug, if removed. Tighten plug to specifications.

**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.*

Continued on next page RE38635,000005F –19–12FEB05–1/2

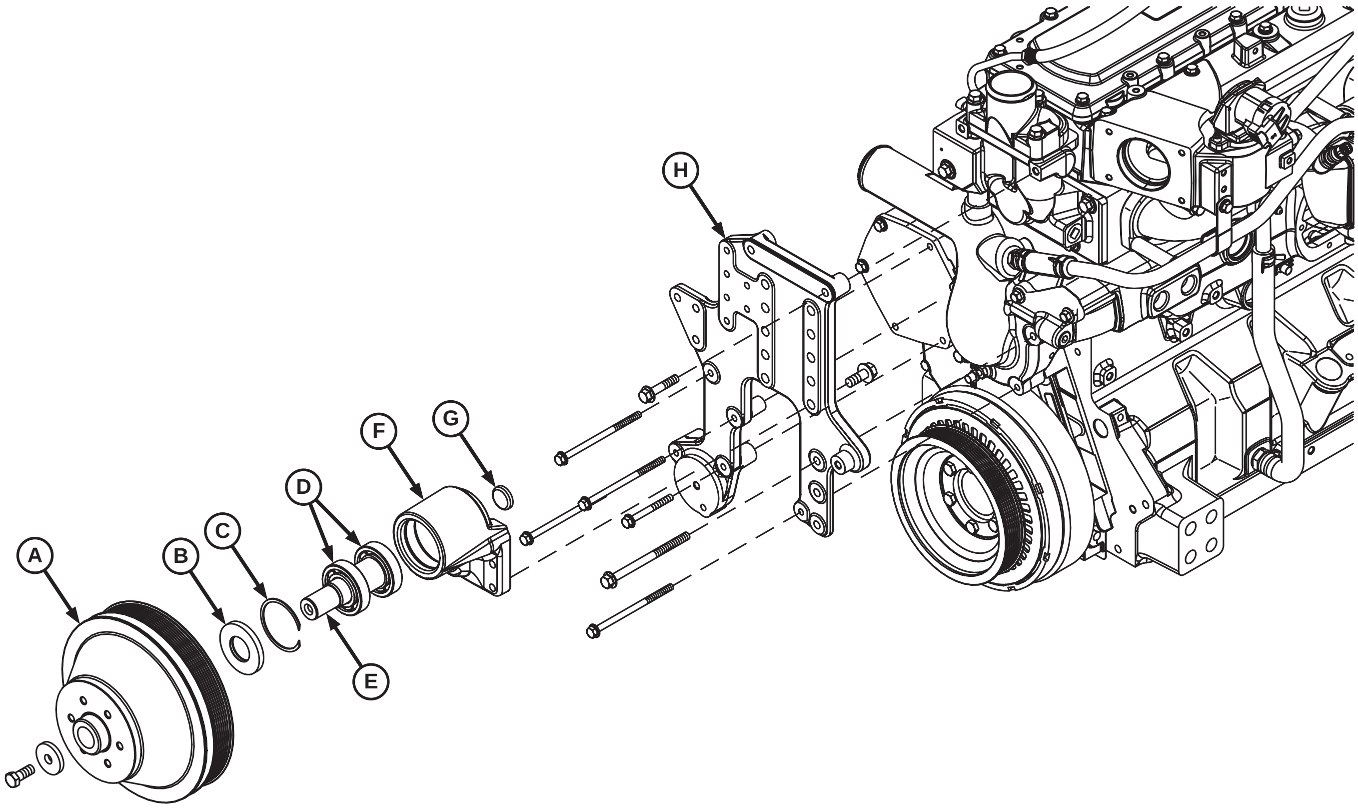



*Front Frame/Oil Sump for Tractors*

**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-**

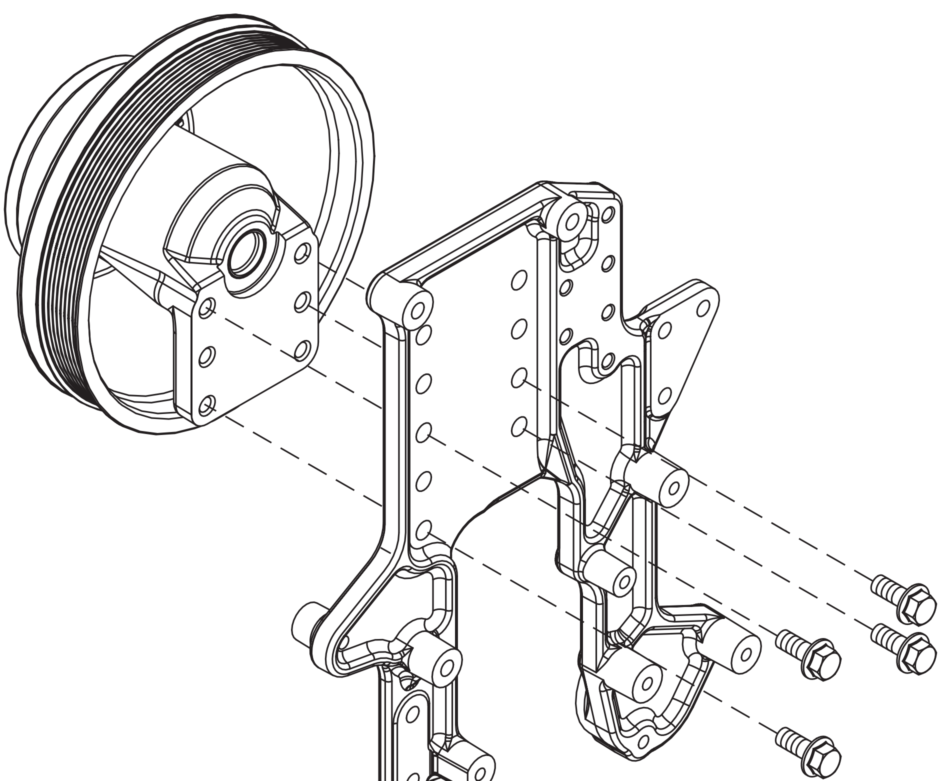
RE38635,000005F –19–12FEB05–2/2

## Inspect Fan Hub & Replace Bearings in Heavy-Duty, Adjustable Fan Drive Assembly




RG14051 –UN–27MAY05

*Heavy Duty Adjustable Fan Drive Assembly*



RG14050 –UN–31MAY05

Continued on next page

RE38635,000008A –19–22MAR05–1/3

**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 |

Continued on next page

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 N••m (18 lb-ft)
10 mm. Mounting Cap Screws (2 total)—Torque..................................................... 60 N••m (45 lb-ft)

14. Install fan and belts and adjust tension. See REPLACING FAN/ALTERNATOR V-BELT in operator's manual.

*LOCTITE is a registered trademark of Loctite Corp.*

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.

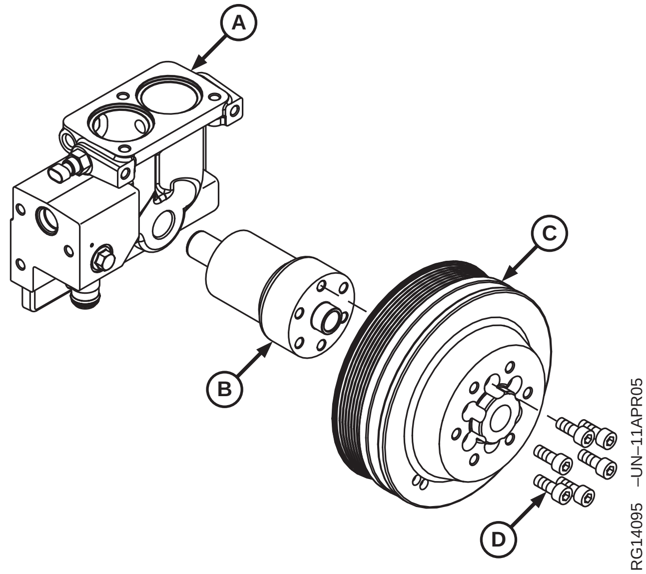
2. Support front face of coolant manifold and use a press to push bearing and pulley out of housing.

3. Support front face of fan pulley and push bearing out of pulley, and fan spacer (if equipped). Discard bearing.

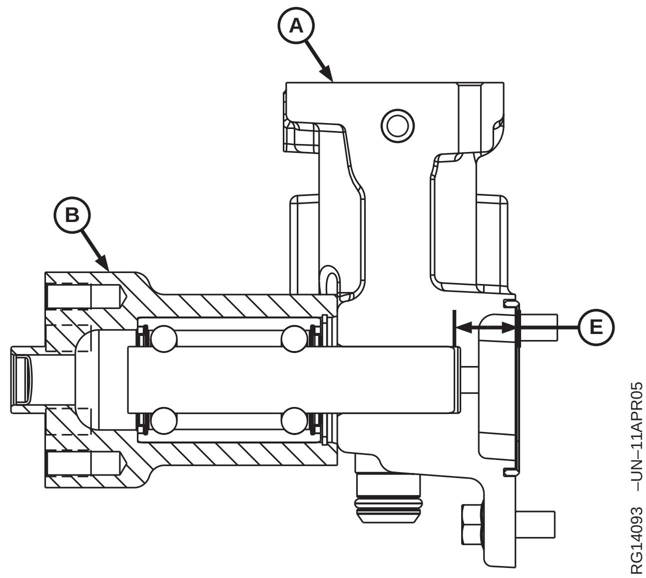
4. Thoroughly inspect thermostat housing and pulley for cracks or damage. Measure parts and compare readings with specifications shown. Replace parts as necessary.

**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.




*Fixed Fan Drive Assembly*




**A—Thermostat Housing**
**B—Bearing Shaft & Fan Spacer Hub[1]**
**C—Fan Pulley**
**D—Fan Pulley to Spacer Hub Cap Screws**
**E—Bearing Shaft Installed Dimension**

### 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.) |

*[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.*

**Continued on next page**

| | |
|---|---|
| Fixed Fan Drive Pulley (Fan Spacer End )[2]—ID | 49.485—49.518 mm (1.9482—1.9495 in.) |
| Fan Spacer[2]—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.**

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 |

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.

[2] *Units with press-fit fan spacer only.*

Continued on next page

**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.

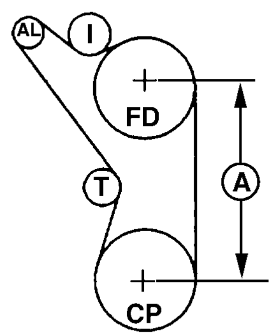
RE38635,00000B4 –19–11APR05–3/3

## Fan Drive Assembly

Use the following tables to determine proper fan drive height.

RG41165,000006D –19–30JAN01–1/10

| 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.) |



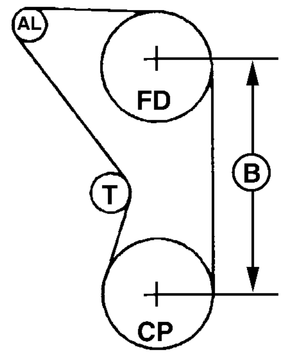

RG11666 –UN–31JAN01

**A—Fan Drive Height**
**AL—Alternator**
**I—Idler**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**

**Continued on next page**

RG41165,000006D –19–30JAN01–2/10

| 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.) |

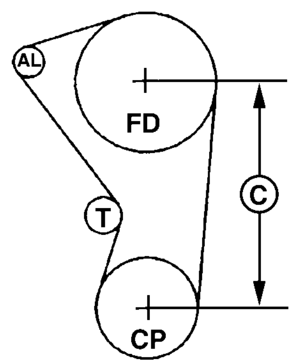



RG11667 –UN–31JAN01

**B—Fan Drive Height**
**AL—Alternator**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**

RG41165,000006D –19–30JAN01–3/10

| 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.) |

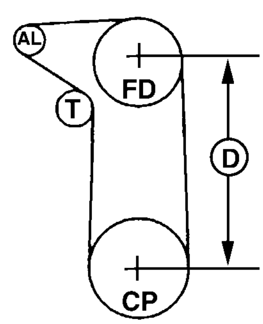



RG11668 –UN–31JAN01

**C—Fan Drive Height**
**AL—Alternator**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**

RG41165,000006D –19–30JAN01–4/10

| Fixed Fan Drives (D) | | |
|---|---|---|
| Fan Belt Option | Fan Drive Option | Fan Height |
| 2408 | 236A | 425 mm (16.7 in.) |



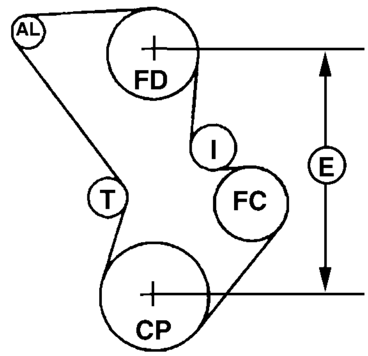

RG11669 –UN–31JAN01

**D—Fan Drive Height**
**AL—Alternator**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**

**Continued on next page**

RG41165,000006D –19–30JAN01–5/10

| 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.) |

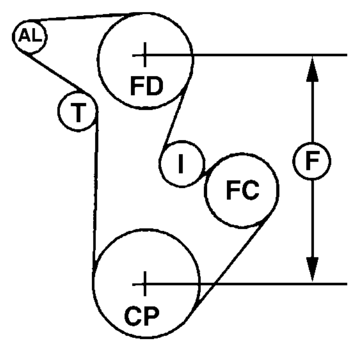



RG11670 –UN–31JAN01

**E—Fan Drive Height**
**AL—Alternator**
**I—Idler**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**

RG41165,000006D –19–30JAN01–6/10

| Fixed Fan Drives (F) | | |
|---|---|---|
| Fan Belt Option | Fan Drive Option | Fan Height |
| 2408 | 236A | 425 mm (16.7 in.) |



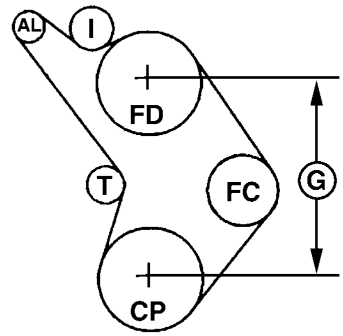

RG11671 –UN–31JAN01

**F—Fan Drive Height**
**AL—Alternator**
**I—Idler**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**

**Continued on next page**

RG41165,000006D –19–30JAN01–7/10

| 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.) |




RG11672 –UN–31JAN01

**G—Fan Drive Height**
**AL—Alternator**
**I—Idler**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**
**FC—Freon Compressor**

**Continued on next page**

RG41165,000006D –19–30JAN01–8/10

## 6081 AGRICULTURAL APPLICATIONS

## ENGINE MODEL TO AG APPLICATION

| | | |
|---|---|---|
| **010** | **INTRODUCTION** | |
| **200** | **6081HH012** | **9760STS COMBINE** |
| **210** | **6081HH013** | **9660STS COMBINE** |
| **220** | **6081HH019** | **9560STS COMBINE** |

**RGP11673**

RG11673 –UN–10NOV05

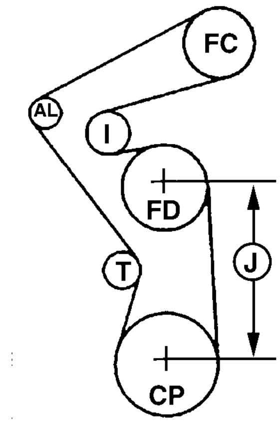
**H—Fan Drive Height**
**AL—Alternator**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**
**FC—Freon Compressor**

| 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.) |

**Continued on next page**

RG41165,000006D –19–30JAN01–9/10

| 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.) |

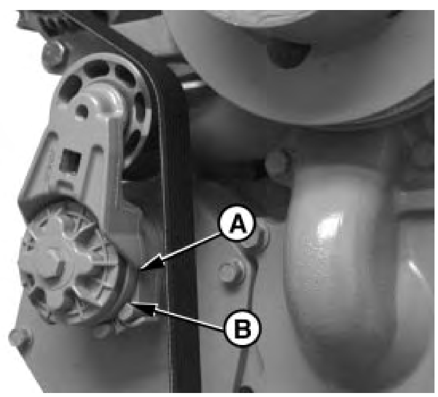



RG11674 –UN–31JAN01

**J—Fan Drive Height**
**AL—Alternator**
**I—Idler**
**FD—Fan Drive**
**T—Tensioner**
**CP—Crank Pulley**
**FC—Freon Compressor**

RG41165,000006D –19–30JAN01–10/10

## Checking Belt Tensioner Spring Tension and Belt Wear




RG7380 –UN–28NOV97

*Belt Tensioner*

**A—Cast Stop**
**B—Cast Stop**

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).

**Continued on next page**

RG,RG34710,1241 –19–23OCT97–1/3

**Checking Tensioner Spring Tension:**

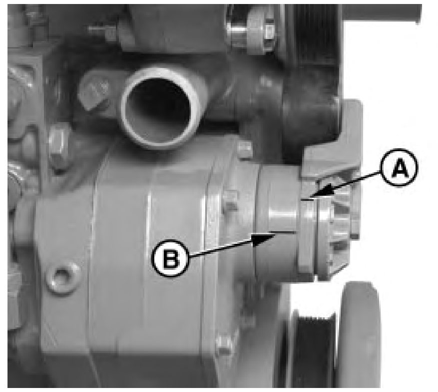
A belt tension gauge will not give an accurate measure of the belt tension when automatic spring tensioner is used. Measure tensioner spring tension using a torque wrench and procedure outlined below:

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

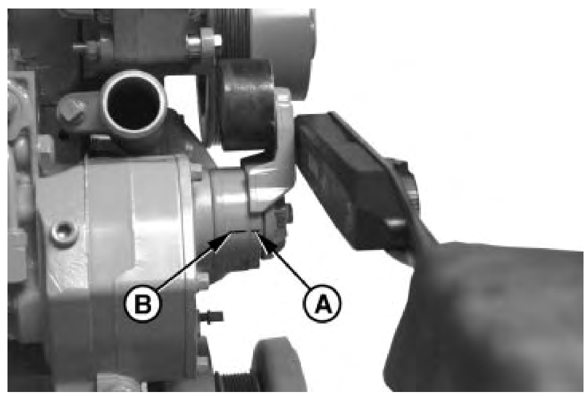
5. Rotate the swing arm using a torque wrench until marks (A and B) are aligned.

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**

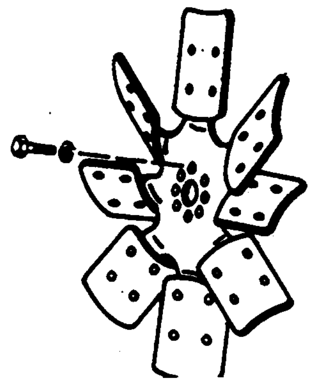



RG7381 –UN–28NOV97

*Measuring Belt Tensioner*

RG,RG34710,1241 –19–23OCT97–3/3

## Inspect and Install Fan Assembly



RG4797 –UN–14DEC88

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)

RG,RG34710,1242 –19–23OCT97–1/1

## Visually Inspect Coolant Pump

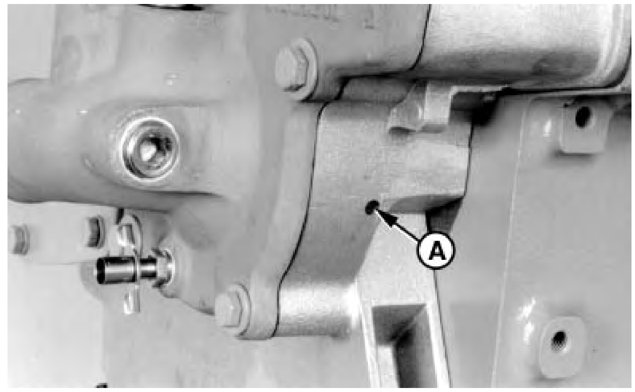
**Inspect Weep Hole:**

Inspect coolant pump weep hole (A) in timing gear cover for oil or coolant leakage.

Oil leakage indicates a damaged rear seal.

Coolant leakage indicates a damaged front seal.

Replace complete coolant pump assembly if leakage is detected; individual repair parts are not available.




*Coolant Pump Weep Hole*

**A—Weep Hole**

**Inspect for Impeller Contact with Cover:**

1. Remove radiator-to-coolant pump hose from coolant pump inlet elbow.

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.

**Continued on next page**

RG,RG34710,1243 –19–23OCT97–1/2

## 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 cavitiation preventatives in the coolant have been depleted.**


RG13203 –UN–15SEP03

*Timing Gear Cover*

RG,RG34710,1243 –19–23OCT97–2/2

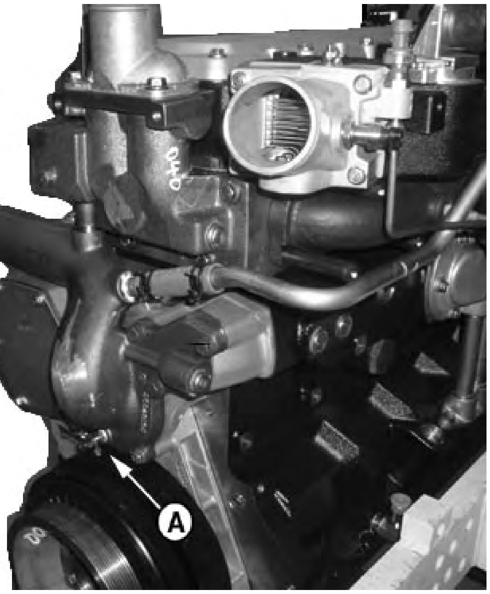
## Remove Coolant Pump Assembly

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.

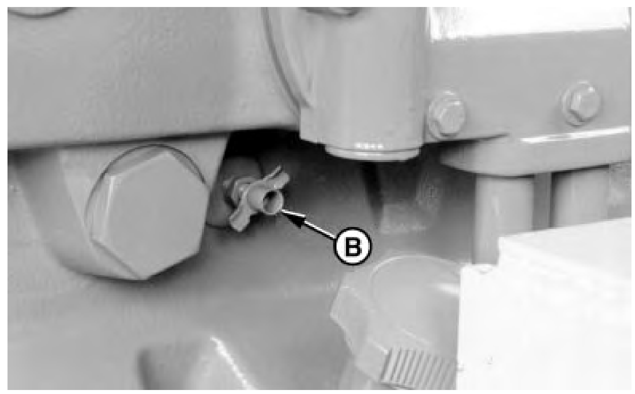
**CAUTION: Explosive release of fluids from pressurized cooling system can cause serious burns. Wait until engine coolant is cool enough to touch with bare hands before draining. Slowly loosen radiator cap to first stop to relieve pressure.**

1. Open coolant pump drain valve (A) and block drain valve (B) to drain coolant from engine.

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




*Coolant Pump Drain Valve*




*Cylinder Block Drain Valve*

RE38635,000008C –19–22MAR05–1/3

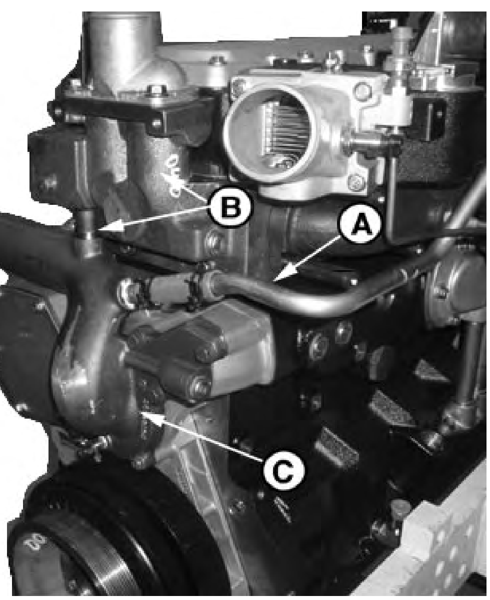
2. Remove radiator hose from coolant pump cover inlet elbow, shown removed.

3. Loosen hose clamps and remove EGR coolant return hose (A) from coolant pump port.

4. Remove six cap screws securing coolant pump cover (C) to timing gear cover and remove coolant pump cover. Bypass tube (B) will remain attached to thermostat housing.

5. Remove gasket from timing gear cover and discard.

**A—EGR Coolant Return Line**
**B—Bypass Tube**
**C—Coolant Pump Cover**



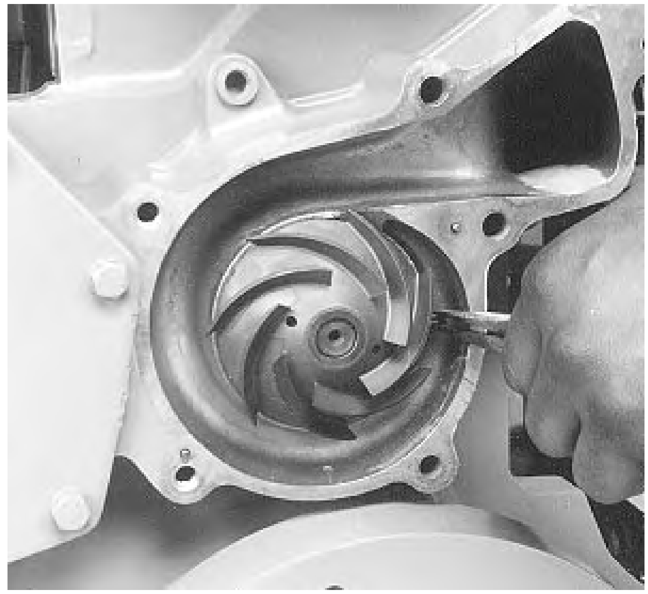

*Removing Coolant Pump Cover*

**Continued on next page**

RE38635,000008C –19–22MAR05–2/3

6. Compress retaining ring ends with a small needle-nose pliers as shown.

7. Grasp impeller with a large pliers and pull coolant pump from timing gear cover using a slight rocking motion until assembly is removed from timing gear cover. Discard coolant pump assembly.


RG7062 –UN–07SEP94

*Removing Coolant Pump*

RE38635,000008C –19–22MAR05–3/3

## Install Coolant Pump Assembly

1. Thoroughly clean and inspect coolant pump mounting bore in timing gear cover before installing pump assembly.

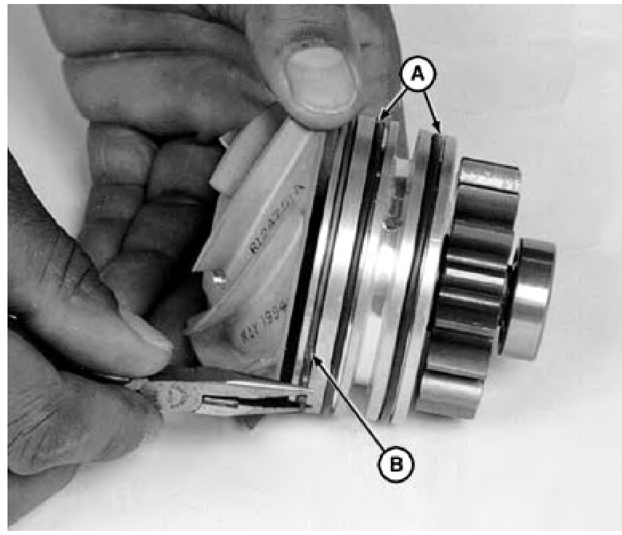
*NOTE: An improved coolant pump with a steel bearing carrier and stainless steel impeller has been designed and adopted. Additionally, color coded O-rings are now used for improved sealing. BE CERTAIN to assemble the O-rings in their proper position.*

2. Install two new O-rings (A) in rear grooves of coolant pump housing (as looking at the picture, the pink o-ring goes with the RH groove, and the blue o-ring the LH groove, closest the impeller) and apply a light coat of clean engine oil to O-rings.

3. Install a new retaining ring (B) in front (smallest) groove of coolant pump housing and compress both ends of retaining ring together with a small needle-nose pliers.

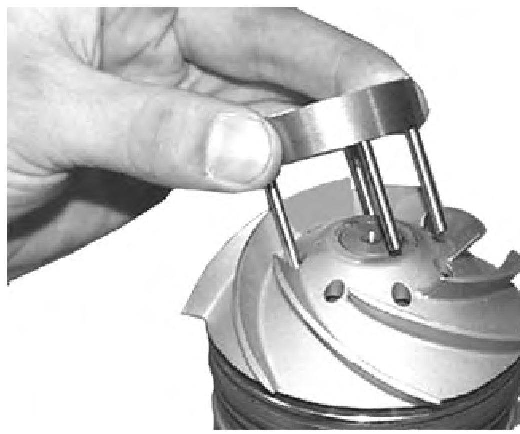
4. Install a new foam filter into coolant pump weep hole.

5. Using the Coolant Pump Service Tool provided in the service replacement kits, insert the four legs (as shown) of the tool into the holes of the impeller, allowing pressure to be applied, during assembly, to the body of the pump, and thus preventing damage to the shaft seal.




RG7227 –UN–05DEC97

*Assembling Coolant Pump*



RG13205 –UN–15SEP03

*Coolant Pump Service Tool*

Continued on next page RE38635,000008B –19–22MAR05–1/2

*NOTE: Retaining ring ends should be at 3 o'clock position and coolant pump weep hole should align with hole in timing gear cover when installing coolant pump assembly.*

6. Compress retaining ring ends and install coolant pump assembly into pilot bore of timing gear cover. Apply pressure, using a pry bar, to the service tool (D). Make sure that pump drive gear properly meshes with crankshaft gear.

7. Release retaining ring ends and verify that retaining ring is firmly seated in groove of timing gear cover.

8. Install new coolant pump cover gasket to dowel pins on timing gear cover.

9. Install coolant pump cover assembly to dowel pins on timing gear cover.

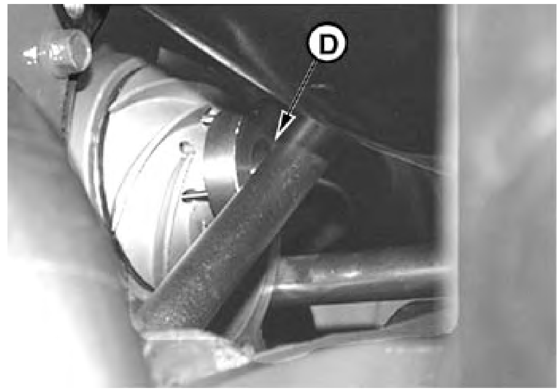
10. Install five M10 cap screws and one M8 cap screw (E) through coolant pump cover into timing gear cover finger tight.

11. Tighten cap screws to specifications.

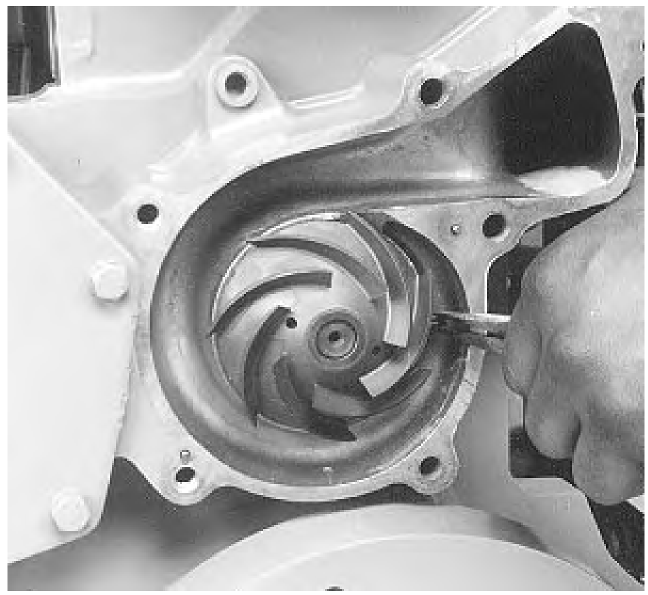
**Coolant Pump Cover Mounting Cap Screws—Specification**

| | |
|---|---|
| M8 Mounting Cap Screw—Torque | 32 N••m (24 lb-ft) |
| M10 Cap Screws—Torque | 47 N•m (35 lb-ft) |

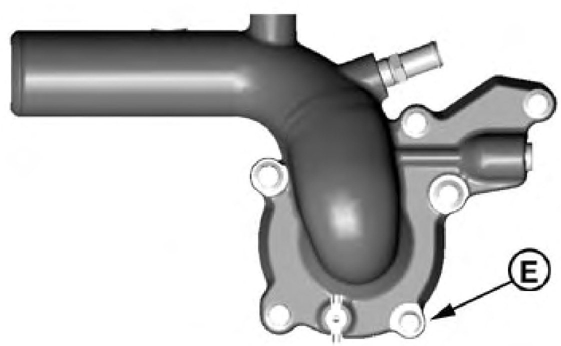
**E—M8 Cap Screw**




*Installation of Coolant Pump w/Pry Bar*




*Installing Coolant Pump*




*Install Coolant Pump Cover*

RE38635,000008B –19–22MAR05–2/2

## 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.

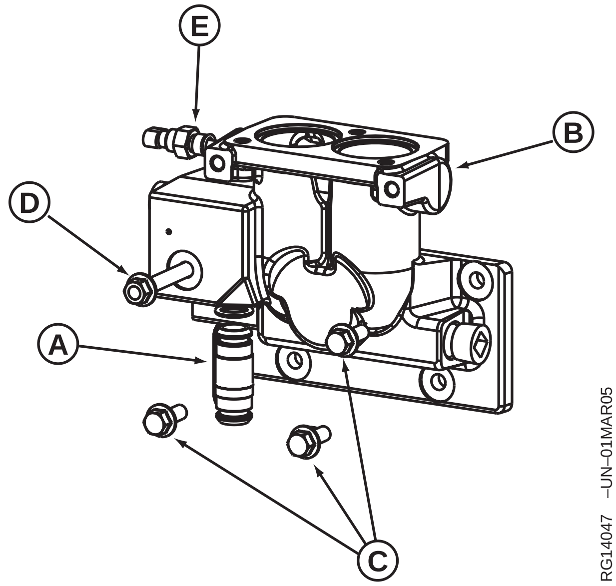
3. Carefully clamp cover in a soft-jawed vise and remove bypass tube from thermostat housing. Be careful not to damage machined gasket surface of housing.

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.



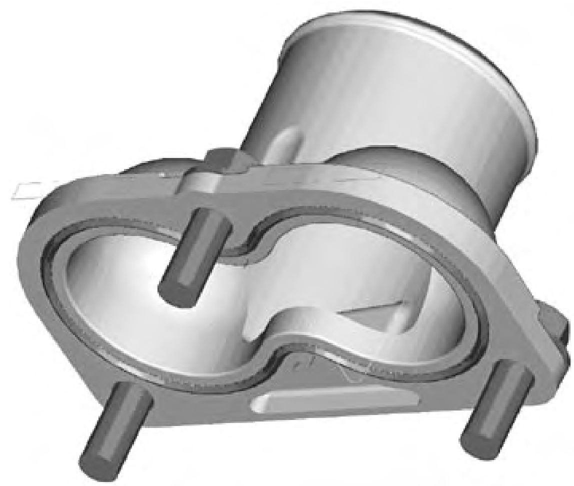

*Thermostat Housing Assembly*

**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.**


RG14112 –UN–29MAR05

*Thermostat Housing Cover*

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.

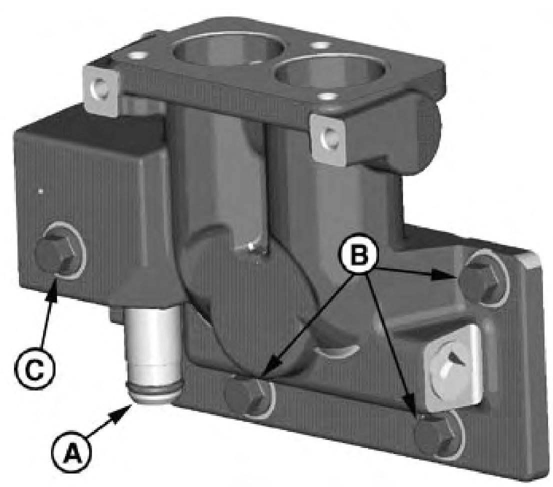
**Specification**

Thermostat 82°C (180°F)—
Opening Temperature .......................................... 80—84°C (175—182°F)

If either thermostat fails to open within this range, replace both thermostats as a set.

RE38635,000008E –19–28MAR05–1/1

## Remove Thermostat Housing



RG14113 –UN–29MAR05

*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**

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.*

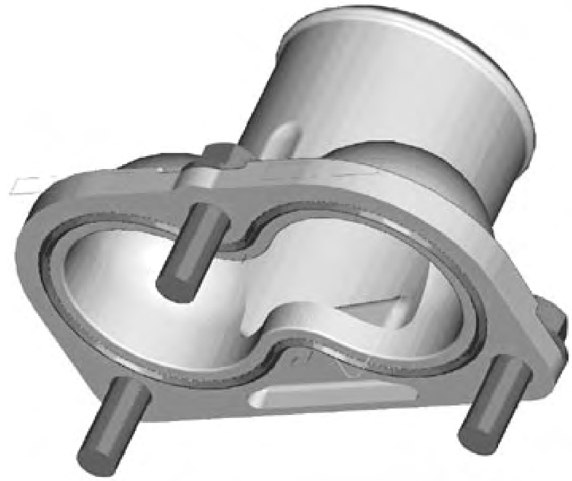
02
070
22

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, installing bypass tube (A) into coolant pump cover.

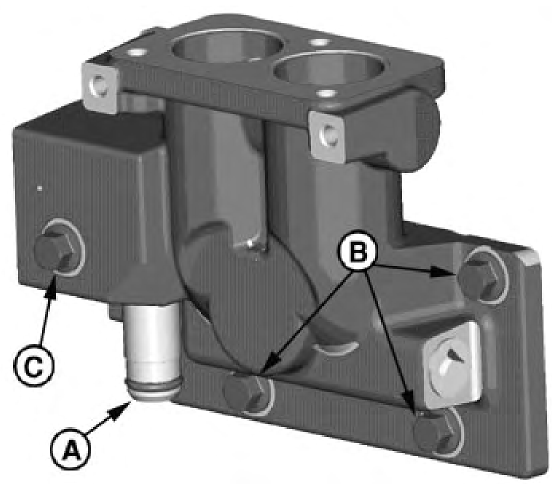
2. Install three short (B) and one long (C) cap screws through thermostat housing and into cylinder head finger tight.

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 INSTALL THERMOSTATS, earlier in this group.

**A—Coolant Bypass Tube**
**B—Short Cap Screws**
**C—Long Cap Screw**




*Thermostat Housing*

RE38635,0000091 –19–28MAR05–1/1

## 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

TS281 –UN–23AUG88

**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.**

**IMPORTANT: Use coolant as specified in Fuel, Lubricants and Coolant section.**

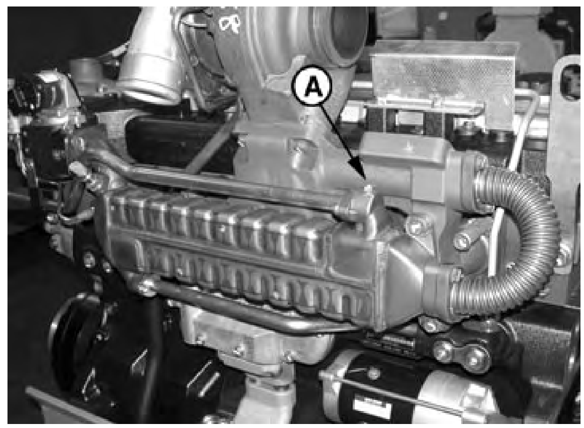
1. Remove cap from top tank (de-aeration tank) of cooling system.

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.




RG14831 –UN–05APR06

*EGR Cooler Vent Plug*

**A—Plug to Bleed Air from EGR Cooler**

| 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.

Continued on next page

RE38635,0000112 –19–05APR06–1/2

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.

**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.

RE38635,0000112 –19–05APR06–2/2

## 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 –19–23OCT97–1/1

## Extending Turbocharger Life

The new generation of John Deere engines feature a Variable Geometry Turbocharger (VGT). This new turbocharger has moveable vanes in the exhaust turbine housing, which directs a portion of the exhaust gases through a cooler and into the intake system. The vanes are controlled by an electronically controlled and water cooled actuator, which is part of the turbocharger assembly. This actuator makes the turbocharger visually different from previous models.

VGT turbochargers, like previous models, 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.

Continued on next page

**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.

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.

RE38635,000004B –19–24JAN05–2/2

## 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).

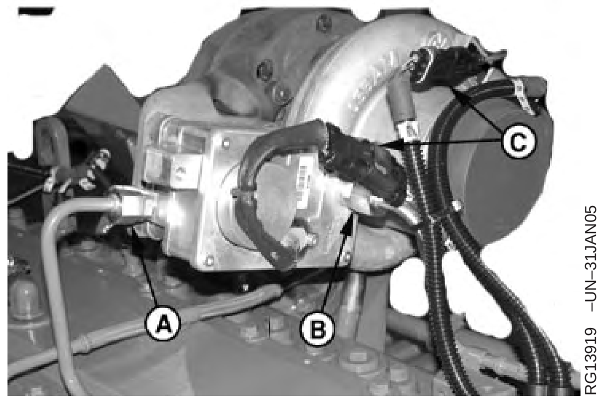
4. Disconnect turbocharger sensor connections (C).

5. Disconnect turbocharger oil supply line (D) at turbocharger and oil filter base. Set line aside.

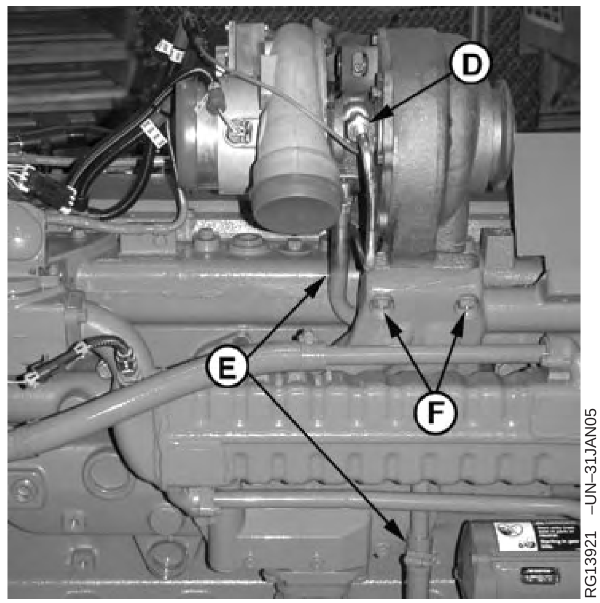
6. Disconnect turbocharger oil drain line (E), removing two cap screws at flange at bottom of turbo housing and at tension clamp joint with hose as shown. Remove drain line from behind exhaust manifold, and gasket. Set drain line aside and discard gasket.

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.




*Turbocharger Actuator*




*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**

**Continued on next page** RE38635,000004F –19–04FEB05–1/2

9. Perform turbocharger seven-step inspection, as described later, if failure mode has not been determined. See TURBOCHARGER INSPECTION later in this group.



RE38635,000004F –19–04FEB05–2/2

## Remove Turbocharger Oil Drain Line

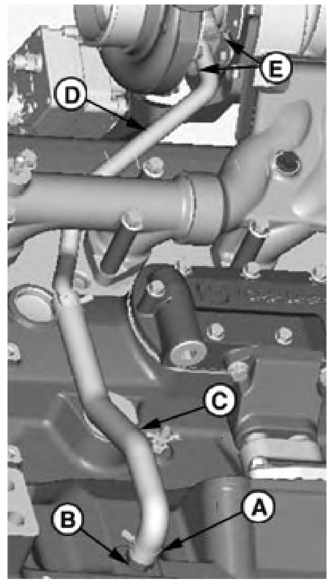
1. Loosen hose clamp (A) at cylinder block fitting (B).

2. Loosen and remove 2 cap screws (E) from flange end of line, securing drain line to turbocharger bearing housing (H).

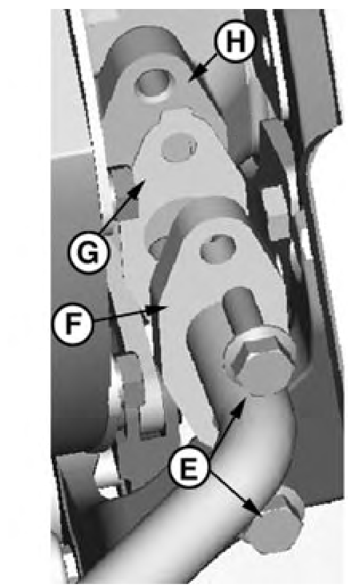
3. Remove and discard gasket (G).

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**




*Turbocharger Oil Drain Line*




*Oil Drain Line - Flange End*

RE38635,000001E –19–01JUN05–1/1

## Remove Turbocharger Oil Supply Line

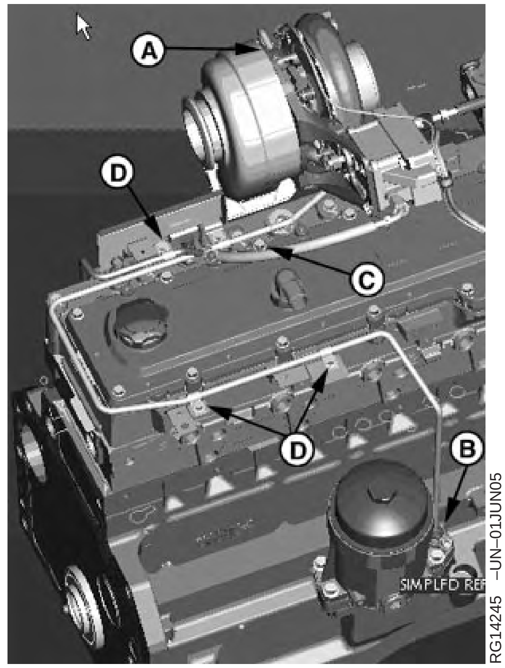
1. Loosen 3 cap screws securing P clamps (D) used to support oil line from oil filter adapter to turbocharger.

2. Loosen fittings at each end of oil line - turbocharger end (A) and oil filter adapter end (B).

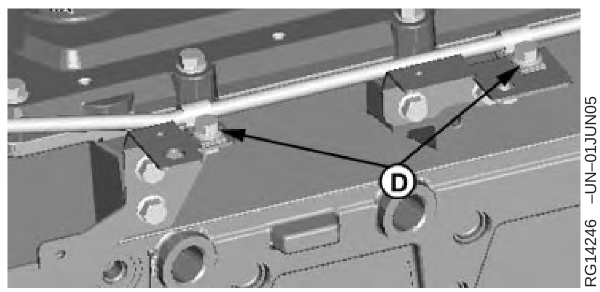
3. Remove P Clamp Cap Screws.

4. Remove oil supply line from turbocharger and oil filter adapter and set aside.

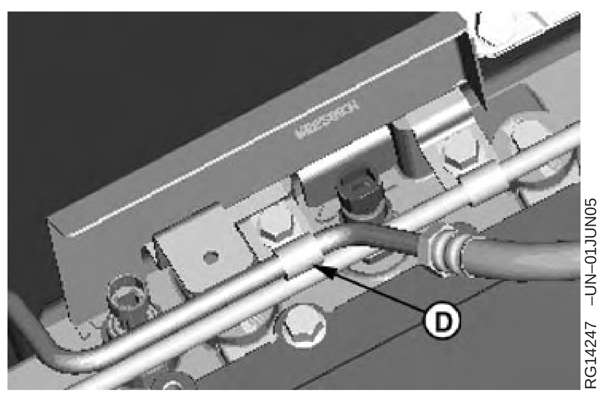
**A—Oil Line Fitting - Turbocharger**
**B—Oil Line Fitting - Oil Filter Adapter**
**C—Clearance Point**
**D—P Clamps (3) to Secure Line - Intake Manifold & Heat Shield**




*Turbocharger Oil Supply Line*




*P Clamps - Right Rear of Intake Manifold*




*P Clamp - Heat Shield*

RE38635,000001F –19–01JUN05–1/1

## 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).<br>Inspect engine for internal damage. |
| | Leaking and/or defective intake system. | Inspect air intake system connections including air filter; repair as required (this group).<br>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 ail 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.<br>Check engine for overfueling.<br>Check injection pump timing. |

**Continued on next page**

**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). |
| | 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. |

RE38635,000002E –19–15JUL05–2/2

## 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.*

RG,RG34710,1259 –19–23OCT97–1/12

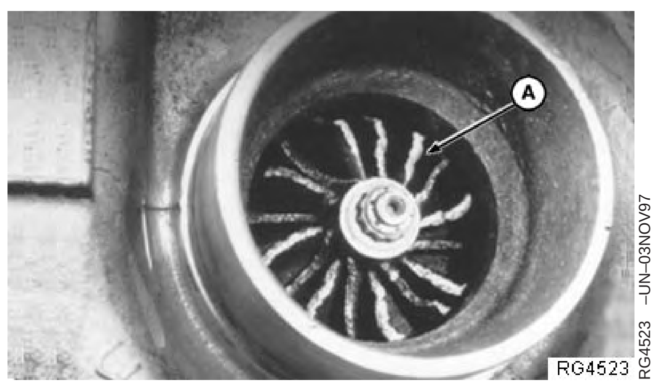
### Compressor Housing Inlet and Compressor Wheel

1. Check compressor inlet and compressor wheel (A) for foreign object damage.

*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.

**A—Compressor Wheel**

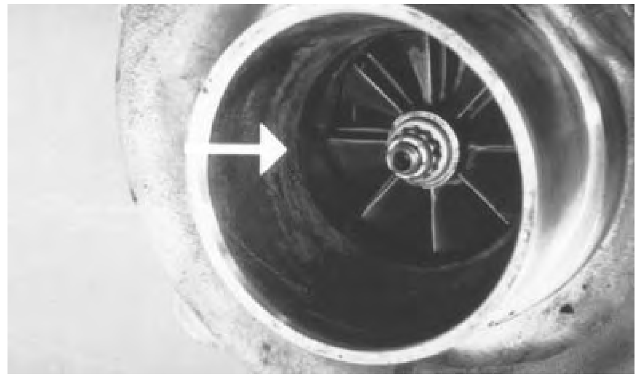



*Checking Inlet and Compressor Wheel*

**Continued on next page** RG,RG34710,1259 –19–23OCT97–2/12

*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*

RG,RG34710,1259 –19–23OCT97–3/12

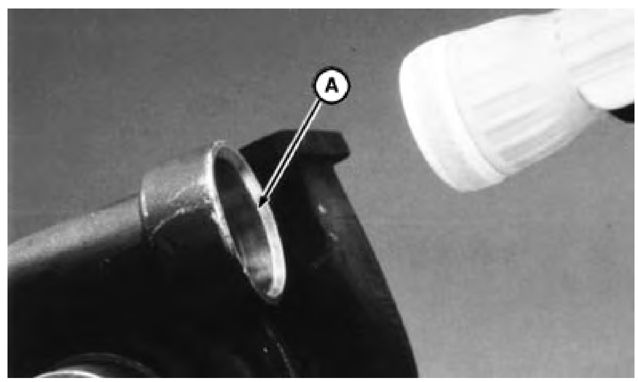


**Compressor Housing Outlet**

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**



RG4525 –UN–05DEC97

*Checking Compressor Outlet*

**Continued on next page**

RG,RG34710,1259 –19–23OCT97–4/12

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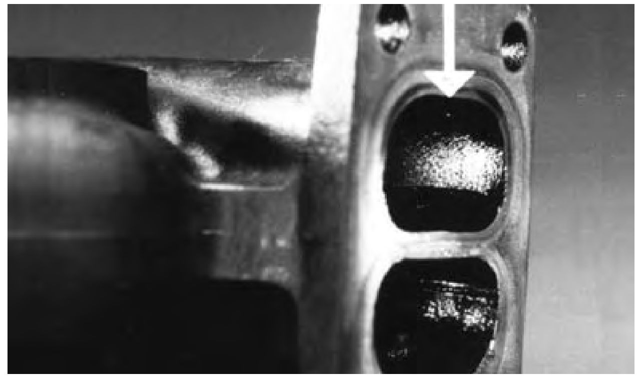
10

### 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.*



RG4526 –UN–05DEC97

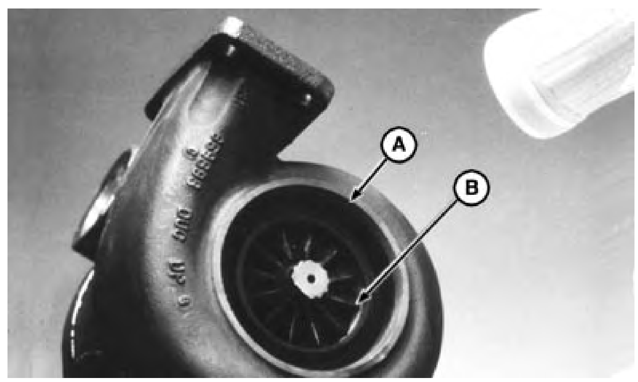
*Checking Turbine Housing Inlet Ports*

RG,RG34710,1259 –19–23OCT97–5/12

### 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**



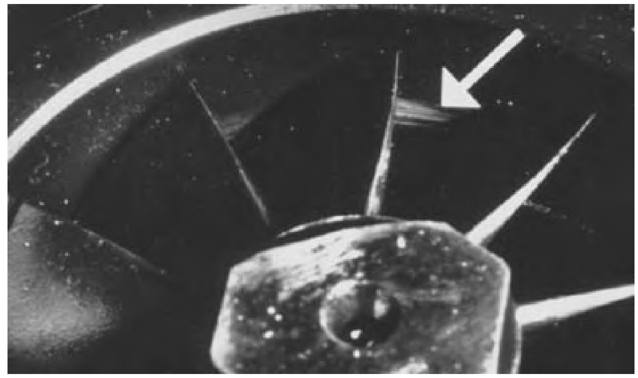

RG4527 –UN–05DEC97

*Checking Turbine Wheel and Outlet*

Continued on next page

RG,RG34710,1259 –19–23OCT97–6/12

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*

RG,RG34710,1259 –19–23OCT97–7/12

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.

RG4532 –UN–05DEC97

*Checking Shaft Rotation and Clearance*

**Continued on next page**

RG,RG34710,1259 –19–23OCT97–8/12

**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.*

RG4533 –UN–05DEC97

*Checking for Contact of Compressor and Turbine Wheels*

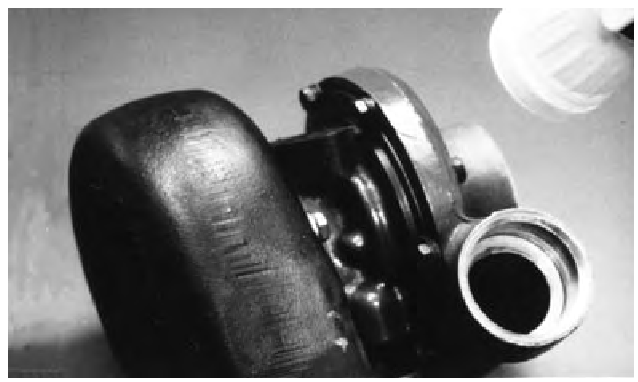
RG,RG34710,1259 –19–23OCT97–9/12

### 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.**



RG4529 –UN–05DEC97

*Checking Center Housing*

Continued on next page

RG,RG34710,1259 –19–23OCT97–10/12

**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.

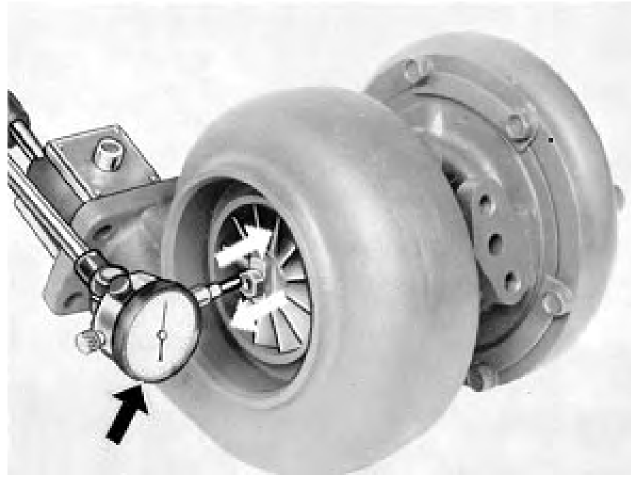
2. Move shaft axially back and forth by hand.

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.



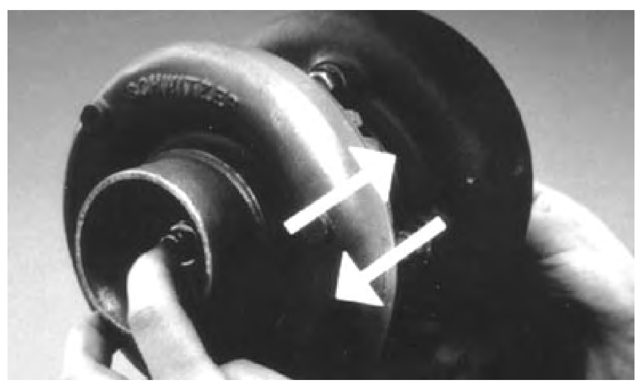
RG11675 –UN–01FEB01

*Checking Axial Bearing End Play*

RG,RG34710,1259 –19–23OCT97–11/12

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.*



RG4534 –UN–05DEC97

*Checking Shaft End Play*

RG,RG34710,1259 –19–23OCT97–12/12

## 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.



RG,30,JW7571 –19–20NOV97–1/1

## 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.

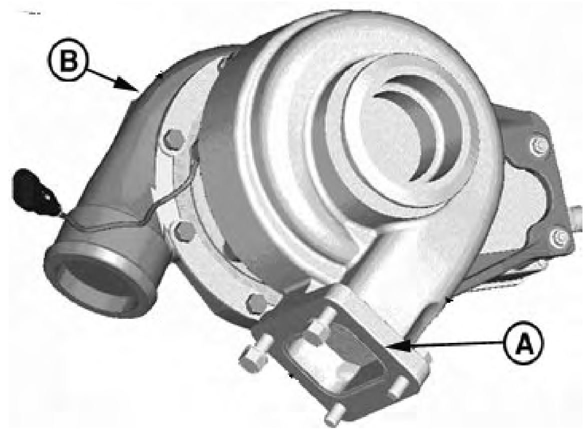
RG5858 –UN–13AUG91

*Prelubing Turbocharger*

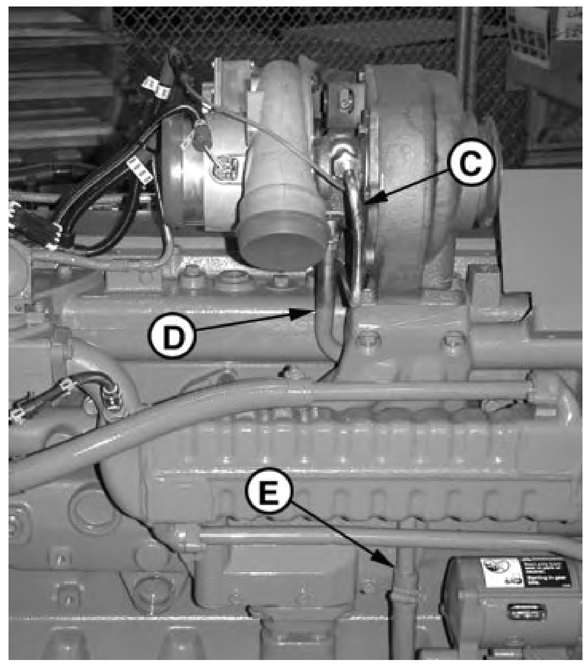
RG,RG34710,1266 –19–04FEB05–1/1

## Install Turbocharger

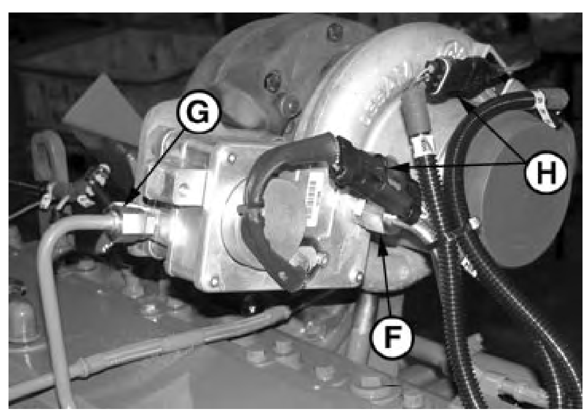
**A—Turbocharger Gasket**
**B—Turbocharger Compressor Inlet**
**C—Oil Supply Line**
**D—Oil Drain Line**
**E—Oil Drain Line-to-Hose Joint**
**F—Actuator Coolant Drain Line**
**G—Actuator Coolant Supply Line**
**H—Sensor Connections**




*6090 Turbocharger*




*Turbocharger Oil Line Installation*




*Turbocharger Actuator Coolant Lines*

**Continued on next page** RE38635,0000050 –19–04FEB05–1/4

**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.

Continued on next page

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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.

13. Connect coolant drain line to turbocharger actuator (F) and tighten securely.

14. Connect both sensors to wiring harness (H).

*NEVER-SEEZ is a registered trademark of Emhart Chemical Group.*

**Continued on next page**

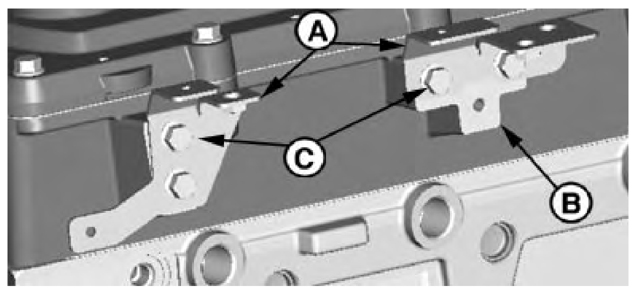
15. Connect air intake and exhaust piping to turbocharger. Tighten all connections securely. (For vehicle engines, refer to machine Technical Manual.)

**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.

RE38635,0000050 –19–04FEB05–4/4

## Install Turbocharger Oil Supply Line Brackets



RG14244 –UN–01JUN05

*Oil Supply Line Brackets - Right Rear Side of Engine*

**A—Oil Line Support Brackets**
**B—Intake Manifold**
**C—Cap Screws (4)**

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)

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**

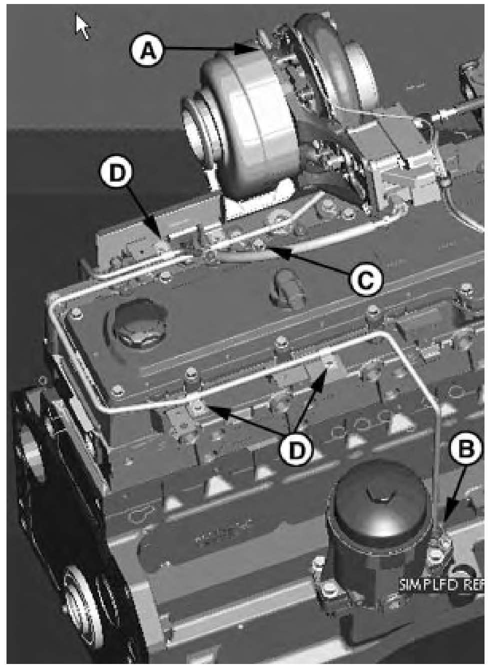
P-Clamp Cap Screws—Torque ...................................... 15 N•m (11 lb-ft)

4. Using a double wrench, tighten the oil filter adapter and turbocharger inlet fittings to specification.

**Specification**

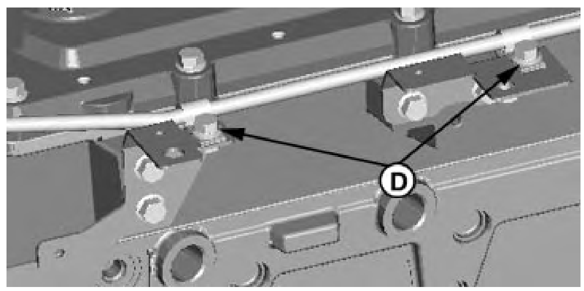
Turbocharger Oil Supply Line Nut to Turbocharger Inlet Fitting—Torque ........................................ 24 N•m (18 lb-ft)
Turbocharger Oil Supply Line Nut to Oil Filter Adapter Fitting—Torque ........................................ 24 N•m (18 lb-ft)

**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**



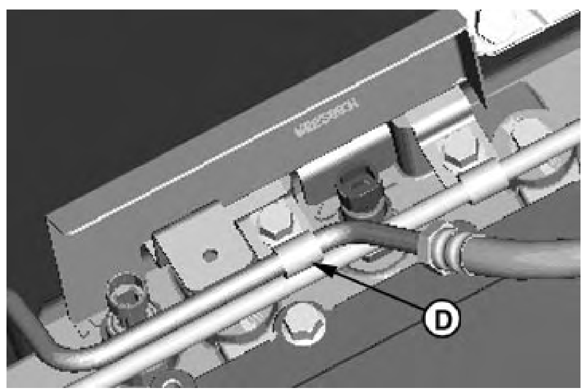

RG14245 –UN–01JUN05

*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.

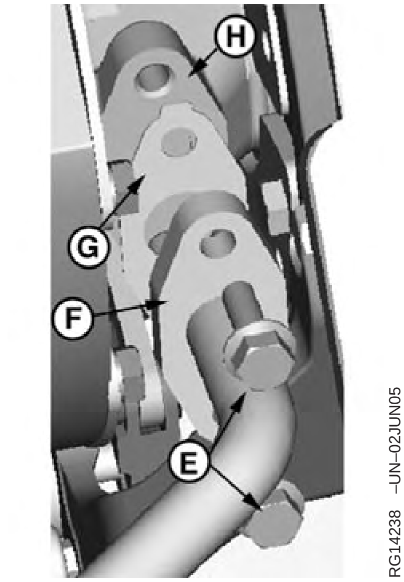
**Specification**

Turbocharger Oil Drain Line
Fitting to Cylinder Block—Torque .................................. 60 N•m (44 lb-ft)

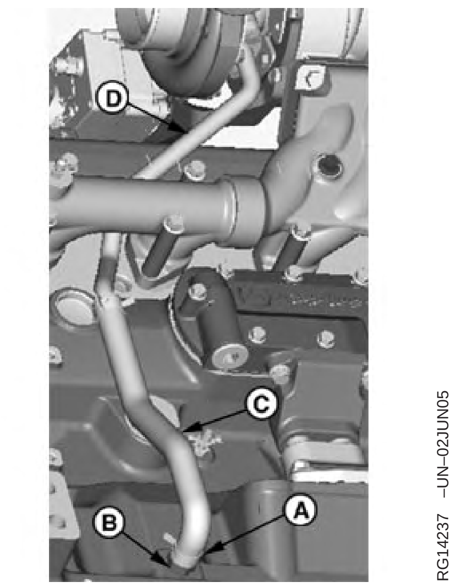
7. Apply soap lubricant to inside diameter of turbocharger drain hose (C) end - apply to both ends if hose has been removed from line.

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.




*Turbocharger Oil Drain - Flange End*




*Turbocharger Oil Drain*

**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**

## Install Heat Shield & Turbocharger Oil Supply Line Bracket

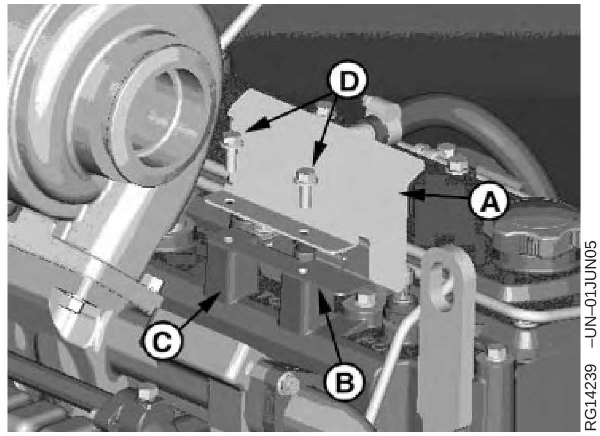
*NOTE: There are three support brackets for the oil supply line. The third bracket is assembled with the turbocharger heat shield, as the oil line is routed inside this shield.*

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)



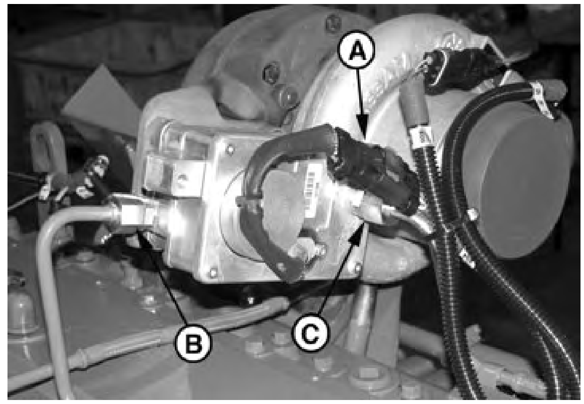

*Heat Shield & Bracket*

**A—Heat Shield**
**B—Oil Supply Line Bracket**
**C—Intake Manifold**
**D—Cap Screws**

RE38635,0000022 –19–01JUN05–1/1

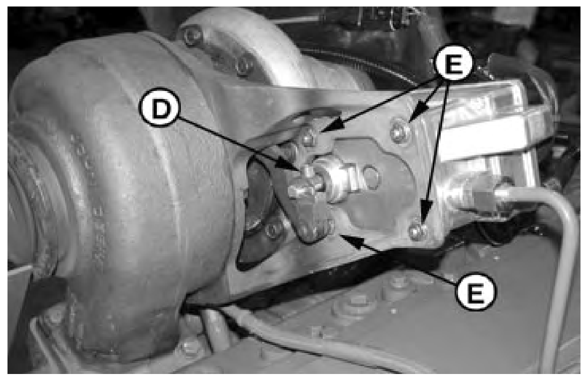
## Remove and Install Turbocharger Actuator

**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.**




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**

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)

**Continued on next page** RE38635,00000BC –19–22APR05–1/2

**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.

| Specification | |
|---|---|
| Linkage Arm to Actuator Shaft—Torque Turn | 7 N•m (5 lb-ft) |

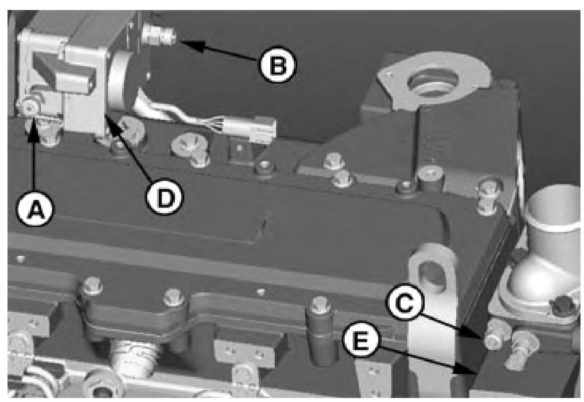
5. Connect actuator coolant supply and return lines to actuator. Secure nuts on both fittings, and using a second wrench, tighten fittings to specification.

| Specification | |
|---|---|
| Coolant Lines to Actuator—Torque | 24 N•m (18 lb-ft) |

RE38635,00000BC –19–22APR05–2/2



## Install Actuator Coolant Line Fittings



*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) |

**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

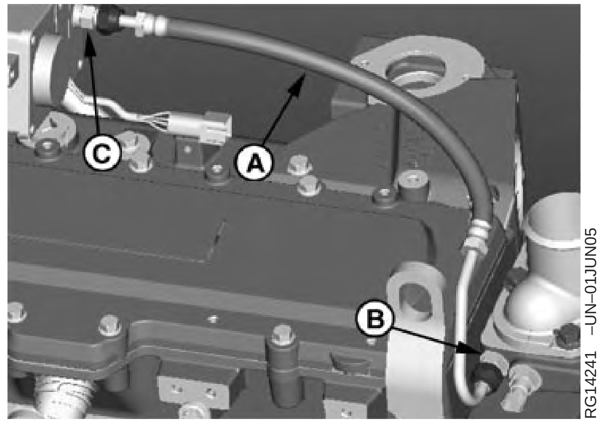
1. Assemble nut on coolant return line (A) finger tight to coolant return fitting in thermostat housing (B).

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) |

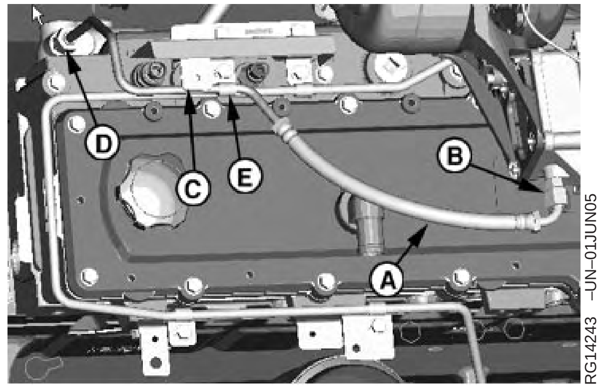



*Coolant Return Line*

**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




*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**

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.

**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.

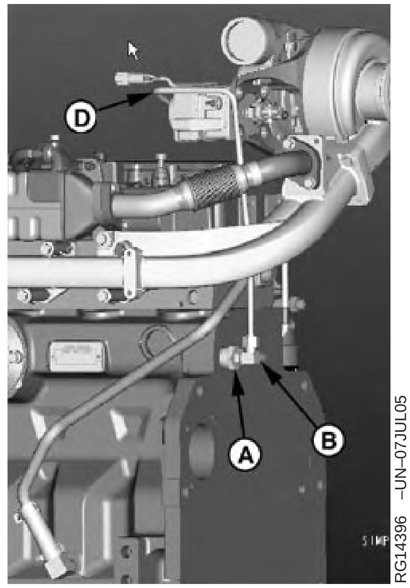
3. Install elbow fitting finger tight into front facing turbocharger actuator port (C). Reverse until oriented approximately 20° upward from horizontal (as shown), facing left side of engine.

4. Install coolant supply line (D) to actuator and cylinder block fittings and tighten to specification.

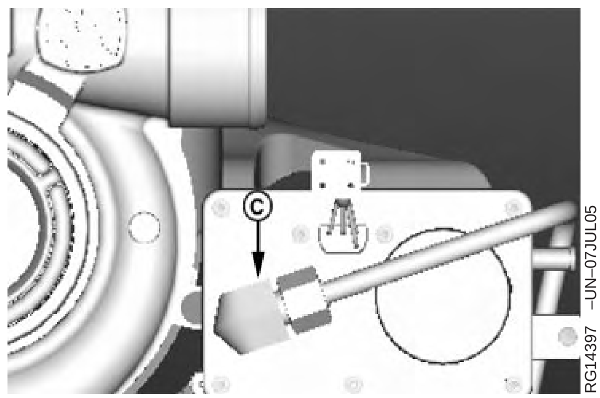
**Specification**

| | |
|---|---|
| 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**




*Coolant Supply Line*




*Actuator Coolant Line Fitting*

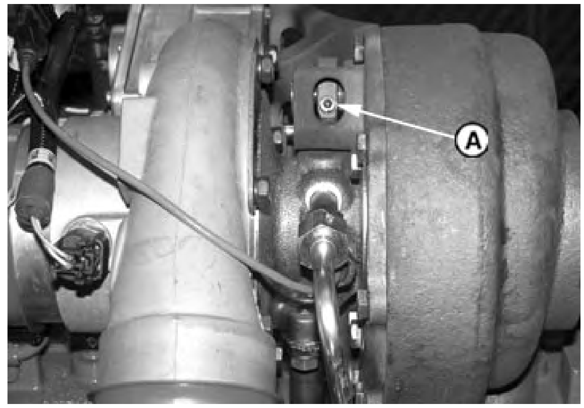
RE38635,0000028 –19–08JUL05–1/1

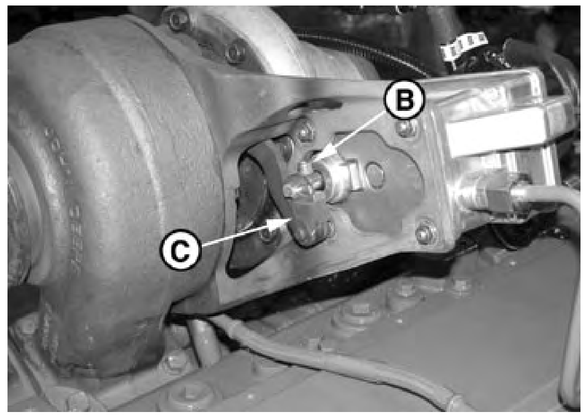
## Remove and Install Actuator Linkage

### 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.**




*Actuator Linkage Screw - Outboard Position*

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**

**Continued on next page** RE38635,0000012 –19–23MAY05–1/4

### Install Turbocharger Actuator Linkage

**IMPORTANT: BE CERTAIN actuator wiring harness is disconnected before completing any repairs on linkage.**

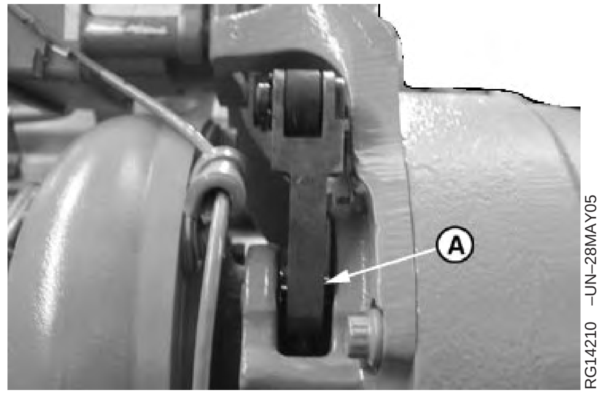
1. Insert linkage onto turbocharger pivot shaft flats (A).

*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.*

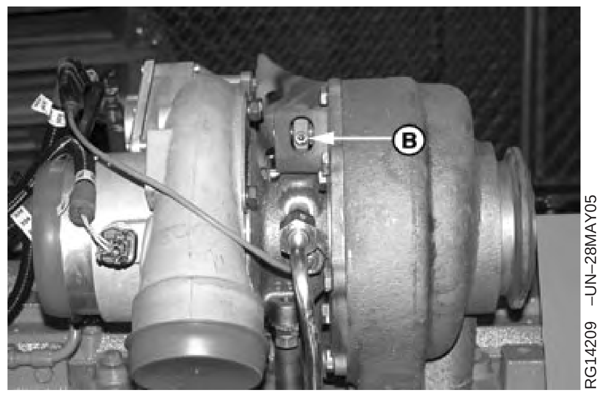
2. Install linkage (C) onto actuator shaft notch (D) and install M5 bolt through linkage and shaft finger tight (E).

3. Position linkage to notch on turbocharger shaft (B) and assemble linkage over shaft. Install M5 bolt to secure finger tight.

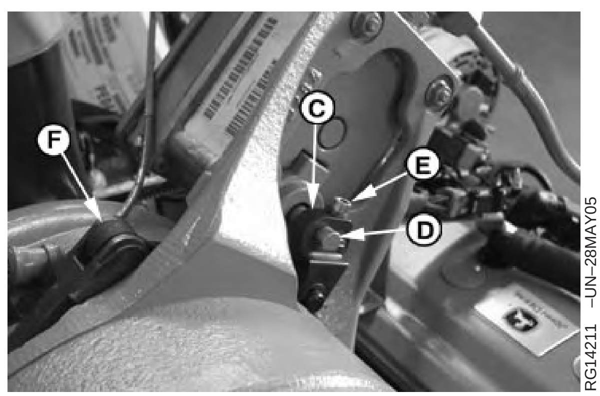
**A—VGT Link - Turbocharger Shaft**
**B—M5 Bolt - Turbocharger Shaft**
**C—VGT Link - Actuator Shaft**
**D—Actuator Pivot Shaft**
**E—M5 Bolt - Actuator Shaft**
**F—Center Pivot Joint**




*Install Link to Turbocharger Shaft*




*M5 Bolt - Turbocharger Shaft*




*Install Link - Actuator Shaft*

**Continued on next page** 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*

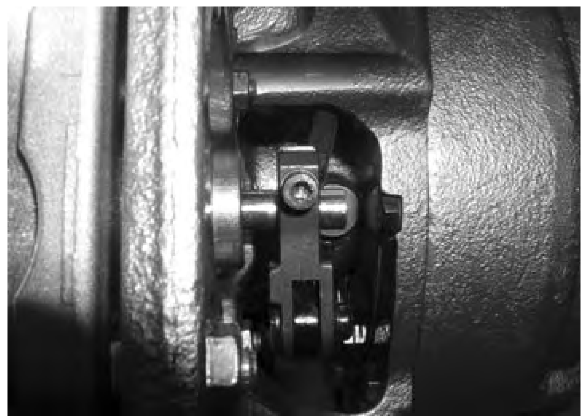
Continued on next page RE38635,0000012 –19–23MAY05–3/4

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.**


RG14218 –UN–28MAY05

*Check for Linkage Free Travel*


RG14474 –UN–12SEP05

*Proper Linkage Adjustment*

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.

9. Conduct a diagnostic check of the harness and actuator. Reference CTM385 for specific procedures.

RE38635,0000012 –19–23MAY05–4/4

## 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.

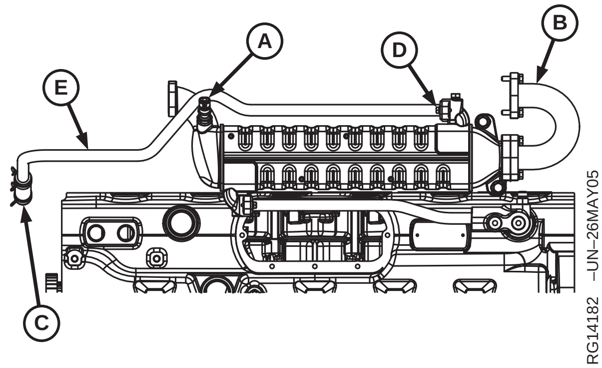
6. Loosen and remove cap screw (F) securing EGR cooler supply line to cooler.

7. Rotate and orient supply line and remove the coolant supply line from coolant manifold (G).

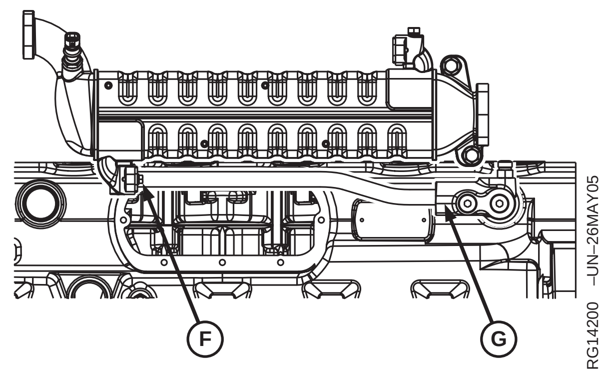
8. Loosen 2 shoulder bolts with spring washers (I).

9. Remove cap screws from cooler to intake manifold joint (H) and shoulder bolts (I). Carefully remove EGR cooler assembly.

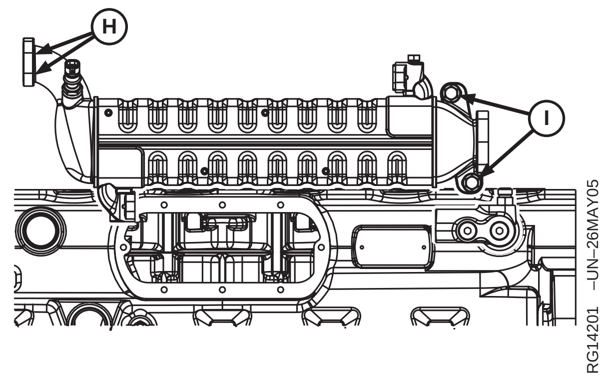
**A—EGR Exhaust Gas Temperature Sensor**
**B—EGR Tube**
**C—EGR Coolant Return Line to Coolant Pump**
**D—Coolant Return Line to Cooler**
**E—EGR Coolant Return Line**
**F—EGR Coolant Supply Line to Cooler**
**G—Coolant Supply Line to Coolant Manifold**
**H—EGR Cooler to Intake Manifold**
**I—Cooler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




*EGR Assembly*




*EGR Coolant Supply Line*




*EGR Cooler Assembly*

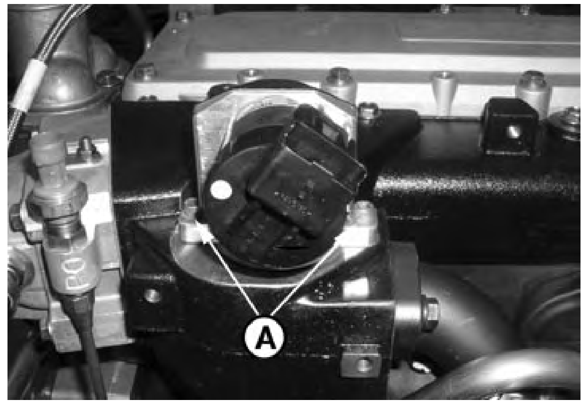
RE38635,0000119 –19–17APR06–1/1

## Remove & Install EGR Valve

### Remove EGR Valve

1. Loosen and remove 2 allen head cap screws (A) securing EGR valve to intake manifold.

2. Remove EGR valve and gasket from intake manifold.



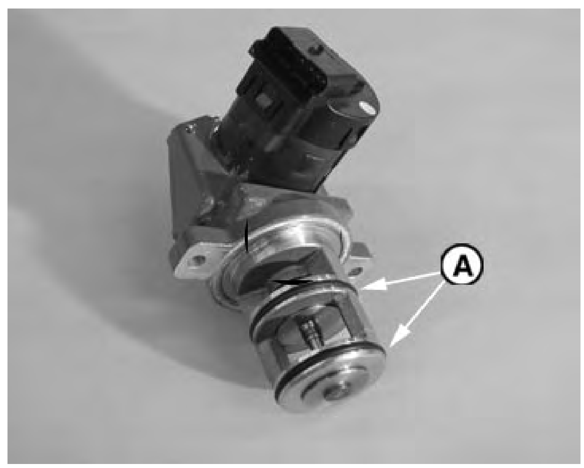

RG13947 –UN–28MAY05

*EGR Valve*

RE38635,0000052 –19–25APR06–1/2

### Install EGR Valve

**IMPORTANT: After installation of an EGR Valve, a re-calibration step must be performed using Service Advisor. If installing a NEW Valve, see EXHAUST GAS RECIRCULATION VALVE RE-CALIBRATION under the INTERACTIVE TEST TAB. If replacing an existing (old) valve, see HARNESS DIAGNOSTIC MODE TEST, also under the INTERACTIVE TEST TAB.**




RG13948 –UN–28MAY05

*EGR Valve O-Rings*

1. Lubricate EGR valve o-rings (A) with clean engine oil and assemble to EGV valve.

*NOTE: Install EGR valve with electrical connector towards outside of engine.*

2. Install EGR valve and new gasket to intake manifold.

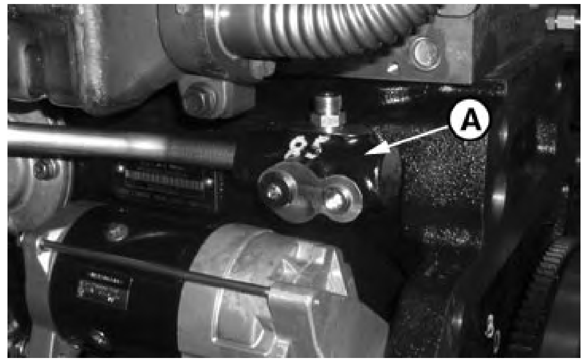
3. Alternate tightening both mounting screws to evenly seat valve. Tighten to specification.

**Specification**

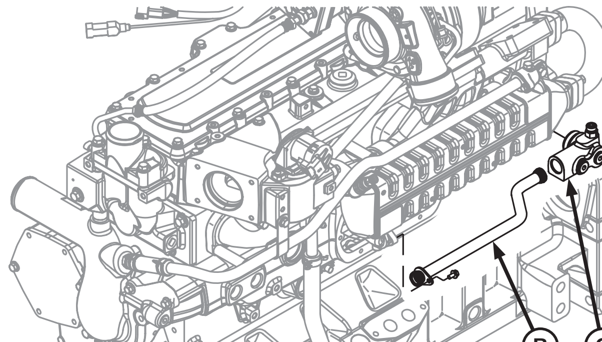
EGR Valve to Intake Manifold—
Torque ............................................................................... 11 N•m (8 lb-ft)

RE38635,0000052 –19–25APR06–2/2

## Remove and Install EGR Coolant Manifold




*EGR Coolant Manifold*




*EGR Cooler Supply Line and 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.

**A—Coolant Manifold**
**B—EGR Cooler Supply Line**

*LOCTITE is a trademark of Loctite Corp.*

RE38635,0000053 –19–05FEB05–1/1

## 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

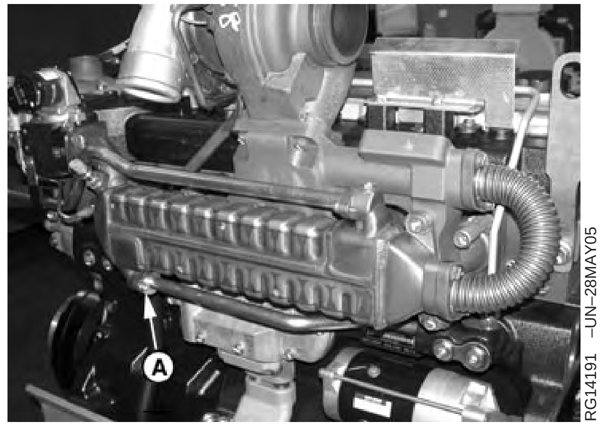
*NOTE: DO NOT use lubricant to aid assembly of the coolant supply line.*

1. Assemble short end of coolant supply line (B) into coolant manifold (C) until it bottoms out on manifold counterbore.

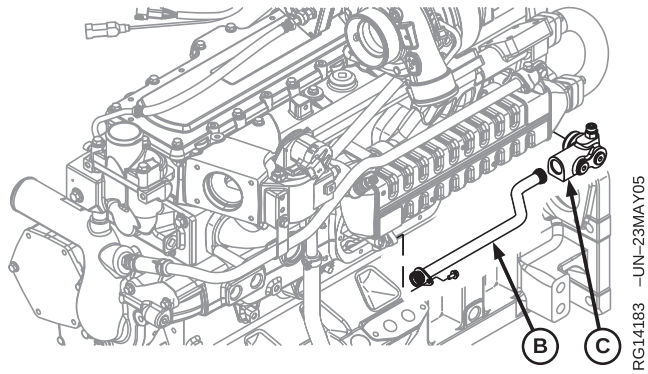
2. Slide and orient EGR coolant supply line to cooler and install cap screw (A) to specification.

**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

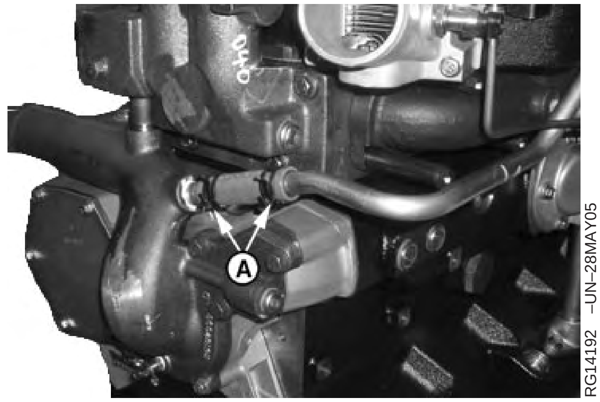
## Remove and Install EGR Cooler Return Line

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.

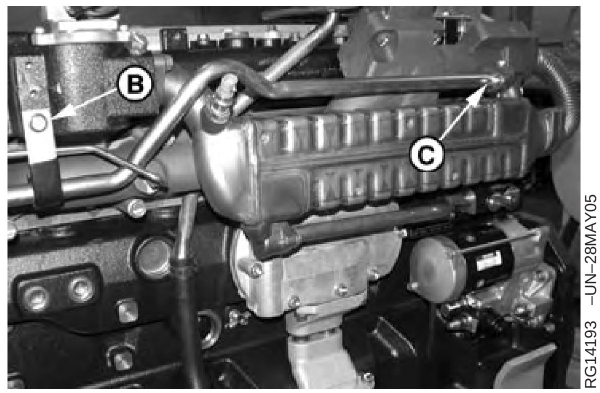
**Specification**

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.

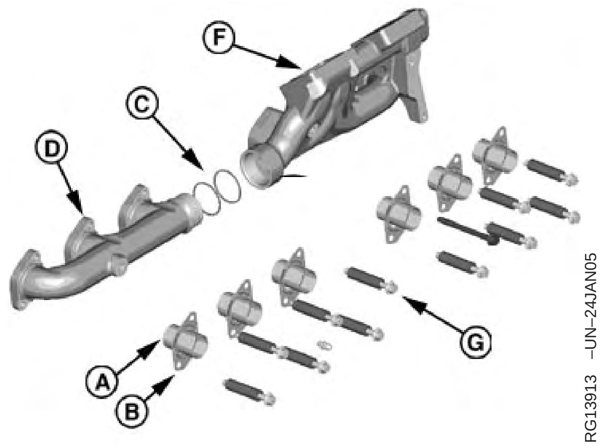
### Install Exhaust Manifold

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

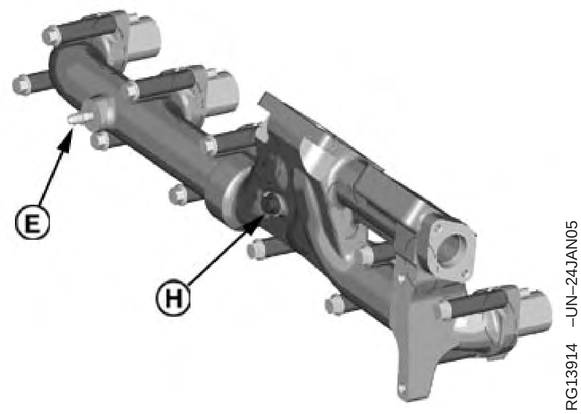
*NOTE: Guide pins and port liners will keep gaskets from rotating during assembly.*

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.




*Exhaust Manifold Assembly Components*




*Exhaust Manifold Assembly*

**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**

**Continued on next page** RE38635,000004C –19–24JAN05–1/3

*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.

*NEVER-SEEZ is a registered trademark of Emhart Chemical Group*

Continued on next page

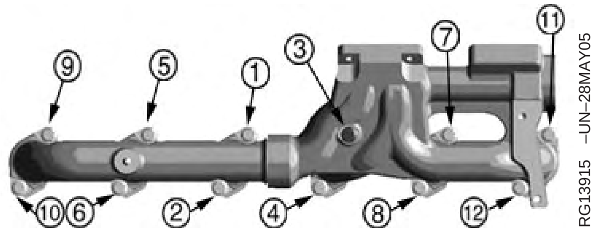
RE38635,000004C –19–24JAN05–2/3

*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)




*Exhaust Manifold Torque Sequence*

RE38635,000004C –19–24JAN05–3/3

## Remove, Inspect, and Install Intake Manifold

### Remove and Inspect Intake Manifold

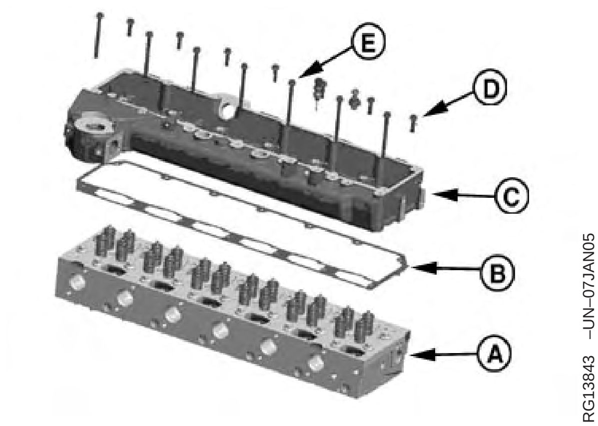
1. Remove turbocharger. See REMOVE TURBOCHARGER earlier in this group.

2. Remove EGR assembly. See REMOVE EGR earlier in this group.

3. Remove air intake connections from intake manifold (A) as detailed in machine Technical Manual.

4. Remove air heater from manifold, if equipped.

5. Remove rocker arm cover and gasket.




*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**

**Continued on next page** RE38635,000004D –19–24JAN05–1/4

*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).

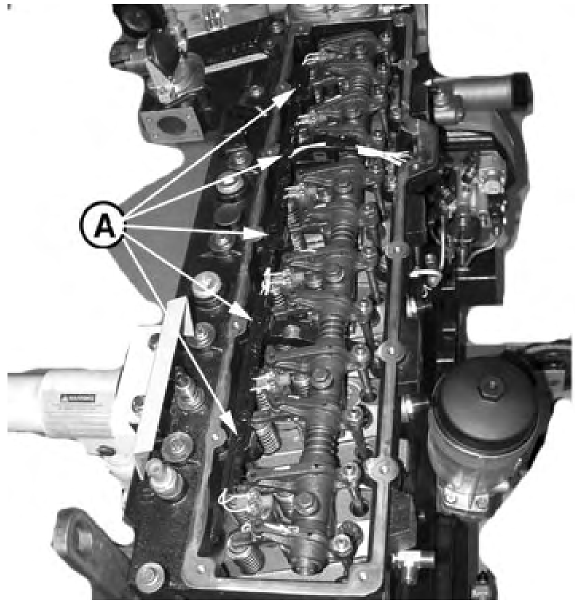
8. Loosen and remove 7 short flange head cap screws on right side of manifold, and 7 long flange head cap screws with sealing washers on left side of manifold.

9. Carefully lift intake manifold from cylinder head.

10. Remove and discard intake manifold gasket.

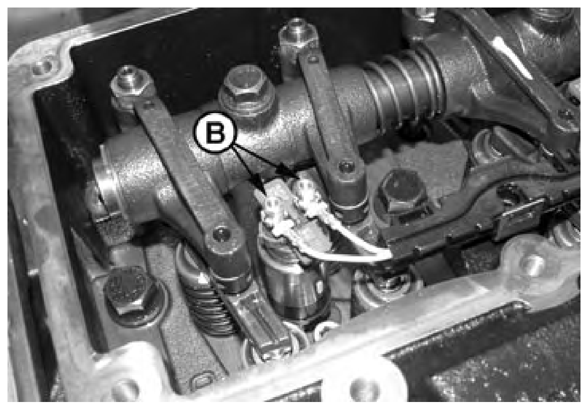
11. Inspect the machined mating surfaces of cylinder head and intake manifold. Clean, as required, by using a scraper and/or wire brush, and compressed air.

**A—Wiring Harness Carrier Screw Locations**
**B—Wiring Harness Leads to Injectors**




RG13916 –UN–19MAR05

*Wiring Harness Carrier*




RG13917 –UN–19MAR05

*Wiring Harness Leads to Injectors*

**Continued on next page** RE38635,000004D –19–24JAN05–2/4

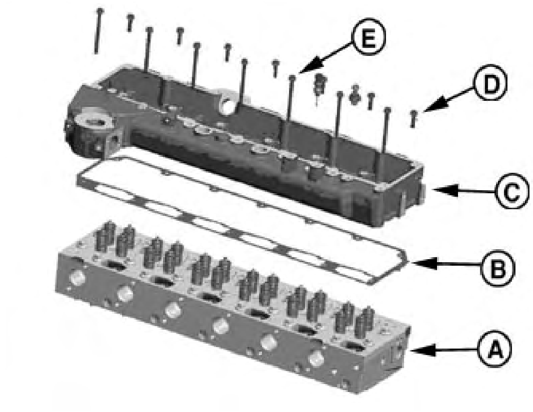
## Install Intake Manifold

**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).
7. Install 7 long flange head cap screws with lubricated washers in left side of intake manifold to cylinder head.

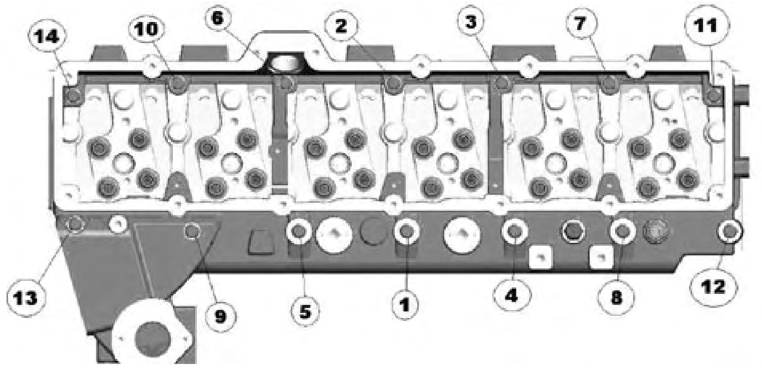



RG13843 –UN–07JAN05

*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**

**Continued on next page** RE38635,000004D –19–24JAN05–3/4




*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)

9. Install exhaust manifold assembly and turbocharger as detailed earlier in this group.

10. Connect all air intake and exhaust piping. (For vehicle engines, refer to machine Technical Manual.)

RE38635,000004D –19–24JAN05–4/4

## Install EGR

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**

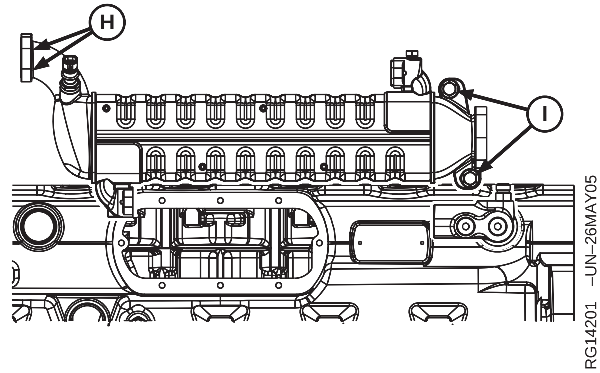
P Clamp Cap Screw—Torque ........................................ 30 N•m (22 lb-ft)

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

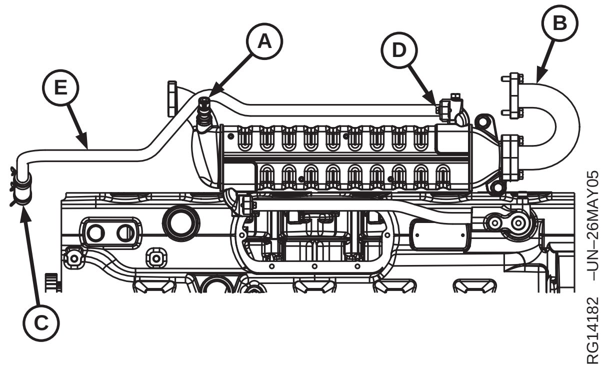
**Specification**

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

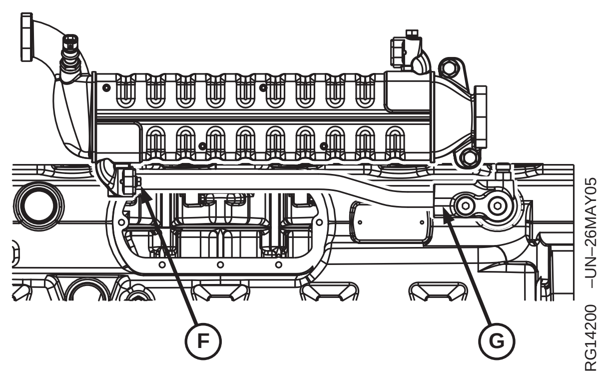
10. Install EGR coolant supply line (short end) into coolant manifold (G).




*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**

**Continued on next page**

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

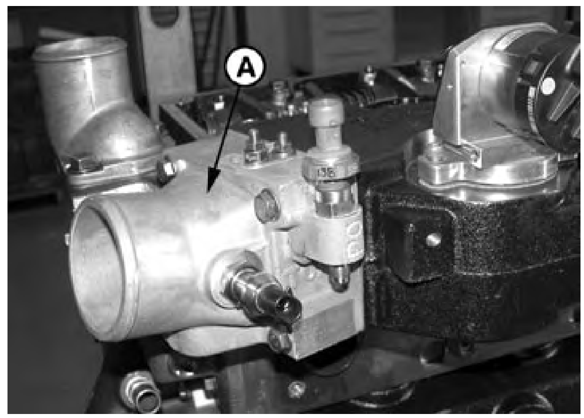
**Specification**

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



RE38635,0000054 –19–05FEB05–2/2

## Remove and Install Air Inlet/Heater



*Air Inlet with 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)

RE38635,000004E –19–25JAN05–1/1

## 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.

### 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.

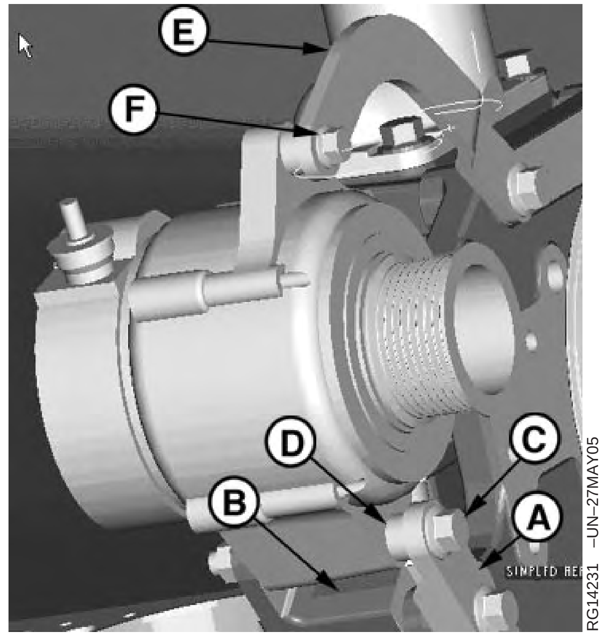
3. Adjust alternator to alternator strap (E). Install cap screw (F) through alternator strap, spacer, and into alternator ear. Tighten cap screw finger tight.

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.




*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**

## 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 2 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.*

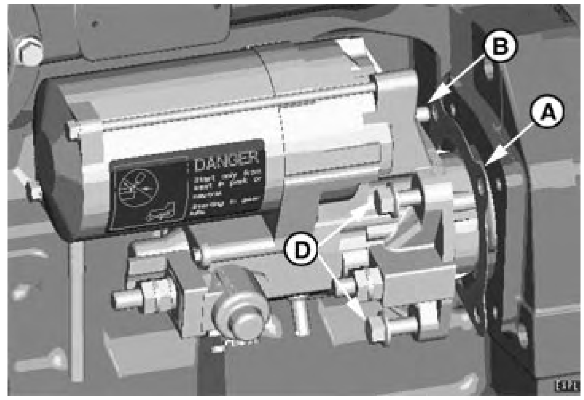
3. Coat threads of 2 starting motor cap screws (D) with DT5037 thread sealant.

4. Start 2 cap screws through starter into cylinder block. Tighten to specification.

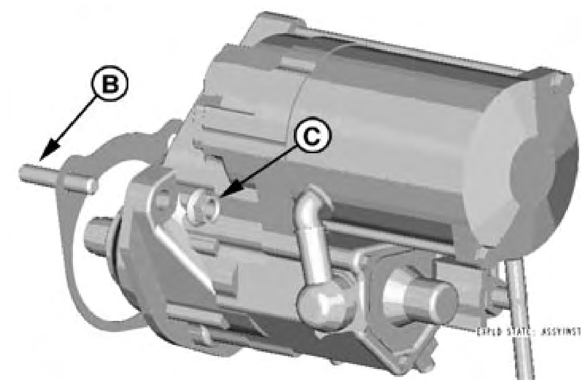
**Specification**

| | |
|---|---|
| Starter Motor Mounting Hardware—Torque | 47.5 N•m (35 lb-ft) |

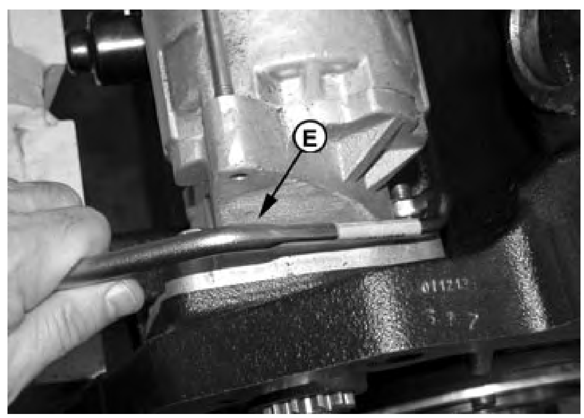
5. Use JDG2046 Special Wrench (E) to tighten flange nut (C) on inside of starter.




*Starter Assembly*




*Starter Stud & Flange Nut*




*Special Wrench*

**A—Starter Gasket**
**B—Starter Stud**
**C—Flange Nut - Starter Stud**
**D—Starter Mounting Cap Screws**
**E—JDG2046 Special 15 mm Wrench**

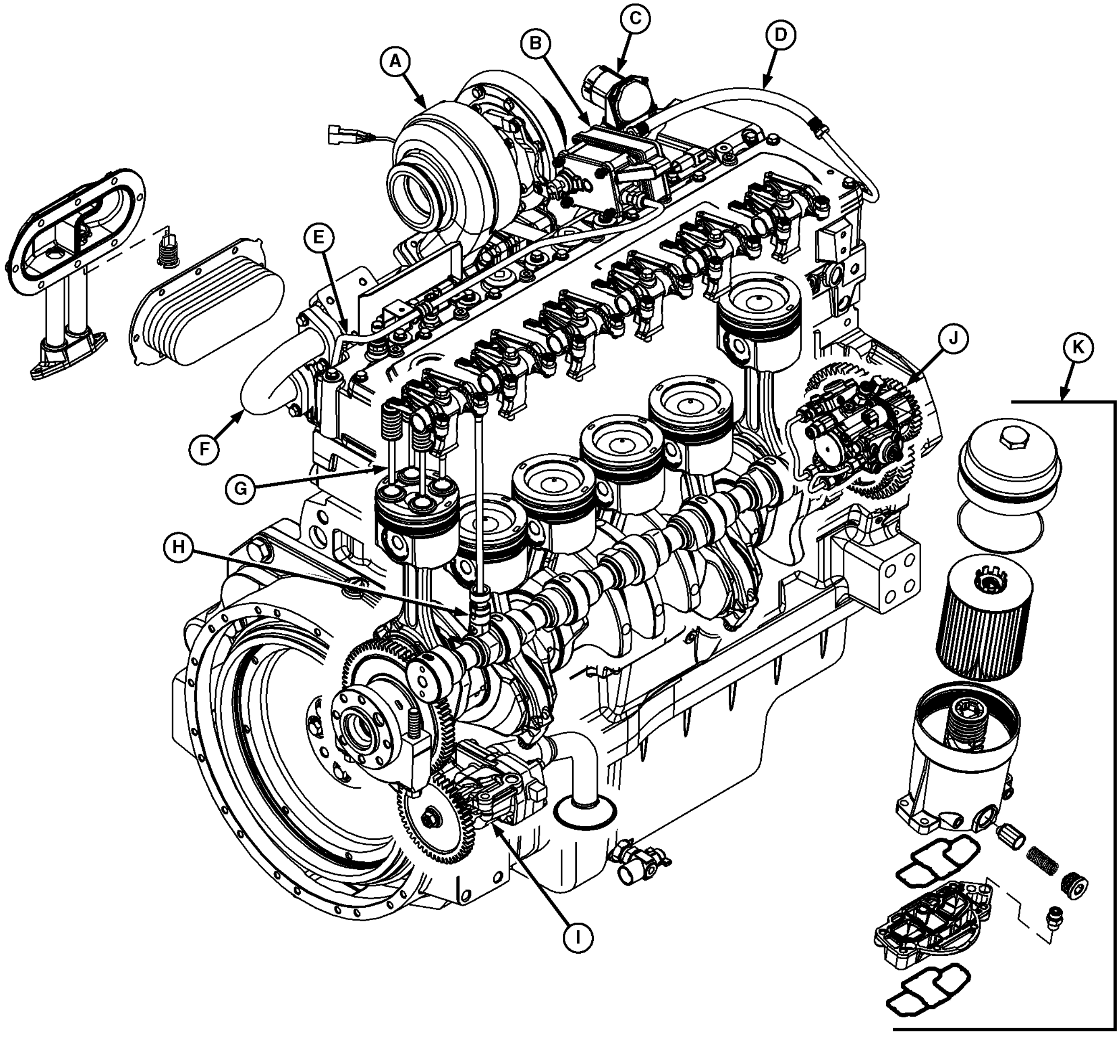
RE38635,0000089 –19–19MAR05–1/1

# Section 03
# Theory of Operation

## Contents

03

## 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.

Continued on next page

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.

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.

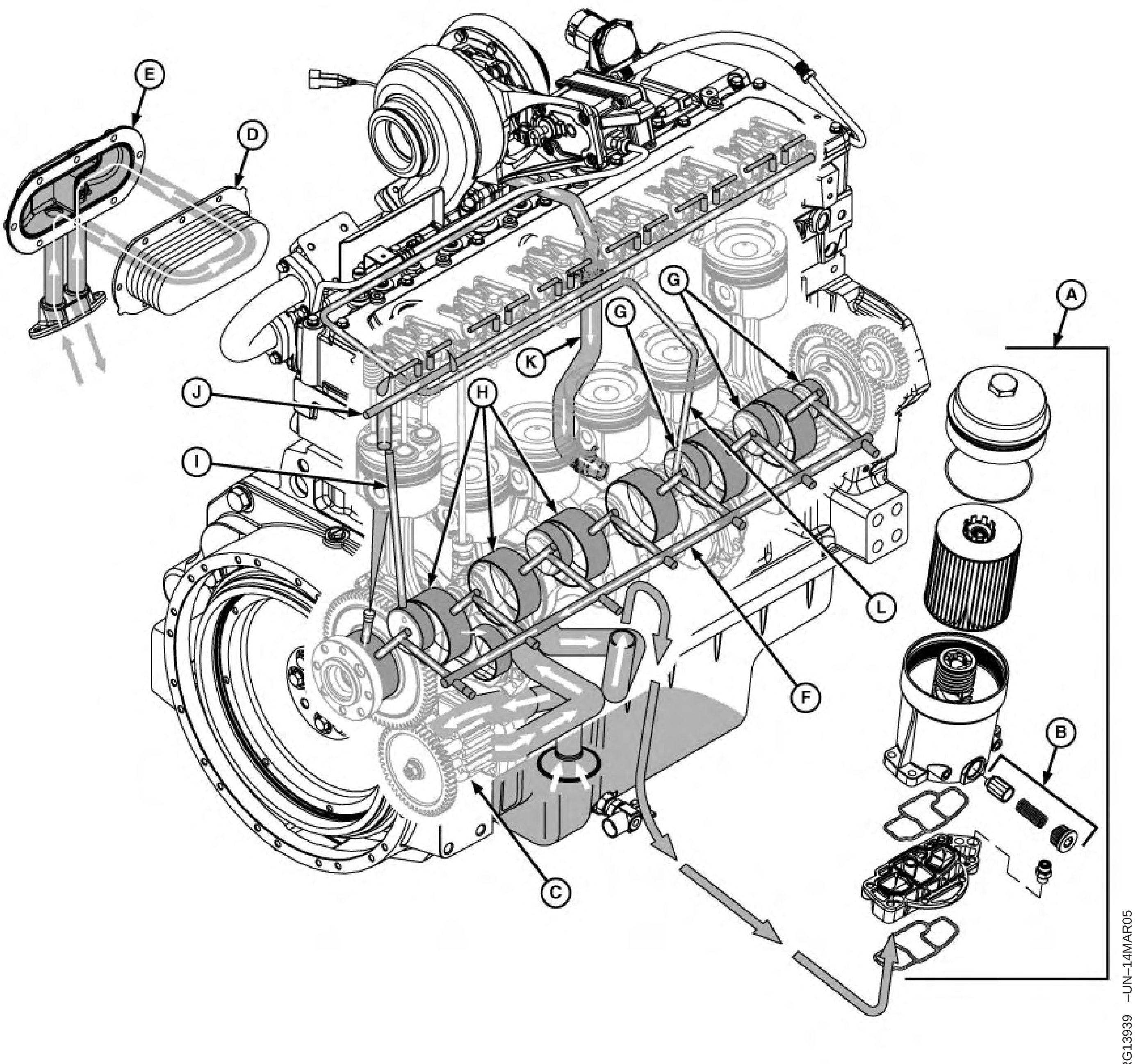
The engine is supplied with lubricating oil by a spur gear pump driven off the rear of the crankshaft. Oil is conditioned by a top load full-flow filter located on the right side of the engine. Oil temperature is limited by an oil cooler located on left side of engine. Individual oil cooler and oil filter 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.



RE38635,000002F –19–22DEC04–2/2

## Lubrication System Operation






*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**

Continued on next page

RE38635,000006B –19–21FEB05–1/3

**Lubrication System Serial Number**

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 (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.

**Continued on next page** RE38635,000006B –19–21FEB05–2/3

### 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.

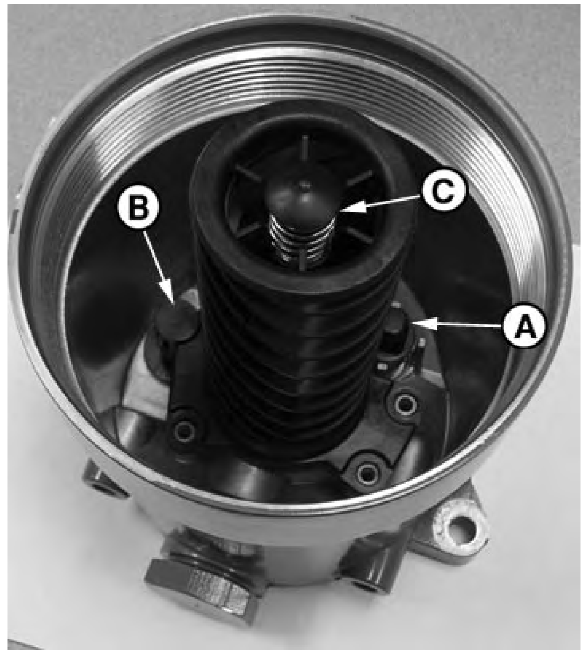


When the filter element is in place and the system thus "closed", the pressure of the filter element keeps the return to sump valve (A) pressed downward, and thus closed. This prevents pressurized oil from being dumped back to sump prior to being filtered. If this valve is missing or not closed, low 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.

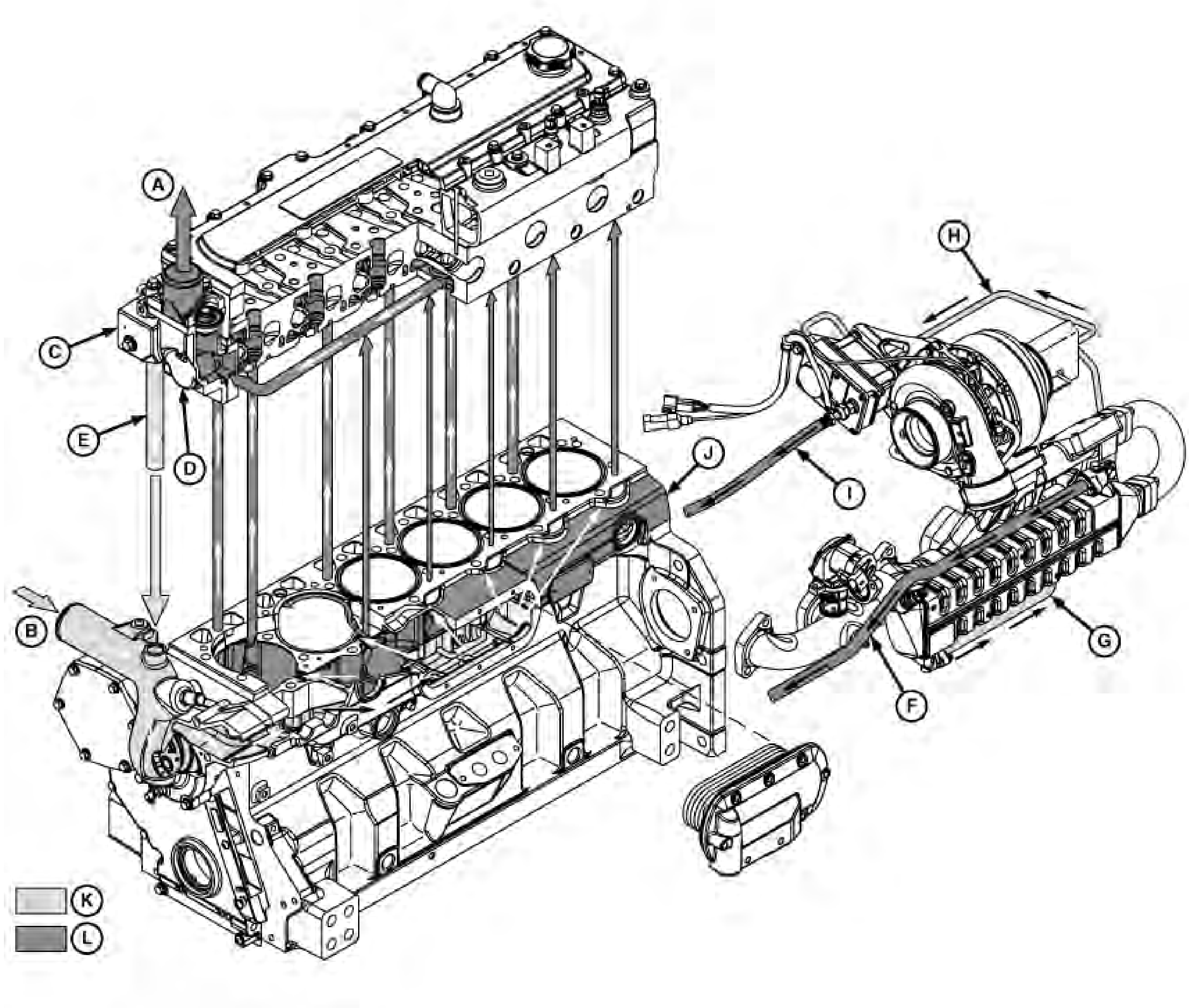



*Top Load Oil Filter Valves*

**A—Drain Valve**
**B—Inlet Valve**
**C—Bypass Valve**

RE38635,000006B –19–21FEB05–3/3

## 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.

**Continued on next page**

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.

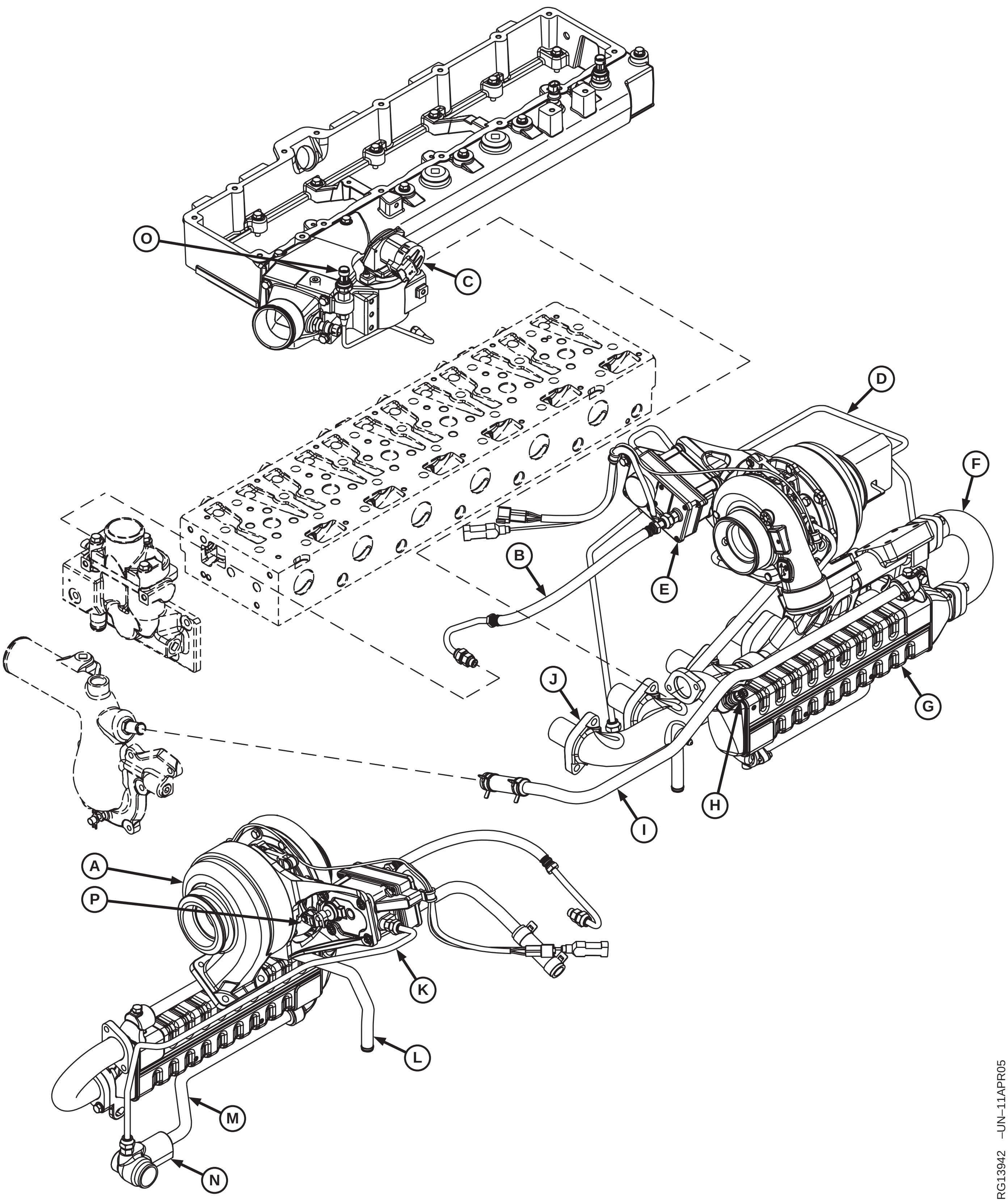
At the left rear (as looking from flywheel) of the cylinder block, mounted to the main cylinder block coolant passage, is an external coolant manifold. Coolant flows from the external manifold to the exhaust gas recirculator (EGR) cooler, and to the variable geometry turbocharger (VGT) actuator through 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 –19–21FEB05–2/2

## Exhaust Gas Recirculator (EGR) and Variable Geometry Turbocharger (VGT)




Continued on next page RE38635,0000070 –19–25APR06–1/3

**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.

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120
11

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.

**Continued on next page** RE38635,0000070 –19–25APR06–2/3

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.

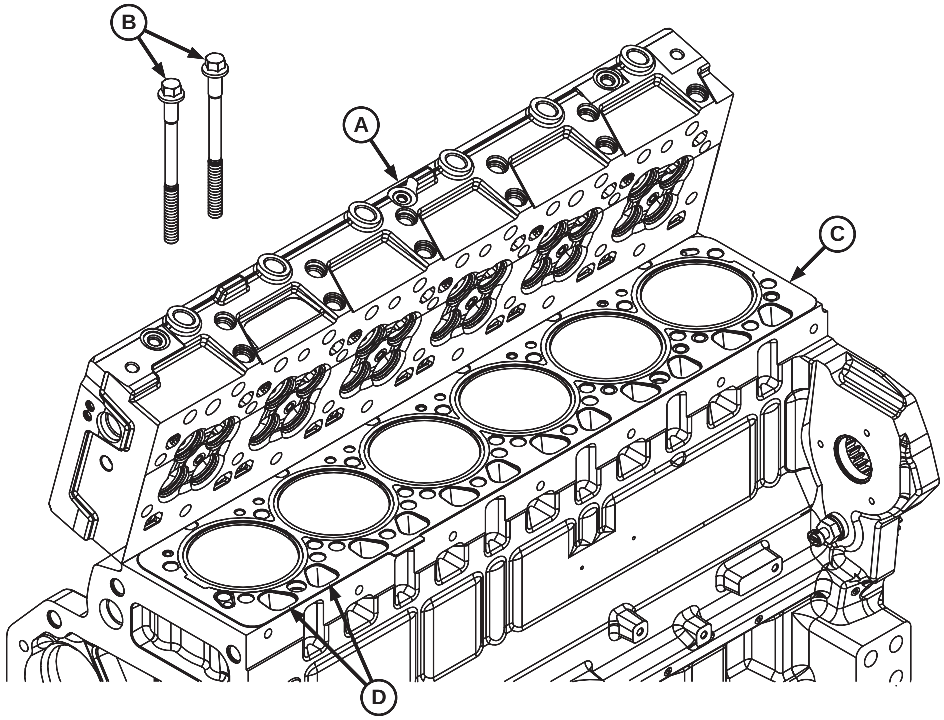


The EGR valve is functional only when the engine is under load and the coolant is at operating temperature. At startup, when engine coolant is cold, and under no-to-light load conditions, the valve remains closed, and exhaust gases exit out the stack. When engine load and/or speed demands reach a predetermined 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 –19–25APR06–3/3

## 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.

**Continued on next page**

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 –19–21FEB05–2/2

## 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 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.

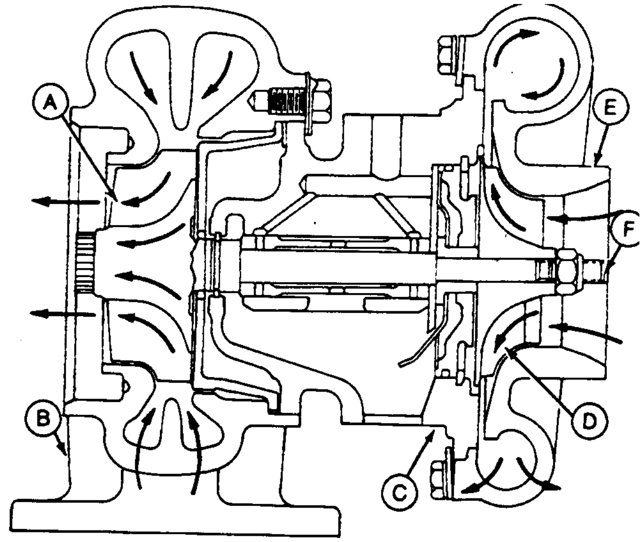
RE38635,000006E –19–21FEB05–1/1

## 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).

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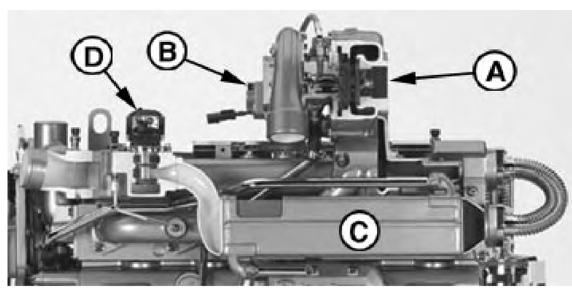
**A—Turbine Wheel**
**B—Turbine Housing**
**C—Center Housing**
**D—Compressor Wheel**
**E—Compressor Housing**
**F—Shaft**

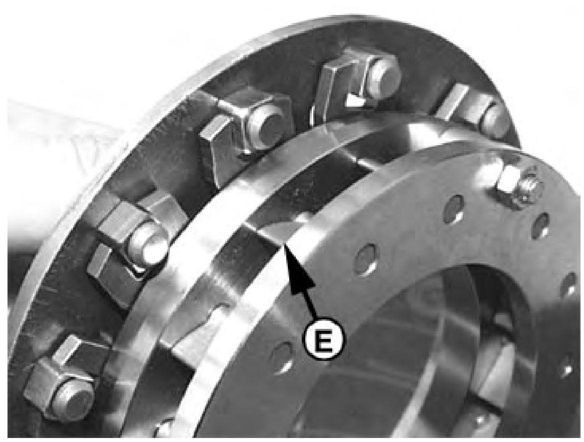
RE38635,000006F –19–21FEB05–1/2

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.




RG13766 —UN—28MAY05

*EGR & VGT*




RG13765 —UN—28MAY05

*VGT Adjustable Vanes*

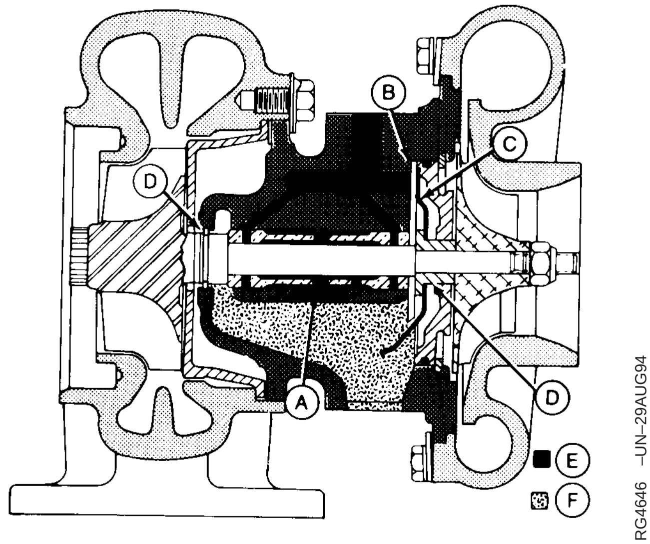
**A—Variable Geometry Turbocharger (VGT)**
**B—VGT Actuator**
**C—Exhaust Gas Recirculator (EGR) Cooler**
**D—EGR Valve**
**E—VGT Adjustable Vanes**

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.




**A—Bearing**
**B—Thrust Plate**
**C—Thrust Sleeve**
**D—Piston Ring**
**E—Pressure Oil**
**F—Discharge Oil**

RG,CTM61,G110,5 –19–16SEP94–1/1

# 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

## 9.0L - L1 - Excessive Oil Consumption

RE38635,000002B –19–17DEC04–1/1

### 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.

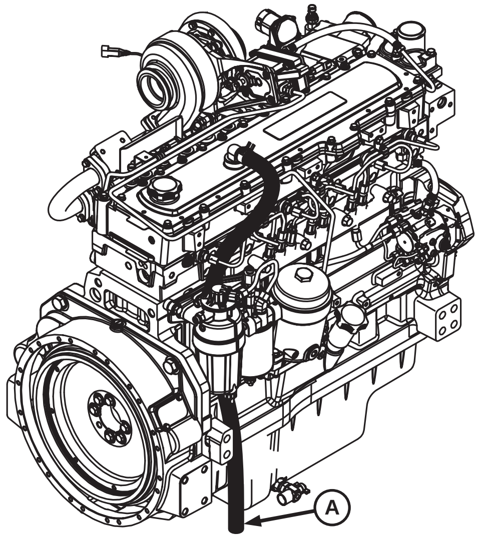
Check for excessive external oil leaks.



– – –1/1

| | | |
|---|---|---|
| ❶ **Oil In Coolant Check** | Check the coolant for signs of oil. | **No oil found in coolant:** GO TO ❷<br><br>**Oil found in coolant:** See C3 - COOLANT IN OIL OR OIL IN COOLANT later in this Group. |

– – –1/1

| | | |
|---|---|---|
| ❷ **Crankcase Breather Tube Check** |  RG14156 –UN–18APR05 *Crankcase Breather Tube* <br><br> 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 ❸ <br><br> **Restriction found in breather tube:** Remove restriction or replace breather tube and retest. <br><br> – – –1/1 |

| | | |
|---|---|---|
| ❸ **Excessive Crankcase Pressure Check** | Check for excessive crankcase pressure. See CHECK FOR EXCESSIVE ENGINE CRANKCASE PRESSURE (BLOW-BY) later in this Group. | **No fumes and no dripping oil observed:** GO TO ❹<br><br>**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.<br><br>**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 TEST ENGINE COMPRESSION PRESSURE later in this Group.<br><br>– – –1/1 |

| | | |
|---|---|---|
| ❹ **Turbocharger Oil Seal Leak Check** | Check for turbocharger oil seal leaks. See CHECK FOR TURBOCHARGER OIL SEAL LEAK later in this Group. | **NO signs of oil leakage:** GO TO ❺<br><br>**Signs of oil leakage present:** Investigate problems associated with oil leakage as outlined it the test procedure, perform necessary repairs, and retest.<br><br>– – –1/1 |

| | | |
|---|---|---|
| ❺ **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.<br><br>• Oil control rings worn or broken<br>• Scored cylinder liners or pistons<br>• Piston ring grooves excessively worn<br>• Piston rings sticking in ring grooves<br>• Insufficient piston ring tension<br>• Piston ring gaps not staggered<br>• Cylinder liners glazed (insufficient load during engine break-in)<br>• Worn valve guides or stems | **Problem found with pistons, rings, and/or liners or valve guides:** Repair problem as necessary.<br><br>– – –1/1 |

## 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.*

*Intake valves do not have valve stem seals, and some oil deposits on the valve stem tulip are normal.*

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.

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

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## 9.0L - L2 - Engine Oil Pressure Low

| Symptom | Problem | Solution |
|---|---|---|
| **9.0L - L2 - Engine Oil Pressure Low** | 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. |

Continued on next page

| 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. |



DPSG,RG40854,710 –19–16NOV04–2/2

## 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

## 9.0L - 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. See VISUALLY INSPECT COOLANT PUMP and REMOVE COOLANT PUMP ASSEMBLY in Section 02, Group 070 of this manual. |

RE38635,0000094 –19–29MAR05–1/1

## 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. SeeREMOVE FUEL INJECTION NOZZLES CTM385.

3. Install the JTG2047 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.

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. See INSTALL CYLINDER LINER IN BLOCK and INSTALL PISTON AND CONNECTING ROD 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. See in Section 02, Group 020 of this manualCHECK VALVE CLEARANCE.

9. Measure compression pressure in all remaining cylinders and compare readings. Recondition power cylinders and cylinder head as required.

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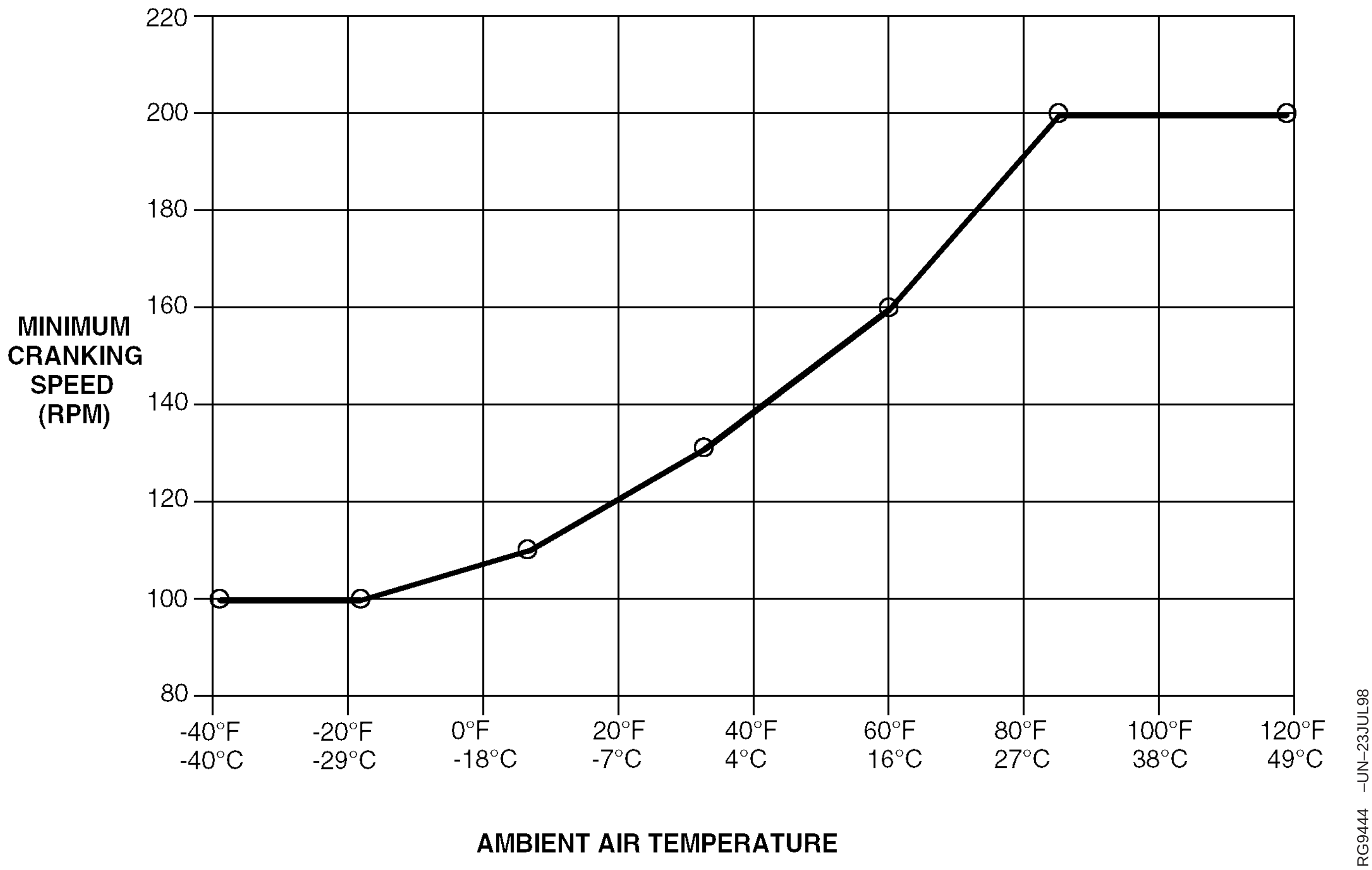
## Check Engine Cranking Speed




**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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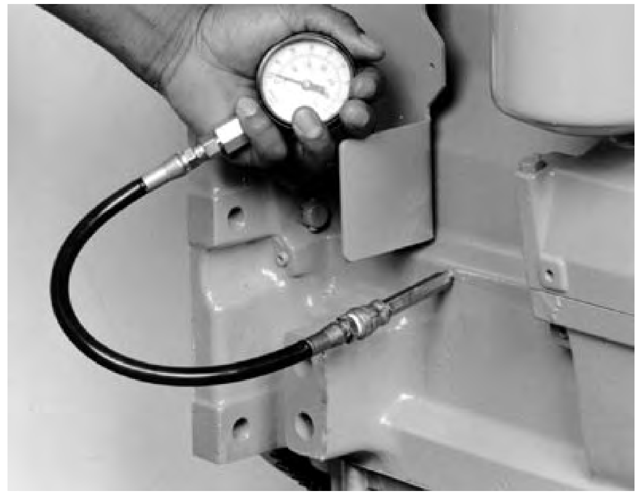
## Check Engine Oil Pressure



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) .......................... 170 kPa (1.70 bar) (25 psi)
Maximum Full Load at 2200 rpm (Tractors = 2100) Rated Speed ....................... 290 kPa (2.9 bar) (42 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 –19–07APR05–1/1

## 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.

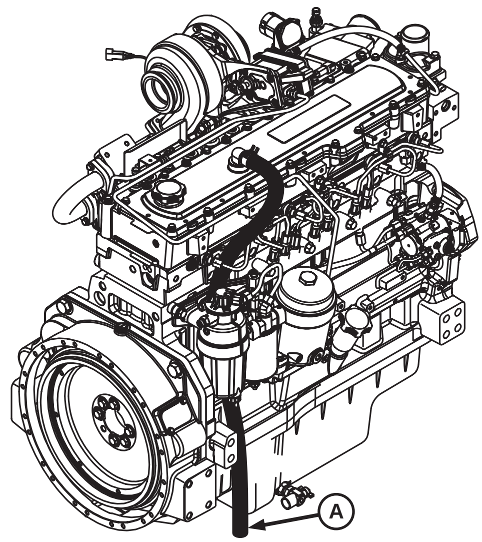
Run engine at high idle and check crankcase breather tube. Look for significant fumes and/or dripping oil coming out of the breather tube at fast idle, with no load.

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*

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.

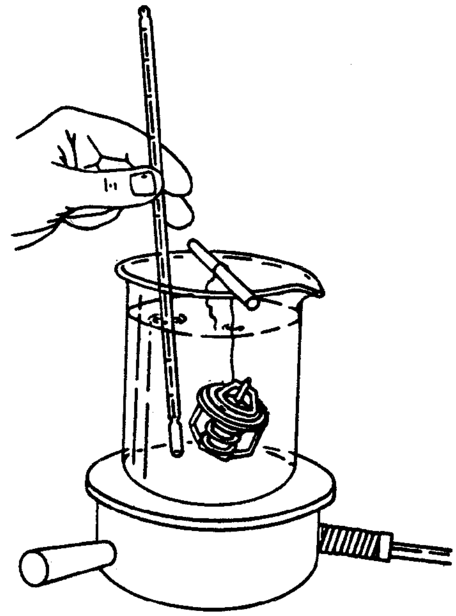
   If oil leakage is present, perform the following:

   - 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


RG5971 –UN–23NOV97

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**

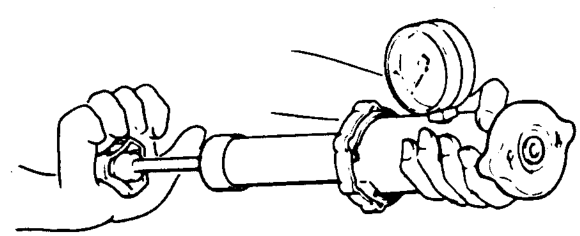
| Rating | Initial Opening (Range) | Full Open (Nominal) |
|---|---|---|
| 71°C (160°F) | 69—72°C (156—162°F) | 84°C (182°F) |
| 77°C (170°F) | 74—78°C (166—172°F) | 89°C (192°F) |
| 82°C (180°F) | 80—84°C (175—182°F) | 94°C (202°F) |
| 89°C (192°F) | 86—90°C (187—194°F) | 101°C (214°F) |
| 90°C (195°F) | 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) |

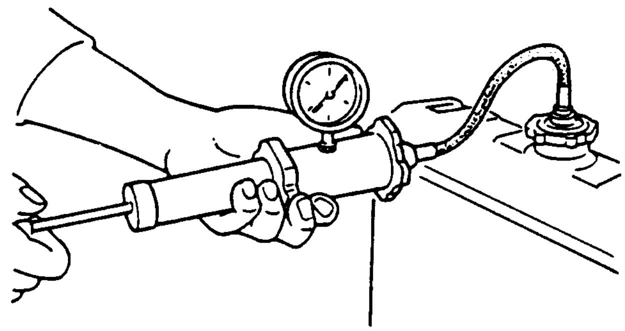
3. Remove thermostat and observe its closing action as it cools. In ambient air the thermostat should close completely. Closing action should be smooth and slow.

4. If any thermostat is defective on a multiple thermostat engine, replace all thermostats.

DPSG,RG40854,10 –19–25NOV98–1/1

## Pressure Test Cooling System and Radiator Cap


RG6557 –UN–20JAN93


RG6558 –UN–20JAN93

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

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

**Test Radiator Cap 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].

*[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.*

Continued on next page
DPSG,RG40854,11 –19–25NOV98–1/2

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.

DPSG,RG40854,11 –19–25NOV98–2/2

## 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

## Check for Head Gasket Failures

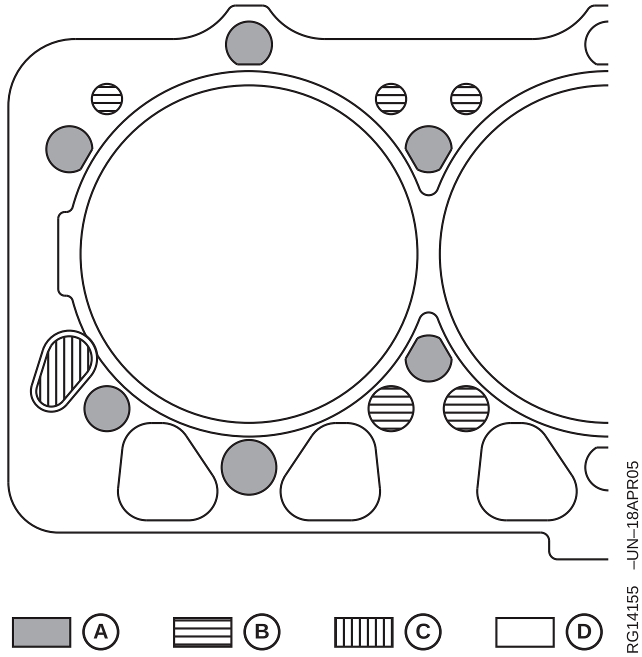
Head gasket failures generally fall into three categories:

- 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.



*9 L Head Gasket*

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

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.

Continued on next page

RE38635,00000BA –19–18APR05–1/4

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.

**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 HEAD GASKET INSPECTION AND REPAIR SEQUENCE in Section 02, Group 020 of this manual.

Continued on next page

RE38635,00000BA –19–18APR05–2/4

## COOLANT SEAL LEAKAGE

**Symptoms:**

- Coolant discharge from head gasket crevice.
- Coolant in crankcase oil.
- 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 HEAD GASKET INSPECTION AND REPAIR SEQUENCE 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.

Continued on next page

RE38635,00000BA –19–18APR05–3/4

If above symptoms are found, see HEAD GASKET INSPECTION AND REPAIR SEQUENCE in Section 02, Group 020 of this manual.

*NOTE: Defective oil cooler may also allow oil leakage into coolant.*

RE38635,00000BA –19–18APR05–4/4

## 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.

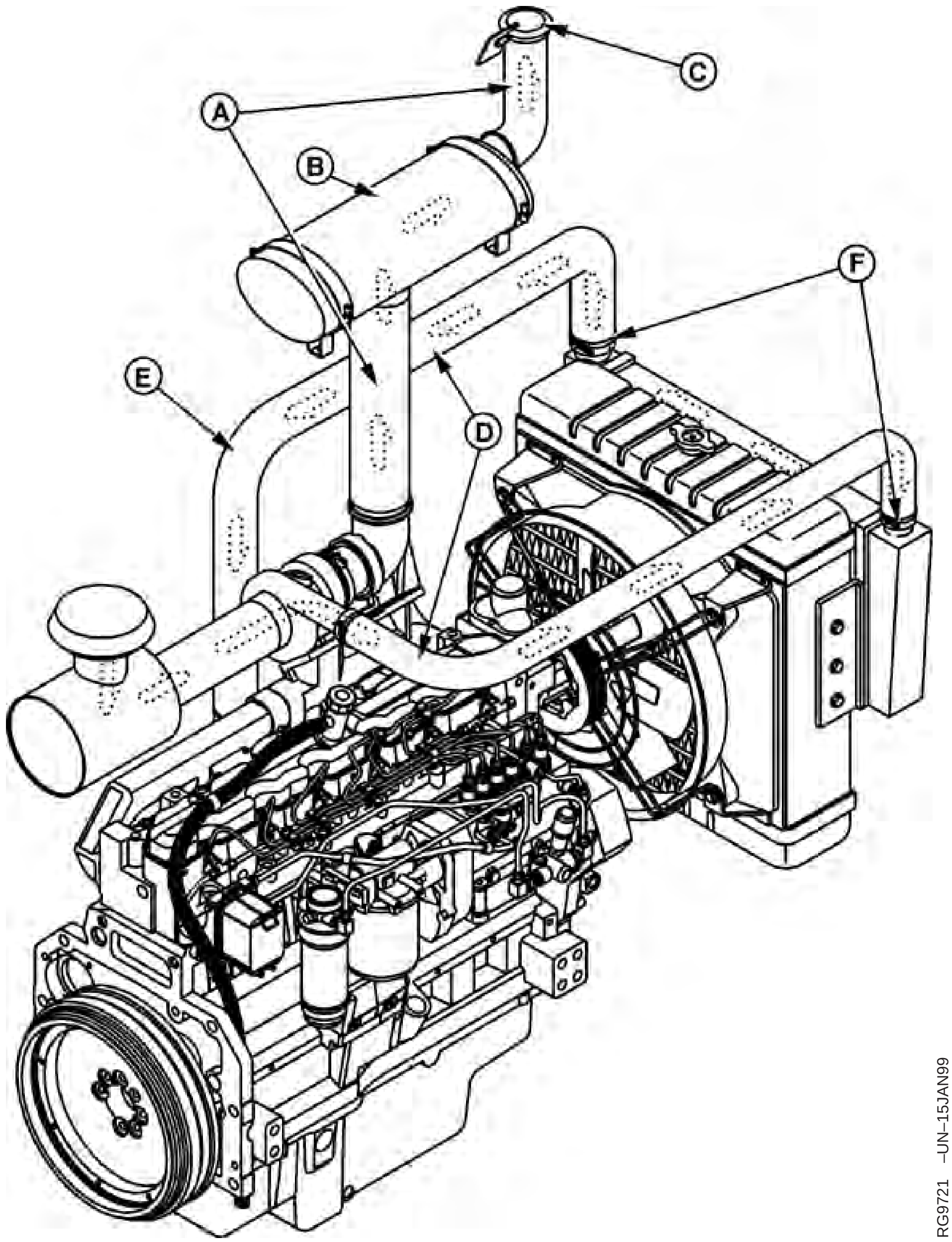
The engine has a Manifold Air Pressure Sensor that provides values to the ECU. Diagnostic procedures with Service Advisor can provide an accurate measurement of how well the engine is performing.

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 –19–25NOV98–1/1

## Test for Intake Air Leaks

T5906AP –UN–23FEB89

Loose connections or cracks in the suction side of the air intake pipe can allow debris to be ingested into the engine causing rapid wear in the cylinders. Additionally, on turbocharged engines, compressor damage may occur and cause an imbalance resulting in bearing failure. Air leaking from loose connections or cracks on the pressure side of the turbocharger can cause excessive smoke and low power.

*NOTE: The following test procedure requires that the air intake be sealed off to pressurize the system. Using a plastic bag to seal the air intake filter is used as an example.*



**CAUTION: Do not start engine during this test procedure. Plastic bag (or whatever material/object used to seal intake) can be sucked into the engine.**

1. Remove air cleaner cover and main filter element.

2. Put a plastic bag over secondary filter element and install main element cover.

3. Remove plug (A) from manifold and using a suitable adapter, connect a regulated air source.

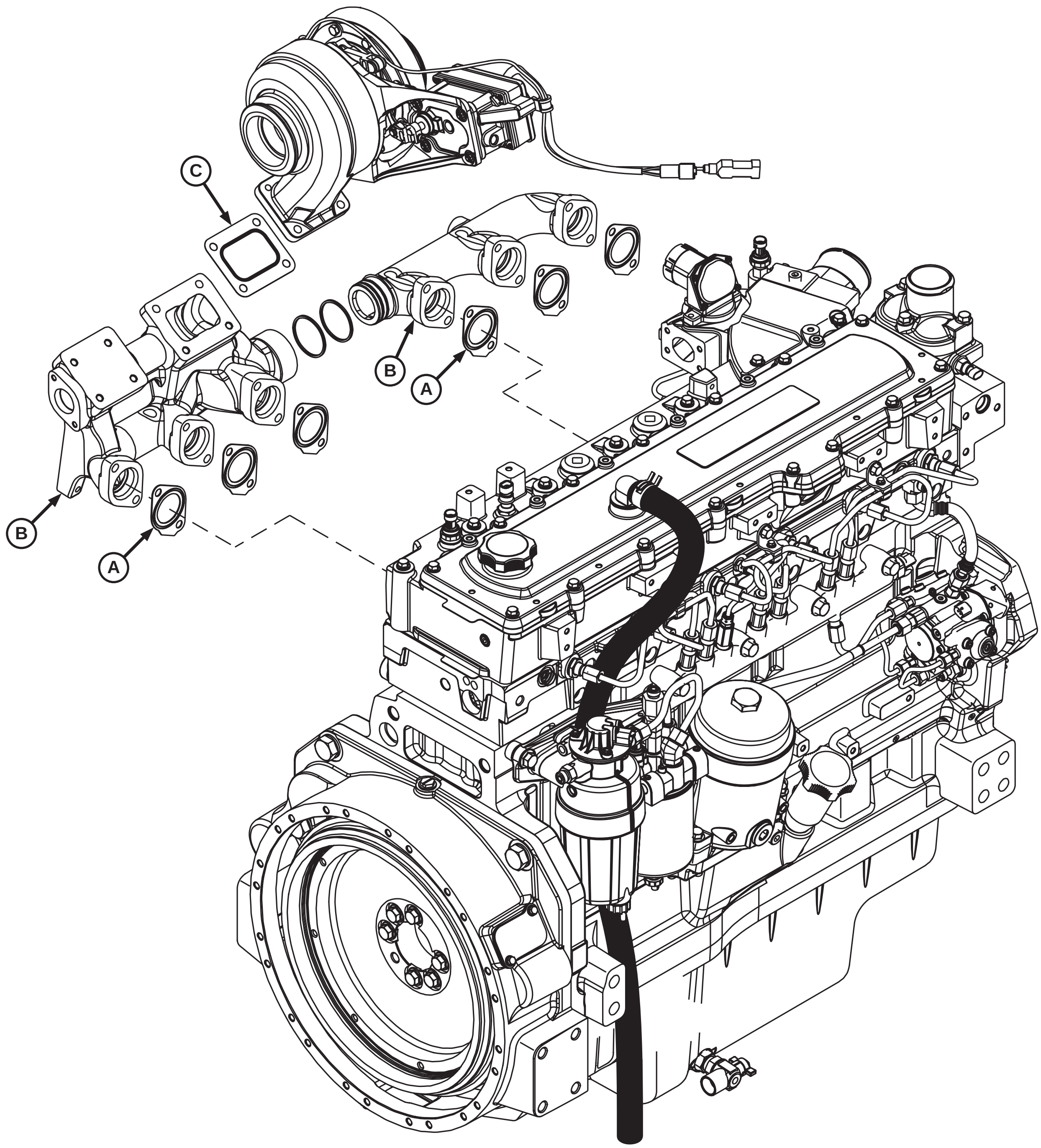
4. Pressurize air intake system to 13.8-20.7 kPa (0.13-0.21 bar) (2-3 psi).

5. Spray soap and water solution over all connections from the air cleaner to the turbocharger or air inlet to check for leaks. Repair all leaks.

6. Remove plastic bag from filter element and reinstall element and cover.

DPSG,RG40854,15 –19–25NOV98–1/1

## Check for Exhaust Air Leaks




RG14157 –UN–18APR05

*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



05

## 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).*

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RE38635,000001D –19–01JUN05–1/11

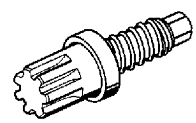
RG5068 –UN–05DEC97

Flywheel Turning Tool . . . . . . . . . . . . . . . . . . JDG820

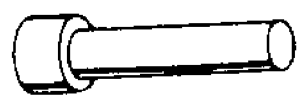
Used to rotate engine to check damper radial runout and time engine. JDE81-1 may be used also if JDG820 is not available.

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.



*JDG820*



RG5068

*JDE81-4*

RE38635,000001D –19–01JUN05–2/11

RG6246 –UN–05DEC97

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

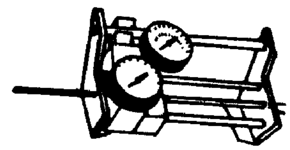
*D17526CI or D17527CI*

**Continued on next page** RE38635,000001D –19–01JUN05–3/11

RG5061 –UN–05DEC97

Spring Compression Tester . . . . . . . . . . . . . D01168AA

Test valve spring compression.



RG5061

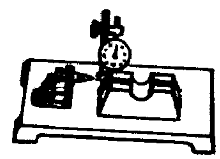
*D01168AA*

RE38635,000001D –19–01JUN05–4/11

RG5062 –UN–05DEC97

Valve Inspection Center . . . . . . . . . . . . . . . D05058ST

Check valves for out-of-round.



RG5062

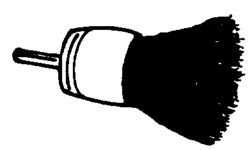
*D05058ST*

RE38635,000001D –19–01JUN05–5/11

RG5063 –UN–05DEC97

End Brush . . . . . . . . . . . . . . . . . . . . . . . . D17024BR

Clean valve seat and bores.



RG5063

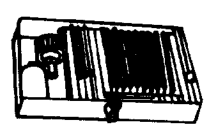
*D172024BR*

RE38635,000001D –19–01JUN05–6/11

RG5064 –UN–05DEC97

Valve Guide Knurler Kit . . . . . . . . . . . . . . . . .JT05949

Knurl valve guides.



RG5064

*JT05949*

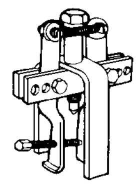
Continued on next page

RE38635,000001D –19–01JUN05–7/11

RG5071 –UN–05DEC97

Valve Seat Puller . . . . . . . . . . . . . . . . . . . .JDE41296

Remove valve seats.




*JDE41296*

RE38635,000001D –19–01JUN05–8/11

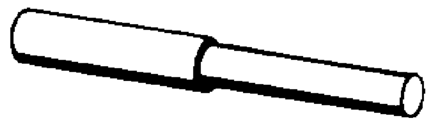
RG5065 –UN–05DEC97

Valve Seat Pilot Driver . . . . . . . . . . . . . . . . . . . . . JDE7

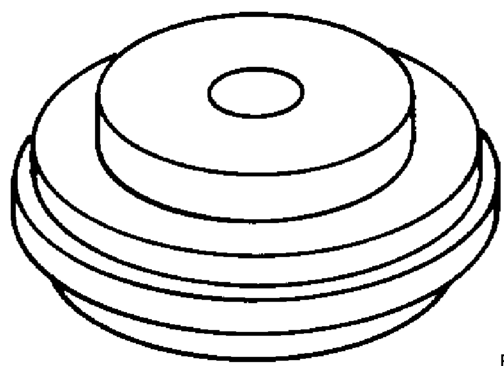
Install replacement valve seat inserts. Use with JDG605.

Valve Seat Installer . . . . . . . . . . . . . . . . . . . . JDG605

Install intake and exhaust valve seat inserts. Use with JDE7.




*JDE7*



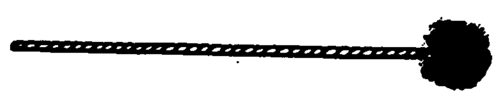

*JDG10057*

RE38635,000001D –19–01JUN05–9/11

RG5099 –UN–23AUG88

Nozzle Threads Cleaning Brush . . . . . . . . . . D17030BR

Used to clean electronic injector bore.



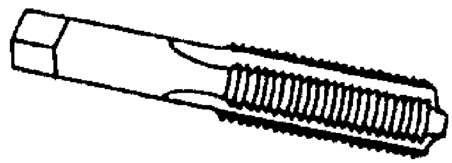
*D17030BR*

Continued on next page RE38635,000001D –19–01JUN05–10/11

RG5100 –UN–05DEC97

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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170
4

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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



RG6246 –UN–05DEC97

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

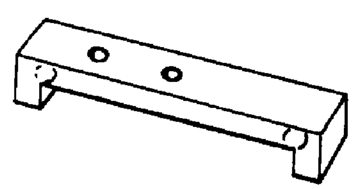
*D17526CI or D17527CI*

RE38635,0000019 –19–31MAY05–2/14

RG7029 –UN–05DEC97

Piston and Liner Height Gauge . . . . . . . . . . . . JDG451

Use with dial indicator to measure piston and liner heights above cylinder block.


RG7029

*JDG451*

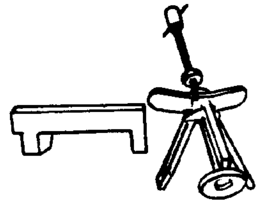
Continued on next page

RE38635,0000019 –19–31MAY05–3/14

RG5019 –UN–05DEC97

Cylinder Liner Puller . . . . . . . . D01062AA orD01073AA.

Remove cylinder liners.


RG5019

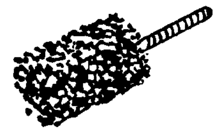
*D01062AA or D01073AA.*

RE38635,0000019 –19–31MAY05–4/14

RG5074 –UN–07NOV97

Flexible Cylinder Hone . . . . . . . . . . . . . . . . D17005BR

Hone cylinder liners.


RG5074

*D17005BR*



RE38635,0000019 –19–31MAY05–5/14

RG5077 –UN–07NOV97

Piston Ring Expander . . . . . . . . . . . . . . . . . . . JDE93

Remove and install piston rings.


RG5077

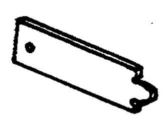
*JDE93*

RE38635,0000019 –19–31MAY05–6/14

RG5076 –UN–23AUG88

No. 1 Ring Groove Wear Gauge. . . . . . . . . . . . . JDE55

Check upper compression ring groove wear.



*JDE55*

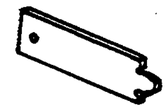
Continued on next page

RE38635,0000019 –19–31MAY05–7/14

RG5076 –UN–23AUG88

No. 2 Ring Groove Wear Gauge. . . . . . . . . . . . JDG852

Check lower compression ring groove wear.

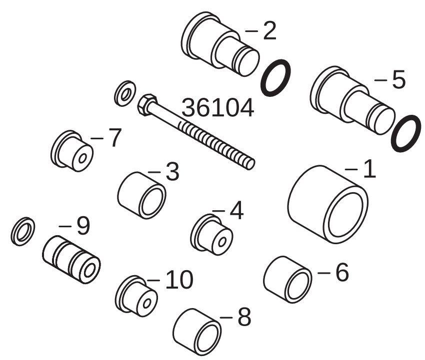


JDG852

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–25APR02

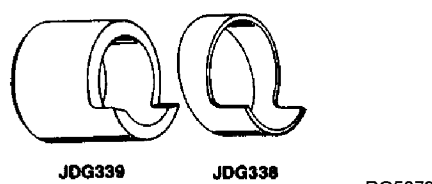
JDE98A

RE38635,0000019 –19–31MAY05–9/14

RG5079 –UN–07NOV97

Connecting Rod Bushing Service Set . . . . . . . . JDG337

Use with JDE98A Bushing Service Set to remove and install connecting rod bushings.

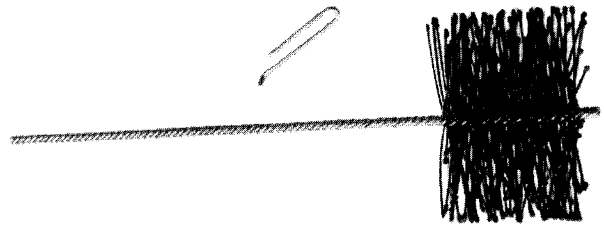



JDG337

Continued on next page RE38635,0000019 –19–31MAY05–10/14

O-Ring Groove Cleaning Brush . . . . . . . . . . D17015BR

Clean cylinder liner O-ring groove in block.




*D17015BR*

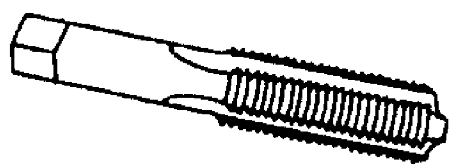
RE38635,0000019 –19–31MAY05–11/14

RG5100 –UN–05DEC97



Tap . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . JDG681

Used to restore threaded holes in cylinder block for cylinder head cap screws.




*JDG681*

**Continued on next page**

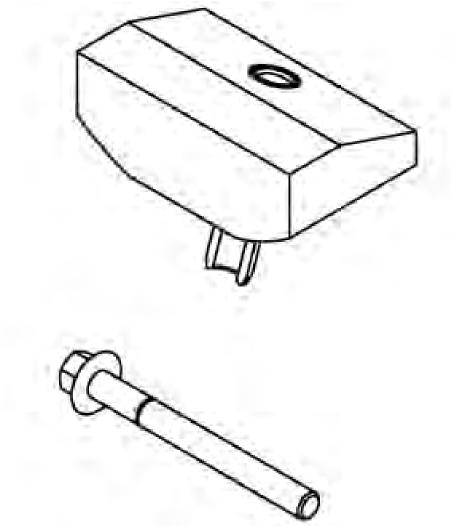
RE38635,0000019 –19–31MAY05–12/14

Piston Spray Jet Installation Tool . . . . . . . . . . . JDG1948

Install piston spray jet into main bearing web of cylinder block

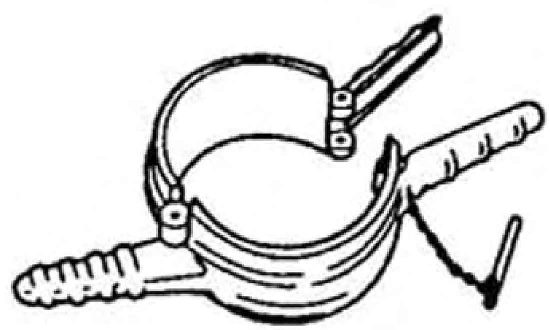
Piston Ring Compressor . . . . . . . . . . . . . . . . . JDG1963

Compress rings while installing pistons.



RG14225 –UN–31MAY05

*Piston Spray Jet Installer*



RG14233 –UN–31MAY05

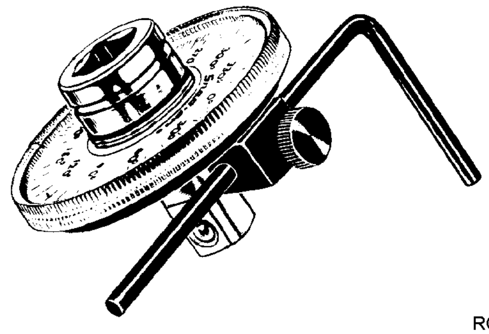
*Piston Ring Compressor*

**Continued on next page**

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*

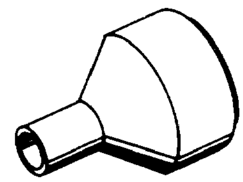
Continued on next page

RE38635,000001A –19–31MAY05–1/12

RG6214 –UN–05DEC97

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.

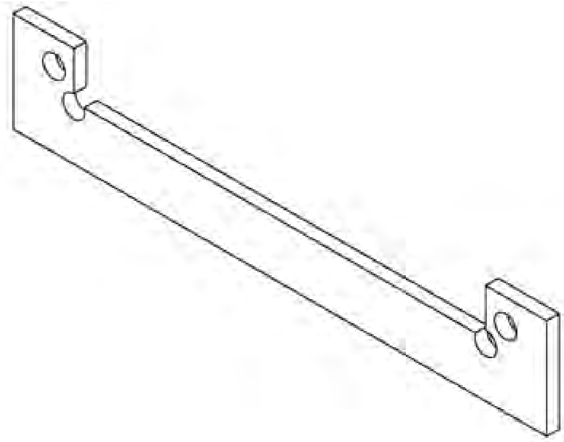



*JDG719*

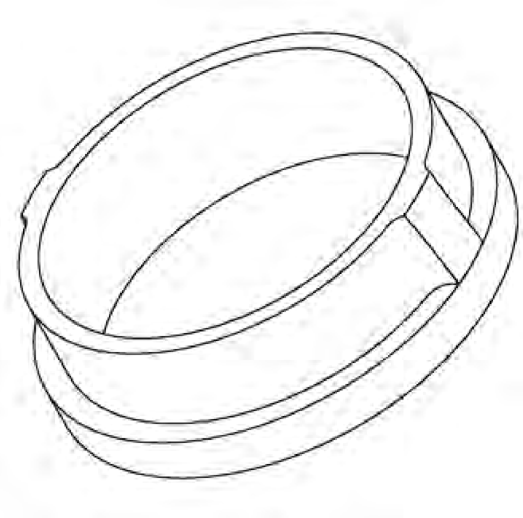
Continued on next page RE38635,000001A –19–31MAY05–2/12

Seal and Wear Sleeve Installer . . . . JDG1952, JDG1953, JDG1954

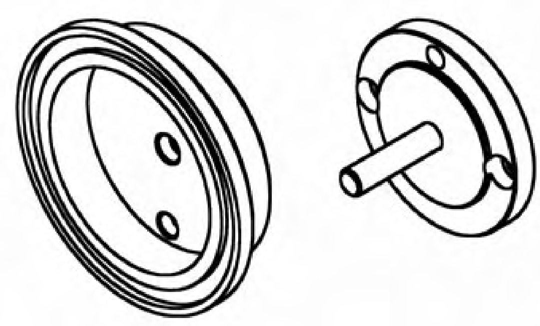
Used to simultaneously install the new teflon unitized oil seal and wear sleeve on the rear crankshaft flange. Also use with JDG1953 & JDG1954 Alignment Tools to align and install rear oil seal housing, eliminating need for dial indicator to measure runout.


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*

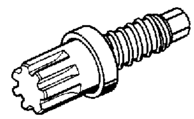


Continued on next page

RG7056 –UN–17JUN05

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.

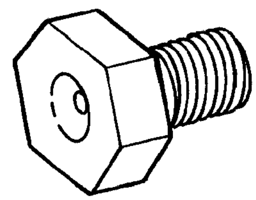


*JDG820*

RE38635,000001A –19–31MAY05–4/12

Thread Protector. . . . . . . . . . . . . . . . . . . . . . JDG787

Used with JDG721 Hub Puller Kit to remove vibration damper puller assembly. 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

*JDG787*

RE38635,000001A –19–31MAY05–5/12

Hub Puller Kit. . . . . . . . . . . . . . . . . . . . . . . . JDG721

Used with JDG787 Thread Protector to remove vibration damper pulley assembly.

RG5763 –UN–05DEC97

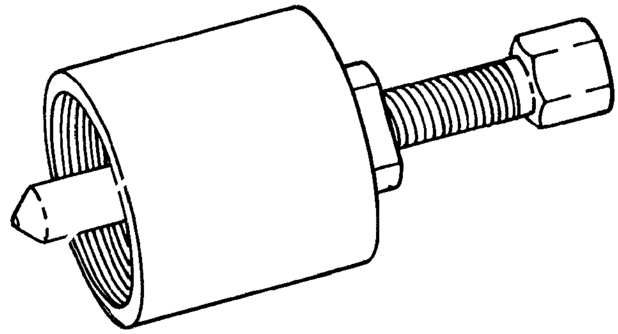
*JDG721*

Continued on next page

RE38635,000001A –19–31MAY05–6/12

Front Wear Sleeve Puller . . . . . . . . . . . . . . . . JDG786

Used to remove front crankshaft wear sleeve with timing gear cover installed.



RG6428 RG6428 –UN–05DEC97

*JDG786*

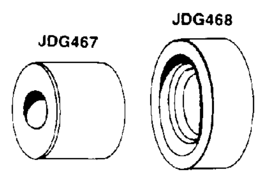
RE38635,000001A –19–31MAY05–7/12

RG5508 –UN–05DEC97



Front Wear Sleeve Installer Set . . . . . . . . . . . . . . JDE3

Install front crankshaft wear sleeve.



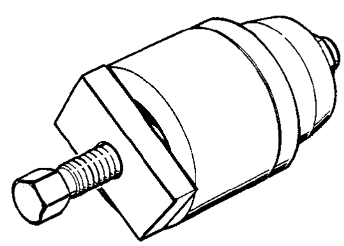

RG5508

*JDE3*

RE38635,000001A –19–31MAY05–8/12

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.



RG6215 RG6215 –UN–05DEC97

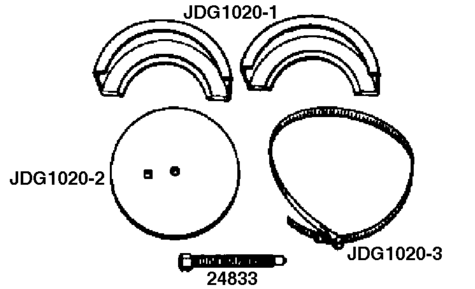
*JDG720A*

Continued on next page

RE38635,000001A –19–31MAY05–9/12

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.

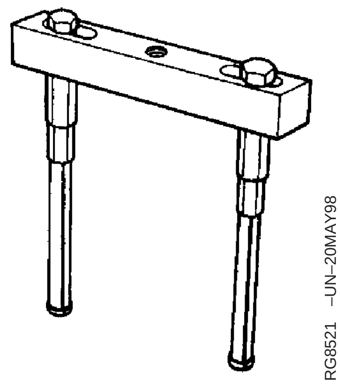



*Rear Crankshaft Seal & Wear Sleeve Puller*

RE38635,000001A –19–31MAY05–10/12

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.



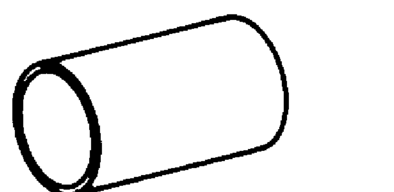

*JDG1069*

RE38635,000001A –19–31MAY05–11/12

RG5108 –UN–05DEC97

Gear Driver . . . . . . . . . . . . . . . . . . . . . . . . . . .JDH7

Install crankshaft drive gear.




*JDH7*

RE38635,000001A –19–31MAY05–12/12

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## 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.*

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RG41183,000000E –19–03JAN01–1/3

Slide Hammer . . . . . . . . . . . . . . . . . . . . . . D01300AA

Use with JDG1069 to remove main bearing caps.

RG41183,000000E –19–03JAN01–2/3



Puller[1] . . . . . . . . . . . . . . . . . . . . . . . . . . . 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.)<br>TY9479 (Canadian)<br>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.)<br>TY9473 (Canadian)<br>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. |

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*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).*

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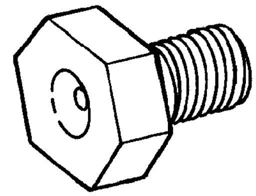
Continued on next page

DPSG,OUO1004,838 –19–27APR99–1/10

Thread Protector . . . . . . . . . . . . . . . . . . . . . . JDG787

Used with JDG721 Hub Puller Kit to remove vibration damper puller assembly.




*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.


*JDG721*

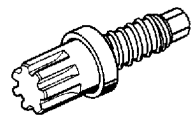
Continued on next page

DPSG,OUO1004,838 –19–27APR99–3/10

RG5068 –UN–01DEC97

Flywheel Turning Tool . . . . . . . . . . . . . . . . . . JDG820

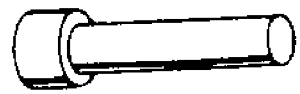
Used to rotate engine to check damper radial runout and time engine. JDE81-1 may be used also if JDG820 is not available.



*JDG820*

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.



RG5068

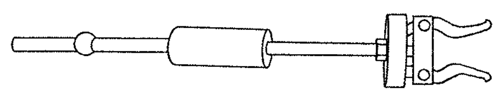
*JDE81-4*

DPSG,OUO1004,838 –19–27APR99–4/10

RG10060 –UN–10JUN99

Slide Hammer and Attachment. . . . . . . . . . . D01209AA

Used to remove auxiliary drive idler bushing/spacer from timing gear cover.

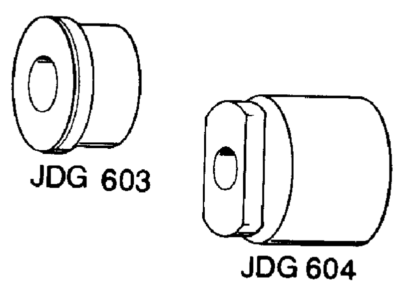


*D01209AA*

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 –UN–07NOV97

RG5336

*JDG602*

Continued on next page DPSG,OUO1004,838 –19–27APR99–6/10

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19

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.**

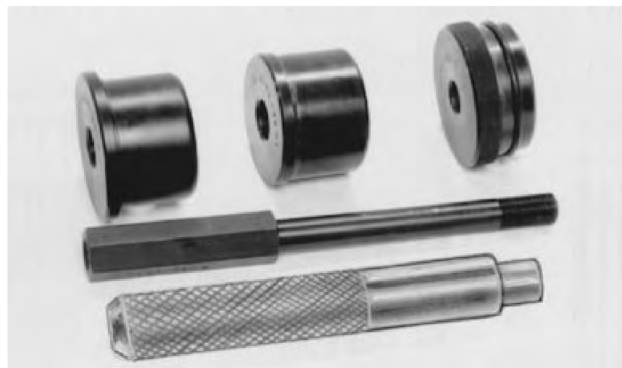
R26149N –UN–04DEC97

*JDE6*

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.**



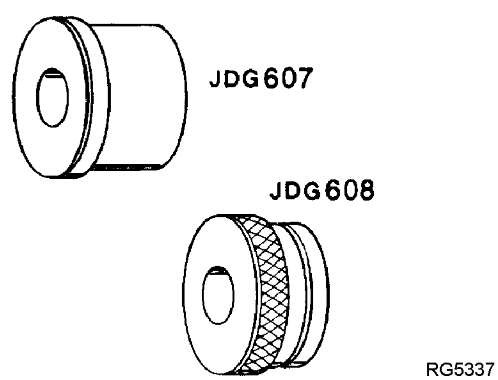
RG4228 –UN–05DEC97

*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.




RG5337 –UN–07NOV97

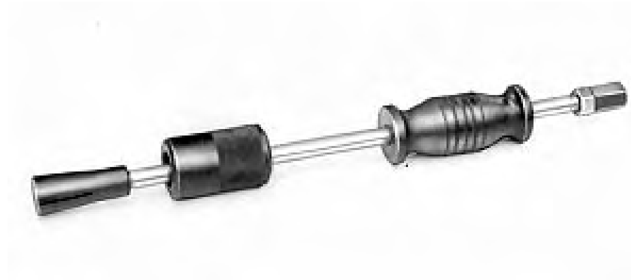
*JDG606*

Continued on next page

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. |

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*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.)<br>TY9473 (Canadian)<br>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.)<br>TY9480 (Canadian)<br>592 (LOCTITE®) | Pipe Sealant with TEFLON® | To seal oil pan elbow drain fitting. |

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*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.)<br>TY9480 (Canadian)<br>592 (LOCTITE®) | Pipe Sealant with TEFLON® | Coolant pump and block drain valves and coolant temperature switch. |
| T43512 (U.S.)<br>TY9473 (Canadian)<br>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

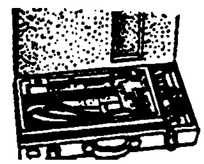
## Base Engine Diagnostic Tools

*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

RG5161 –UN–23AUG88



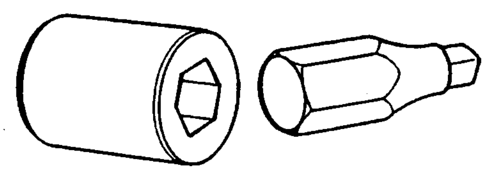
Compression Test Set . . JT01674 (formerly D14546BA or FKM10021)

Used to check cylinder compression pressure. Use adapter and gauge/hose assembly from set.

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

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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–14OCT05

DPSG,OUO1004,201 –19–07JUL98–4/7



Cooling System Pressure Pump . . . . . . . . . . D05104ST

Used to pressure test radiator cap and cooling system.

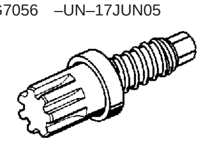
R26406N –UN–29NOV88

DPSG,OUO1004,201 –19–07JUL98–5/7

RG7056 –UN–17JUN05

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.



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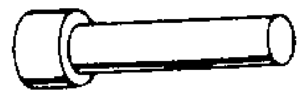
DPSG,OUO1004,201 –19–07JUL98–6/7

RG5068 –UN–05DEC97

Timing Pin . . . . . . . . . . . . . . . . . . . . . . . . . JDE81-4

Used to lock engine at “TDC”. Use with JDG820 Flywheel Turning Tool.



RG5068

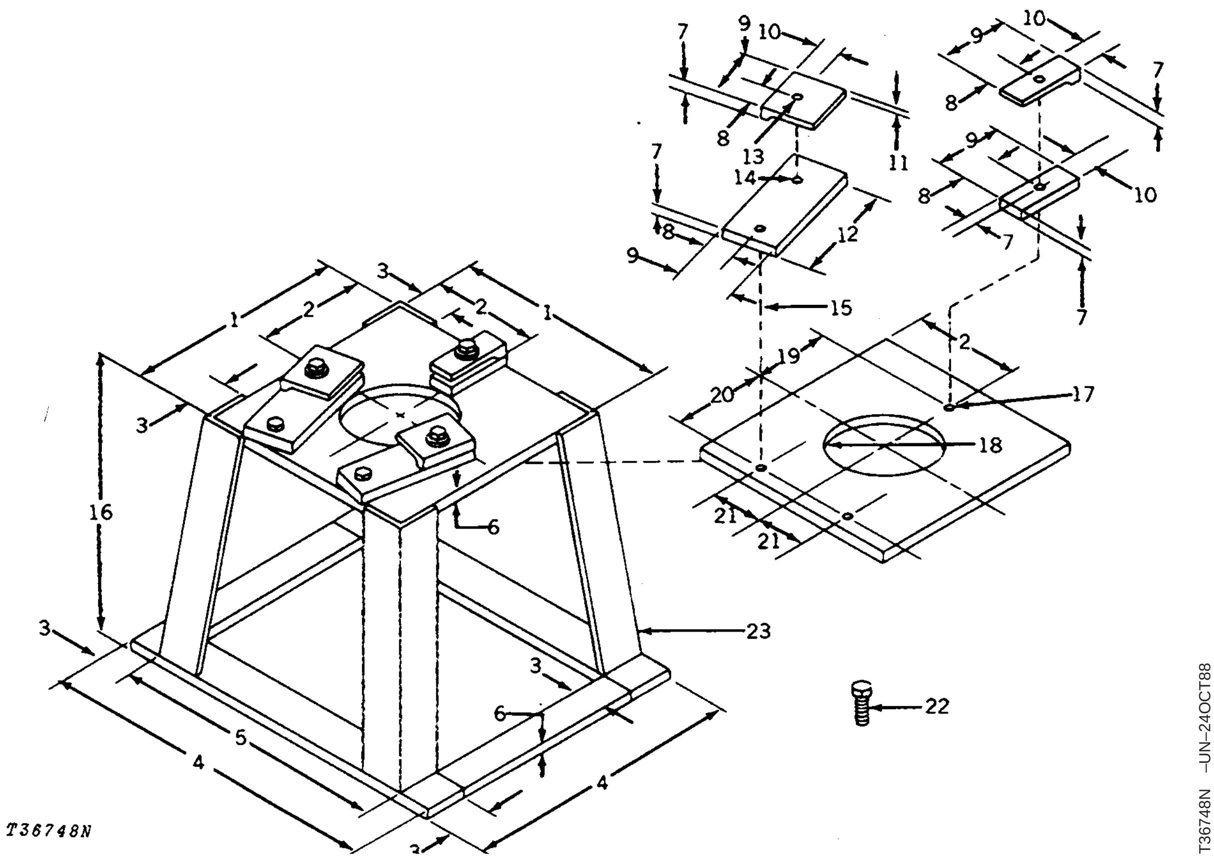
DPSG,OUO1004,201 –19–07JUL98–7/7

## How to Make Tools

This tool can be made in a service shop using common shop tools and locally obtained materials.

RG,RG34710,1338 –19–23OCT97–1/1

## 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 –19–23OCT97–1/1

05
190
2

# 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.) | 1168 (4.70) |
| Stroke | mm (in.) | 136 (5.40) |
| 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 |

Continued on next page

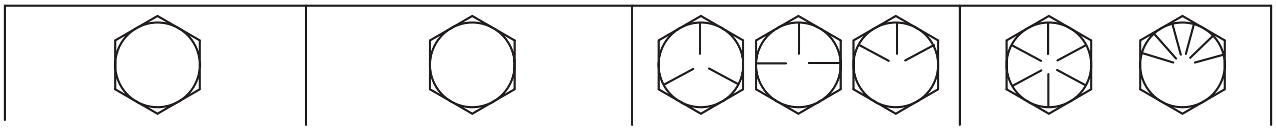
RE38635,00000A6 –19–04APR05–1/2

| ITEM | UNIT OF MEASURE | ENGINE MODEL 6090HF485 |
|---|---|---|
| Battery Capacity (minimum) - 24 Volt System | CCA | 750 |
| | Minutes | 275 |
| **Air System** | | |
| Maximum Air Intake Restriction | in. $H_2O$ (kPa) (bar) (psi) | 25 (6.25) (0.06) (1.0) |

RE38635,00000A6 –19–04APR05–2/2

## Unified Inch Bolt and Screw Torque Values

TS1671 –UN–01MAY03



| Bolt or | SAE Grade 1 | | | | SAE Grade 2[a] | | | | SAE Grade 5, 5.1 or 5.2 | | | | SAE Grade 8 or 8.2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Screw** | **Lubricated[b]** | | **Dry[c]** | | **Lubricated[b]** | | **Dry[c]** | | **Lubricated[b]** | | **Dry[c]** | | **Lubricated[b]** | | **Dry[c]** | |
| **Size** | **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.

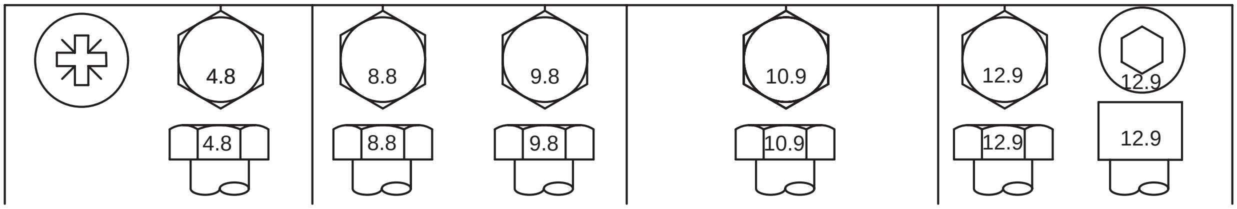
[b]"Lubricated" means coated with a lubricant such as engine oil, fasteners with phosphate and oil coatings, or 7/8 in. and larger fasteners with JDM F13C zinc flake coating.

[c]"Dry" means plain or zinc plated without any lubrication, or 1/4 to 3/4 in. fasteners with JDM F13B zinc flake coating.



DX,TORQ1 –19–24APR03–1/1

## Metric Bolt and Screw Torque Values




TS1670 –UN–01MAY03

| Bolt or | Class 4.8 | | | | Class 8.8 or 9.8 | | | | Class 10.9 | | | | Class 12.9 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Screw** | **Lubricated[a]** | | **Dry[b]** | | **Lubricated[a]** | | **Dry[b]** | | **Lubricated[a]** | | **Dry[b]** | | **Lubricated[a]** | | **Dry[b]** | |
| **Size** | **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 zinc flake coating.

[b] "Dry" means plain or zinc plated without any lubrication, or M6 to M18 fasteners with JDM F13B zinc flake coating.

DX,TORQ2 –19–24APR03–1/1

## Group 020 — Cylinder Head and Valves Repair Specifications

| Item | Measurement | Specification |
|---|---|---|
| Intake Valve Clearance Check & Adjust (Rocker Arm-to-Valve Tip With Engine Cold) | Clearance | 0.13—0.23 mm (0.005—0.009 in.) |
| Exhaust Valve Clearance Check & Adjust (Rocker Arm-to-Valve Tip 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 | 20 N••m (15 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.) |

Continued on next page

RG41165,0000018 –19–16NOV04–1/3

| Item | Measurement | Specification |
|---|---|---|
| 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 N••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 |
| | 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 |

Continued on next page

RG41165,0000018 –19–16NOV04–2/3

| Item | Measurement | Specification |
|---|---|---|
| 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 | Back screw out 75% thread engagement, then torque to 40 N••m + additional 75° (30 lb-ft + 75°) |
| Rocker Arm Cover-to-Cylinder Head Cap Screw | Torque | 20 N•m (15 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) |

RG41165,0000018 –19–16NOV04–3/3

## 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 | 0.43—0.69 mm (0.017—0.027 in.) |
| No. 2 Piston Compression Ring | End Gap | 1.01—1.27 mm (0.040—0.050 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—118.35 mm (4.658—4.659 in.) |
| Cylinder Liner | ID | 118.39—118.47 mm (4.661—4.664 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 |

Continued on next page
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| Item | Measurement | Specification |
|---|---|---|
| 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 | 76.150—76.180 mm (2.9980—2.9992 in.) |
| Assembled Connecting Rod Bearing | ID | 76.210—76.260 mm (3.0004—3.0024 in.) |
| Connecting Rod Bearing-to-Journal (New Parts) | Oil Clearance | 0.030—0.110 mm (0.0012—0.0044 in.) |
| Connecting Rod Bore (Without Bearings) | ID | 87.487—87.513 mm (3.444—3.445 in.) |
| 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.) |



*Precision Joint is a trademark of Deere & Company*

Continued on next page

| Item | Measurement | Specification |
|---|---|---|
| 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 N••m (12 lb-ft) |
| Cylinder Liner Shim | not available | na |



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## 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.) |

Continued on next page

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| Item | Measurement | Specification |
|---|---|---|
| Crankshaft Main Journal | Taper per 25.4 mm (1.0 in.) length<br>Out-of-Roundness | 0.0025 mm (0.0001 in.)<br>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 |
| 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.) |

Continued on next page

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| Item | Measurement | Specification |
|---|---|---|
| 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<br>Torque M10 Cap Screws | 25 N••m (19 lb-ft)<br>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) |

[1] *See INSTALL TIMING GEAR COVER, later in this group, for proper cap screw tightening sequence.*

**Continued on next page**

| Item | Measurement | Specification |
|---|---|---|
| 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) |
| SAE 1 Flywheel Housing-to-Cylinder Block Cap Screws | Torque | 365 N••m (269 lb-ft) |

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## 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.) |

Continued on next page

| Item | Measurement | Specification |
|---|---|---|
| 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 |
| 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<br>Oil Pressure - 2200 rpm (Tractors = 2100) Rated Speed Full Load | 170 (1.7 bar) (25 psi)<br>290 (2.9 bar) (42 psi) |
| Oil Filter Adapter-to-Cylinder Block (Top Load Oil Filter) | Initial Torque<br>Final Torque | 5 N••m (4 lb-ft)<br>36 N•m (27 lb-ft) |
| Oil Filter Bypass Valve Plug | Torque | 100 N•m (27 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<br>Free Length | 30.0 mm (1.18 in.) @ 64—78 N (14—18 lb-force)<br>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<br>Free Length | 30.0 mm (1.18 in.) @ 64—78 N (14—18 lb-force)<br>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 |

[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.*

**Continued on next page**

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| Item | Measurement | Specification |
|---|---|---|
| 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) |
| 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) |

[3]*See INSTALL ENGINE OIL PAN later in this group, for cap screw tightening sequence.*

[4]*See TIGHTEN CAP SCREWS ON FRONT FRAME/OIL SUMP (8000 SERIES TRACTORS) later in this group, for cap screw tightening sequence.*

**Continued on next page**

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| Item | Measurement | Specification |
|---|---|---|
| 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) |

*[4]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.) |

Continued on next page

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| Item | Measurement | Specification |
|---|---|---|
| Fixed Fan Drive Pulley (Bearing End) | ID | 47.576—47.612 mm (1.8731—1.8745 in.) |
| Fixed Fan Drive Pulley (Fan Spacer End )[1] | ID | 49.485—49.518 mm (1.9482—1.9495 in.) |
| Fan Spacer[1] | 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 |
| 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) |

[1]*Units with press-fit fan spacer only.*

**Continued on next page**

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| Item | Measurement | Specification |
|---|---|---|
| Thermostat Housing-to-Cylinder Head Cap Screws | Torque | 61 N••m (45 lb-ft) |
| Coolant Temperature Sensor | Torque | 40 N••m (30 lb-ft) |

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## Group 080 — Air Intake and Exhaust System Repair Specifications

| 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 100 — OEM Starting and Charging Systems Repair Specifications

| Item | Measurement | Specification |
|---|---|---|
| Alternator Strap to Alternator Mounting Hardware | Torque | 25 N••m (19 lb-ft) |
| Alternator to Fan Drive Plate Mounting Hardware (Lower) | Torque | 50 N••m (37 lb-ft) |
| Alternator Strap to Fan Drive Plate Mounting Hardware (Upper) | Torque | 35 N•m (26 lb-ft) |
| Starter Motor to Cylinder Block Cap Screws (Two outside screws) | Torque | 48 N••m (36 lb-ft) |
| Starter Motor to Cylinder Block Flange Nut (Inside) | Torque | 48 N••m (36 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.



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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, | 2200 | 2180 | 800 | 205 (275)[4] |
| | 16JD | 2200 | 2380 | 800 | 205 (275)[4] |
| | | 2200 | 2180 | 800 | 224 (300)[4] |
| | | 2000 | 2380 | 800 | 224 (300) |
| | | 2000 | 2180 | 800 | 242 (325)[4] |
| | | 2200 | 2380 | 800 | 242 (325) |
| | | 2000 | 2180 | 800 | 261 (350)[4] |
| | | 2200 | 2380 | 800 | 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

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.



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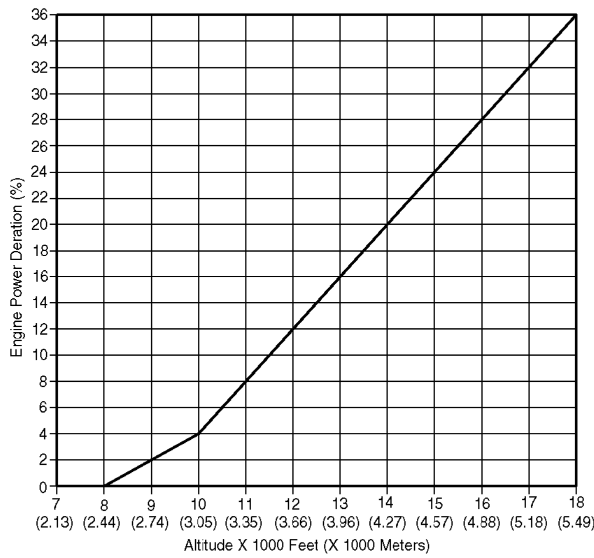
## Effects of Altitude and Temperature on Engine Performance

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 |

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*Turbocharged Engines*

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